GTAP

Extending the GTAP Data Base and Model
to Cover Domestic Support Issues using
the EU as Example

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Abstract

The EU Single Farm Payment (SFP)[2] is currently distributed in proportion to primary factor shares in version 8 of the GTAP database. In this paper, we investigate whether this way of modeling the EU SFP makes a difference in analyzing agricultural policy reforms. To do so, we create alternative versions of the GTAP database to compare the effects with the default setting in GTAP. Employing OECD data, along with the GTAP framework, we vary the assumptions about the allocation of the SFP. In the process, we demonstrate how to alter and update the GTAP database to implement domestic support of OECD PSE tables. We provide a detailed overview supplemented with assumptions of payment allocation, shock calculations and in particular, the *Altertax* procedure to update value flows and price equations extended in the GTAP model. Subsequently, we illustrate the impact of those assumptions by simulating a 100% removal of the SFP using the deviating versions of GTAP database. This sensitivity analysis reveals strong differences in results, but particularly in production responses of food and agricultural sectors that decrease with an increasing degree of decoupling. Furthermore, our analysis shows that the effect on welfare and the trade balance decreases with an increasing degree of decoupling. This experiment shows that the allocation of the SFP can have strong impact on simulation results.

Keywords: GTAP, CGE modeling and database, domestic support, EU Common Agricultural Policy, Single Farm Payment.

JEL Classification: D58, Q17, Q18

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[2] Please find the list of abbreviations on page IV.

Outline

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List of Abbreviations

ACT	All Commodity Transfer
AMS	Aggregate Measurement of Support
AoA	Agreement on Agriculture
CAP	Common Agricultural Policy
EAFRD	European Agricultural Fund for Rural Development
EAGF	European Agricultural Guarantee Fund
GCT	Group Commodity Transfer
GTAP	Global Trade Analysis Project
MTR	Mid-Term Review
PSE	Producer Support Estimate
OTDS	Overall Trade Distorting Domestic Support
OTP	Other Transfer to Producers (OECD), Synonym for SFP
SAPS	Single Area Payment Scheme (EU CAP)
SCT	Single Commodity Transfer
SFP	Single Farm Payment (EU CAP)
SPS	Single Payment Scheme (EU CAP)
UR	Uruguay Round

1 Introduction

The European Union (EU) has introduced a Single Farm Payment (SFP) in its 2003 reform of the Common Agricultural Policy (CAP) with the objective to provide basic income support to farmers without a linkage between subsidies and any specific production. Hence, those payments are decoupled from production. The extent to which the SFP is non-distorting of production is still a topic of debate. Even if the payments are decoupled from farm level output decisions, they can create incentives to produce via other channels. The SFP e.g., may not directly lead to an increase in production, but may influence a farmer's decision about farm exit or off-farm labor. In any case, it has an effect on the readiness of farmers to accept risks and stay in business. Herewith, the EU has added one more policy instrument to the already complicated mix of measures utilized to establish domestic support.

Previously, domestic support issues have only received minor attention within the Computable General Equilibrium (CGE) modeling community. The main reason for this is the difference in national domestic support programs, which can vary widely between countries. Hence, a resource intense country-specific coverage of domestic support in the model's database and a corresponding country-specific modeling of domestic support issues would be required. It is of importance to represent the SFP as correctly as possible in the database when running trade policy simulations to account for its decoupled character. One model often used for this purpose is the Global Trade Analysis Project (GTAP) model. Domestic support is incorporated into the GTAP database in form of price wedges. The underlying data are taken from the OECD's Producer Support Estimate (PSE) tables.

Focal point of our analysis is to show how domestic support and particularly the SFP can be updated in the GTAP database using the EU as an example. This approach yields an updated version of the GTAP database covering domestic support payments in a more detailed manner through accounting for product specific support, all commodity and group specific support as well as the SFP payment. Beyond this, we present a tool that can be used to adjust the degree of decoupling of the SFP easily to enable GTAP users to alter the database according to their assumptions on the decoupled character of the SFP. In order to depict the effects of the SFP, we create a set of GTAP databases by altering the assumptions made in GTAP for the implementation of the EU SFP. Conducting a complete elimination of the SFP, we present a sensitivity analysis that reveals the impact of the assumptions regarding the SFP on models results exemplary done for the EU. The results clearly mirror the impacts of deviating degrees of decoupling. A SFP allocated with a homogenous rate across sectors solely to the factor land creates no production incentives, does not lead to welfare effects, and generates only very small changes in the trade balance mainly driven by the non-agricultural sectors.

Altogether, we provide thorough information on the extension of the GTAP model and database to capture domestic support and the SFP by describing in detail the implementation procedure to update domestic support in the GTAP database and allow variations in the distribution of the SFP. This method can easily be adjusted and applied to other countries subject to the availability of PSE data.

This paper is organized as follows. In Section 2 we start with the classification and the concept of measurement of domestic support and, in particular, discuss the issue of the term

decoupling. For this purpose, we summarize the main findings in the literature on coupling channels, give an overview on how other modelers deal with decoupled payments, and highlight some empirical results regarding the SFP in the EU. The extension of the GTAP model to capture domestic support is introduced in Section 3. After that, we demonstrate how to manipulate the GTAP database to represent the OECD PSE data, followed by the illustration of our experiment design. The technical update procedure is explained in Section 5. Utilizing a sensitivity analysis, we furthermore show in Section 6 why it matters to implement domestic support and the SFP correctly. A final Section 7 concludes.

2   Domestic support

2.1   Classification of domestic support and concepts of measurement

Different measures are developed to quantify domestic support. The OECD has developed a set of indicators, including the PSE, to monitor and evaluate agricultural support provided through a wide variety of policy measures. The target of the OECD is to establish a common base for policy dialog among countries regarding effectiveness and efficiency of policy reforms. The PSE is defined as "the annual monetary value of gross transfers from consumers and taxpayers to agricultural producers, measured at the farm-gate level, arising from policy measures that support agriculture regardless of their nature, objectives or impacts on farm production or income" (Cahill, 1997; OECD, 2010).

According to the definition of the PSE, a policy measure will be included in the estimation of agricultural support, if either it provides a transfer whose incidence is at the farm level or it is directed specifically to agricultural producers, or it treats agricultural producers differently from other economic agents in the economy. The transfer to agricultural producers can be granted using different ways, e.g., an increased output price (market price support), a reduced input price or cost share for fixed capital or a direct payment (budgetary transfers). Market prices support covers transfers to agricultural producers generated by policy instruments that induce a gap between domestic market price and the border price of a specific product and therefore sustain the domestic prices at a higher level. While the term budgetary transfers covers policy instruments given to agricultural producers based on e.g., criteria as the output quantity, the amount of inputs used, the number of livestock, the area farmed or the received income.

Budgetary transfers are currently classified by the OECD database in the following categories (OECD, 2010):

A2   Payments based on output

B   Payments based on input use

C   Payments based on current Area / Animal Number / Receipts / Income, where production is required

D   Payments based on non-current Area / Animal Number / Receipts / Income, where production is required

E   Payments based on non-current Area / Animal Number / Receipts / Income, where production is not required

F   Payments based on non-commodity criteria

G   Miscellaneous

The PSE categories of support are specified into four groups of support given to primary agricultural production in a country (OECD, 2010 p. 17/18):

- **Activity-specific payments / single commodity transfer (SCT):** Payments given to specific primary agricultural commodities, arising from policies linked to the production of a single commodity such that the producer must produce the commodity in order to receive the transfer.

- **Group-specific payments / group commodity transfer (GCT):** Payments given to a group of primary agricultural commodities, arising from policies whose payments are made on the basis that one or more of a designated list of commodities is produced, e.g., a producer may produce from a set of allowable commodities and receive a transfer that does not vary with respect to this decision.

- **Activity-generic payments / all commodity transfer (ACT):** Payments given to all primary agricultural commodities, arising from policies that place no restrictions on the commodity produced, but require the recipient to produce some commodity of their choice.

- **Other transfer to producers (OTP/SFP)[3]:** Payments given to all primary agricultural commodities, arising from policies that do not require any commodity production at all (OECD, 2010).

Another classification system for domestic support is developed by the WTO. Domestic support discussed in the WTO negotiations refers to the annual level of support in monetary terms provided to agricultural production. The Uruguay Round (UR) negotiations incorporated the Agreement on Agriculture (AoA) which embodies the Aggregated Measurement of Support (AMS) as a key concept and the box classification scheme that group domestic support payments into amber, blue and green boxes according to the trade-distortive effect. The Doha WTO negotiations further specified domestic support by introducing the new measure of Overall Trade Distorting Domestic Support (OTDS). It comprises amber box support plus blue box support plus *de minimis* payments and is bound by a commitment.

Data from the yearly EU's financial reports are used officially to calculate both the PSE and AMS of the EU. Both concepts of measurement are indeed built on the same basis, but are differently extended afterwards. Hence, they are not comparable. The price gaps of the PSE calculation are estimated with reference to current domestic prices, while the AMS method uses a fixed reference to domestic administered prices of the year 1986 to 1988. Furthermore, the PSE concept includes all direct payments, whereas the AMS excludes some and allocates them to green and blue box support. The PSE includes implicit monetary

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[3] OTP is the denomination for the SFP in the OECD PSE database. In the following, we therefore use OTP when talking about the implementation of decoupled payments (SFP) in the GTAP database and model. In contrast, SFP is used when we talk about it in a political context. If it is not clearly related, we use OTP/SFP.

transfers from consumers resulting from import barriers. In the AMS calculation market price support is only defined, when an official administered price exists.[4]

2.2 Decoupling of direct payments

The EU SFP is considered to be decoupled and therefore to not affect production. Cahill (1997) clarifies the term decoupling which also constitutes the basis for the OECD's conceptional overview of decoupling (OECD, 2001). He distinguishes between three stages of decoupling in his formal concept:

- **Full decoupling** is the most restrictive definition and refers to a policy that does not influence production decisions of farmers receiving payments.

- **Effective full decoupling** states that a subsidy can be declared as decoupled, if production does not differ from the production level that would have occurred in the absence of that policy measure.

- **Partial decoupling** corresponds to the provision of a subsidy, which results in production that for any product exceeds the level that would exist without compensation, but does not achieve the level that would exist if the payments were fully coupled.

Accordingly, decoupling is a complex issue and it seems to exist in various degrees. The definitions above show the necessity for a formalization of the degree of decoupling. It is not clear yet, how the degree of decoupling can be measured. Are there other potential channels of coupling, e.g., through labor, land, risk or wealth effects which could have an impact on agricultural production? There is an extensive literature contributing to the ongoing discussion about the effect of various coupling channels on the production decision of farmers by identifying approaches on how to model decoupled payments taking different channels of decoupling into account. In these papers, coupling mechanisms are discussed which arise due to different allocative effects of payments. Bhaskar and Beghin (2009) referred in their survey paper, covering the literature on decoupling of the farm program of the last 10 years, to the five major coupling mechanisms: uncertainty, imperfect credit markets, land and labor markets, as well as farmer's expectations about future payments.

Reviewing the literature with regard to different coupling channels, it seems that most authors consider only one or two of the different channels in their analysis. This review is therefore not intended to give a complete overview of the literature of different coupling channels. It rather provides a rough overview about how different coupling channels take effect and how researchers measure their influence.

Decoupled payments increase farm income and reduce the income variability. This leads to the so-called insurance effect (Bhaskar and Beghin, 2008). Most of the papers considering this issue are dealing with the effect of decoupling on risk and uncertainty. Hennessy (1998) measures the effects on risk aversion using utility functions with constant and decreasing

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[4] Since the OECD PSE concept and the WTO AMS concept both have it seeds in the same initial concept, the Producer Support Equivalent, and are based upon the same data, the PSE data incorporated in a model as e.g., GTAP can be reconciled according to the WTO classification and therefore improve WTO analysis (compare Jensen et al., 2009).

absolute risk aversion. According to Hennessy's analysis, counter-cyclical payments (CCP) create risk-related production incentives. Based on this approach Antón and Mouel (2004) identify that at the same level of price truncation the CCPs program has, holding other factors constant, weaker risk-related effects on production incentives than the loan deficiency program. Based thereon, Just (2011), applying a new calibration-technique, states that significantly changes in wealth transfer are necessary to induce substantial changes in risk aversion and the herewith associated differences in production behavior.

Beside the reduction of income variability, decoupled payments lead under decreasing absolute risk aversion preference to smaller coefficients of absolute risk aversion, which Bhaskar and Beghin (2008) denote as the wealth effect. The measurement of coupling effects through wealth for risk-averse farm households is considered by Femenia et al. (2010). Using a similar approach, they reveal, even without taking capitalization into account, an underestimation of coupling effects expected due to the impact of the programs on farmers' attitudes towards risk.

In a credit-constrained environment, decoupled payments, which lead to an increase in farm income, allow for higher levels of savings and investment as well as improved access to credit. In their analysis, Sckokai and Moro (2009) argue that the degree of uncertainty regarding expected profit is the key to determining the rate of investment. Lobley et al. (2010) emphasize that market signals may become a more powerful driver of farmers' behavior than CAP instruments. They also find that only a minority of farmers seems to be able to exploit related opportunities. Similar results are presented e.g., by Chau and de Gorter (2005), Goodwin and Mishra (2006) and Latruffe et al. (2009).

Additionally, decoupled payments may have an influence on off-farm and on-farm labor supply. Serra et al. (2005) analyze whether 1996 US farm policy reforms altered household decisions using a probit model of labor supply. According to their analysis, decoupled payments have a negative impact on off-farm work participation and diversification of household income sources. Petrick and Zier (2011) account in their analysis for the employment effects of the entire CAP instruments. They find, ceteris paribus, a considerable decline in agricultural employment and point out that, on average, an increase in direct area payments results in labor shedding. In contrast, Key and Roberts (2009) suggest that non-pecuniary benefits from farming which may lead to an increase in on-farm work. On-farm work may be boosted by decoupled payments because they increase farmers' income and liquidity, thereby reducing farm household dependence on off-farm work.

The extent to which decoupled payments like the SFP have an influence on farmers' production decisions has been widely discussed in the literature, but remains inconclusive. It is assumed that the decoupled payment (e.g. SFP) provided through a subsidy given to land are capitalized into the factor price (rent) of land (Latruffe and Le Mouel, 2009). Many authors confirm the capitalization in land rents and the effect on production. Kilian et al. (2012) demonstrate the interdependence of the degree of decoupling on the relation of eligible hectares and SFP entitlements, the selected implementation model, and the land supply elasticity. However, van Meijl et al. (2006) find small negative effects on land use and effects smaller than in case of market price support for the production impacts. Furthermore, decoupled payments may influence exit decisions of farmers, in particular exit decisions for low-profit farm units where the payments can serve to cover fixed costs. Consequently, they may prevent marginal farmers from exiting the sector (Chau and de Gorter, 2005). Reviewing the literature, most studies confirm the effects on production through other coupling channels,

but the extent to which these arise is often unclear (Goodwin and Mishra, 2005; Key and Roberts, 2009). Moreover, Just and Kropp (2009) point out that, while direct payments may be decoupled in a static analysis, they can still become coupled in the long run through dynamic decisions.

This literature overview indicates the complexity of analyzing the extent to which farm support is decoupled. The SFP scheme, in particular, is difficult to analyze when different coupling channels are taken into account. Most authors conclude that there are incentives to increase production induced by decoupled payments. However, they also state that those effects are rather modest. The effects of decoupled payments on land allocation and related production effects are the highest. Furthermore, this review shows that no single paper considers all coupling channels. Hence, when analyzing decoupled payments it is likely necessary to neglect some coupling channels – particularly if they are not of central importance for the analysis.

This literature review also reveals this limited work to date on modeling of decoupled income support, in particular the SFP, within a CGE framework. One of the initial steps towards modeling direct income support decoupled from production was made by Frandsen et al. (2003). They adjusted the standard GTAP model to depict the implications of the EU CAP. They modeled decoupled payment as subsidies given to the factor land irrespective of the use. Due to the underlying model specification, this implies that decoupled support creates no production incentives.

Subsequent work, including Scenario 2020, as described in Nowicki et al. (2009), employed the CGE model LEITAP[5] together with partial equilibrium models as ESIM and CAPRI to analyze the potential effects of the EU CAP. In LEITAP, decoupled payments are modeled as payments linked to land assuming that the factor land in all eligible agricultural activities receives the same rate. Although this implies no influence on the production choice, agricultural sectors has an advantage compared to manufacturing and services since the payments increase farm income and therefore binding more production factors in agriculture reducing the abandonment of land (Nowicki et al. 2009). A similar approach is chosen e.g., in the MIRAGE model (Decreux and Valin (2007).

In addition to these modeling approaches of global CGE models, interesting studies applying single country models are available. Philippidis (2010), for instance, developed a single country CGE model for Spain based on the ORANI model to measure the impact of the EU CAP in Spain. In this study, the SFP is implemented as a uniform subsidy rate on the factor land, as was done in Frandsen et al. (2003). Deviating from this allocation mode, other single country CGE models implemented the SFP in form of income support given to households. One of those approaches is provided by Boysen et al. (2014) who applied a CGE model for Ireland based on a disaggregated SAM. They modeled the SFP as lump sum transfers from the government to households assuming that it creates no production incentives and is consequently fully decoupled. Gelan and Schwarz (2008, 2011) apply a similar approach for Scotland by decoupling the SFP from the agricultural activities and transferring

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[5] LEITAP (MAGNET) is a modified version of the GTAP model that treats agricultural policies (e.g., production quotas, intervention prices, tariff rate quotas together with coupled and decoupled payments) explicitly using information from the OECD's Policy Evaluation Model (PEM). This model gains through an enhanced production structure together with a new methodology of land allocation.

it as income support to households. Modifying the STAGE-model Ferrari et al. (2012) modeled as well agricultural policies and, in particular, the SFP for Ireland. They utilize different policy instruments to account for both fully or partially decoupled and fully coupled support.

Additional progress has been made in the field of Partial Equilibrium (PE) analysis. PE models are often applied at more disaggregated levels and therefore are better aligned through a more detailed depiction of the agricultural sectors to capture the specific properties of decoupled income support. Britz et al. (2012) provide an EU-wide analysis at the regional and farm level to quantify the impacts of decoupled support applying the CAPRI model. Their results state that production is affected by the SFP through its effect on land allocation and herd size, which considerably influences the income distribution.

Gohin (2006) and Balkhausen et al. (2008) evaluated the effects of EU decoupled support applied in different GE (GTAP and GOAL) and PE (AGLINK, AG-MEMOD, CAPRI, CAPSIM, ESIM, FAPRI, and GOLD) models[6]. Balkhausen et al. (2008) provide an overview of the effects of decoupling in the EU on land allocation and production comparing the model specification and parameter assumptions with focus on the SFP. In contrast, the objective of Gohin (2006) is to test whether the effects of the compared simulations models are sensitive to the specifications of the effects of CAP direct payments (AGENDA 2000). Both studies confirm that the effects are similar across different simulation studies, but that the magnitude of these effects varies due to the underlying model specifications. All simulations depict that decoupling reduces the total cereal area and come up with a decline in beef and sheep meat production, but with a large variation in the extent.

The majority of studies assumed maximum decoupling in the conducted scenarios with decoupling rates of 100% (AG-MEMOD, CAPSIM, ESIM, GTAP, AGLINK, and FAPRI). Others deviate from this assumption adopting only partial decoupling based on e.g., production effects of the SFP that are assumed to be 6% of the effect of market price support for arable crops and beef production (AGLINK) (Gohin, 2006). In contrast, the analysis conducted with AG-MEMOD is based on the assumption that the SFP has 30% of the area allocation effect of arable crop payments under the AGENDA 2000, while FAPRI refers to an effect of 15% of the effect of price support on land allocation to activities (Balkhausen et al., 2008). They find that the degree of decoupling is the most important factor in their analysis. Consequently, they criticize simulation models, which rely on ad-hoc assumptions about the degree of decoupling and emphasize the need for better empirical and theoretical support of this work.

In summary, it is critically important to be aware of how the different SFP modeling assumptions can influence model's results. The majority of approaches try to represent the SFP as decoupled or apply some ad-hoc assumptions about partially decoupled payments. Referring to the literature review on coupling channels it seems reasonable to focus on the effects of modeling assumptions referring to deviating degrees of decoupling. Thus, in the next Sections we add to fill this gap and present the extension of the standard GTAP model and database that enables us to account for various degrees of decoupling in GTAP. In so

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[6] Balkhausen et al. (2008) covers all listed models except GOLD. Gohin (2006) included all models except CAPSIM and GOAL in the conducted analysis. They provide information on the standard documentation of the analyzed models in their articles and refer to different studies providing more details on the evaluated results.

doing, we consider not only the assumption of a fully decoupled SFP in our analysis, but also a SFP that is not fully capitalized in land rents. Since Goodwin and Mishra (2005) find that the effect of other coupling channels is modest, while Chau and de Gorter (2005) observe that the SFP reduces the fixed costs of farmers to some extent, we provide a sensitivity analysis that covers a broad range of underlying degrees of decoupling to evaluate the impact.

3   Extended GTAP modeling framework

This analysis is conducted using the comparative static regional general equilibrium model GTAP. The framework of the standard GTAP model is well documented in Hertel (1997) and available on the Internet[7]. Important for the conducted analysis is that all policy instruments are represented as ad valorem tax equivalents that create wedges between the undistorted prices and the prices including the policy. Domestic support is modeled accordingly, but only budgetary payments based on the OECD PSE tables are implemented in the GTAP database and model. Market price support is omitted here, since it is implicitly included via border measures in the GTAP model. An isolation of the market price support from the border measures is clearly beyond the scope of this paper. Hence, when dealing with domestic support issues in the following we focus on the behavioral equations in the production technology representation of the standard GTAP model (production tree). For a specific production activity, this production tree combines intermediate inputs and the primary factor inputs land, labor, capital and natural resources applying a nested structure. The production technology tree is shown in Figure 1.

Firms purchase intermediates inputs that are both produced domestically and are imported. Trade is represented in the GTAP model by bilateral trade matrices based on the Armington assumption, which implies that all products can be differentiated by country of origin and the similarity of commodities from different regions is determined by the elasticity of substitution. In the lower nest of the production tree a CES production function aggregates the imported intermediate inputs from different regions (elasticity of substitution = ESUBM), while in the upper nest a CES production function determines the combination of aggregated imported intermediate inputs and domestically produced ones (elasticity of substitution = ESUBD).

In the last step of the production process, a Leontief production function is applied to combine the aggregate of intermediate inputs with the value added. The value added is obtained using a CES production function to aggregate the factors of production (elasticity of substitution = ESUBVA). The GTAP model distinguishes between endowment commodities that are perfectly mobile between sectors as capital and labor and those that are sluggish, the factors land and natural resources. Mobile endowment commodities receive the same return in every sector while sluggish factor returns differ by sector in equilibrium. The primary production factors land, labor, capital, and natural resources are fully employed within each region. Factors cannot migrate between regions. The elasticity of substitution between factors is much smaller for the agricultural sectors (0.26) than for others (>=1.05) and is therefore inelastic. The factor land is agriculture-specific dampening the supply response of sectors requiring land. A raise in demand for all agricultural commodities will lead to an increase in

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[7] Please refer to https://www.gtap.agecon.purdue.edu/products/gtap_book.asp

the price for land. Growths in agricultural output while land supply is constant require substituting land by other primary factors. The supply response is much higher at the level of individual primary agricultural sectors as for agriculture as a whole, since the factor land is no longer a fixed factor for the disaggregated primary agricultural sectors. This land mobility is determined through the elasticity of transformation (ETRAE = -1) in GTAP[8].

Figure 1. GTAP production technology tree
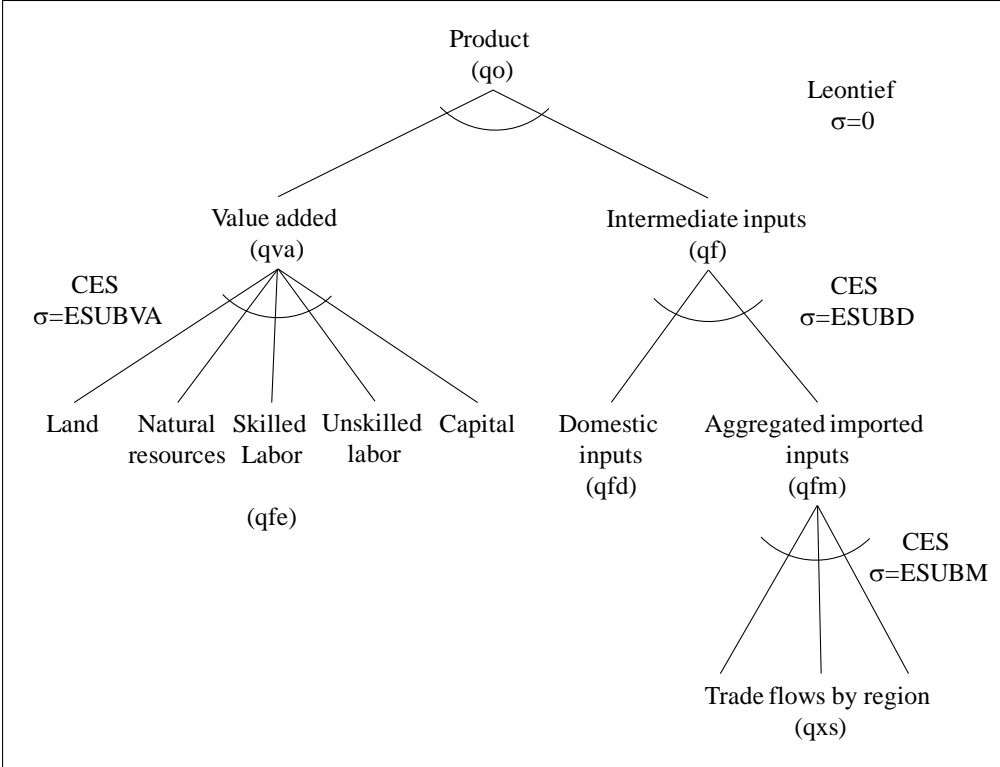
Source: Adapted from Hertel (1997).

A subsidy distributed with a homogenous rate across primary agricultural commodities (all land using sectors) only to the factor land, capitalize in land rent, and hence lead to an increase in the market price for land while the agent's price is not affected[9]. Consequently, a subsidy allocated with a homogenous rate across all primary agricultural commodities and distributed solely to the production factor land creates no production effects in the GTAP model.

At this stage, we would like to draw the reader's attention to the GTAP-AGR model developed by Keeney and Hertel (2005), which introduces detailed agricultural structure covering important linkages between international trade and the farm and food economy into the standard GTAP model. GTAP-AGR would be a good alternative for the simulation of agricultural policy reforms because of the following three features. Keeney and Hertel (2005) modified the factor supply and demand equations in order to account for the crucial role of the factor market regarding producer subsidies. They consider farm households as entities and

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[8] For information that is more detailed refer to the GTAP book (Hertel, 1997) and the documentation of the GTAP database, in particular chapter 12.A (Narayanan et al. 2012).

[9] A detailed explanation is provided in the Appendix Section 8.2.

therefore adjust the model to differentiate between income earned from farm or non-farm activities and to comprise taxes paid by farm households. Additionally they adjust the specification of consumer demand to distinguish among food and non-food commodities. Beyond that, they allow substitution between feedstuffs used in the livestock sector. Our approach introduced in this paper is designed for the standard GTAP model as a general code to address a broader audience of GTAP users. Nevertheless, users can translate this approach to the more detailed GTAP-AGR model.

The methodology introduced in this paper consists of two steps. First, we implement/update domestic support payments into the GTAP database using an extended version of the *Altertax* model (Malcolm, 1998). Second, we extend the standard GTAP model in order to run different policy simulations to analyze the impact of domestic support payments on e.g., trade or welfare.

3.1   Adjusted *Altertax* model

For the integration of domestic support payments into the GTAP database, we apply an extensively adjusted version of the *Altertax* model developed by Gerard Malcolm. The *Altertax* model is a method that is commonly used to adjust the GTAP database by end users. The decision for *Altertax* as database adjustment procedure, instead of other iterative scaling methods as RAS or maximum entropy, was made because of advantages as no further investments are required and the *Altertax* model is accessible for all. Furthermore, our *Altertax* program not only encompasses factor subsidies (land, labor, and capital), but also intermediate and output subsidies, taking onboard all domestic support programs calibrated into the GTAP database. Our provided *Altertax* model takes indeed the EU as an example, but it can be easily applied to other countries. Malcolm's *Altertax* model is based on a variant of the GTAP model. It is developed to update information on taxes in an existing aggregation of the GTAP database. An important feature of the *Altertax* model is that it minimizes the impact of tax changes on the value flows by maintaining the internal consistency of the database through modifications in the underlying model structure and parameter settings.

We utilize the variant of the *Altertax* model, in which all endowments are treated as sluggish and are incorporated using a uniform elasticity of substitution. Referring to Malcolm (1998), this implies that variations in the size of a specific agricultural sector do not have as much influence on other agricultural or non-agricultural sectors in the domestic market through factor markets since factor returns across sectors are not balancing. Nevertheless, the quantity response of the domestic sector itself is much more constraint since factor prices within that sector will vary more. This is consequently mirrored by the changes in output prices. Beyond, this causes subsequent effects on other sectors as the acquisition of intermediate inputs from the sector affected by the shock.

To represent domestic support payments, we extensively modified the *Altertax* model to cover PSE budgetary transfers in more detail in the GTAP model[10]. PSE payments are provided to agricultural producers through various agricultural policy instruments that are mirrored in GTAP in form of five price wedges evaluating transactions of producers at

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[10] More information about the PSE concept and the classification of budgetary transfer is available at the website www.oecd.org and in the PSE manual (OECD, 2010).

agent's and market prices for output, intermediate inputs, land, capital and labor. Each of these price wedges however include payments belonging to the four PSE payment groups. Hence, this initial breakdown of policy instruments is much too rough to capture the diverse effects of domestic support payments. For the implementation of a more detailed depiction of domestic support payments, we added policy instruments representing SCT, GCT, ACT, and OTP in each of the price wedges. In so doing we achieve a more detailed structure of value flows and division of the corresponding price linkage equations.

Following the definitions of the OECD, SCT payments can be modeled product specific. The GCT payments are granted to groups of primary agricultural commodities irrespective which of these commodities the farmer decides to produce. In order to reflect this allocation mechanism in the adjusted *Altertax* model GCT subsidies are implemented with a homogenous rate across all sectors that are part of the predefined group. Similarly, the ACT payments are introduced, since farmers receive such payments as long as they produce at least one commodity out of the group all primary agricultural commodities.

A special case in this analysis is the OTP/SFP[11] where no production is required to receive such payments. Since the SFP is a complex policy instrument, where the EU allows their member state much flexibility in how they calculate and distribute those payments to farmers, we include a short excurse on the SFP at this stage.

Understanding the Single Farm Payment Scheme:

In 2003 the EU introduced the Single Payment Scheme (SPS) with the objective to provide basic income support to farmers without a linkage between subsidies and any specific production (EC 1782/2003; EC 73/2009)*. The SPS consists of two components, the SFP and the Single Area Payment Scheme (SAPS). The SFP is in force since 2005 and is currently applied by 17 EU (EU15 plus Slovenia and Malta) member states. The remaining 10 member states are utilizing the SAPS, which was offered to the member states that joined the EU in 2004 and 2007 in order to relax the implementation requirements. The SFP grants the member state high flexibility in the application and varies therefore from member state to member states. It is paid in form of a single annual payment based on entitlements allocated to farmers. Member states faced three options for determining the payment entitlements: First, based on historical payments received by farmers in a reference period resulting in different aid levels per hectare (historical model). Second, division of the total amount of payments received in one region by the number of eligible hectares resulting in a flat rate (regional model). Third, applying a mixture between both models (hybrid model). In contrast, SAPS replaced all direct payments with a single area payment without establishing entitlements and was therefore simpler than SFP. The SAPS was phased out in 2013.

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* For extensive information on how the SPS works and how this payments scheme may develop after 2013 refer to a study requested by the European Parliament (2010)

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[11] Here, we repeat footnote no. 3 to facilitate the understanding. OTP is the denomination for the SFP in the OECD PSE database. In the following, we therefore use OTP when talking about the implementation of decoupled payments (SFP) in the GTAP database and model. In contrast, SFP is used when we talk about it in a political context. If it is not clearly related, we use OTP/SFP.

Due to the modeling of the factor market in the standard GTAP approach and in particular the representation of the factor land, the distribution of the SFP to the factor land only with an allocation using a homogenous rate across all primary agricultural commodities reflects an effectively fully decoupled SFP in the model. Furthermore, it accounts for both definition of measures, the SFP and the SAPS[12]. Taking the statements of the literature review and in particular, the summarized empirical findings of other analyses into account, it is necessary to deviate somehow from effective fully decoupled payments. Besides, the default setting in the standard GTAP database and model is the allocation with a homogenous rate across factors and primary agricultural sectors, which represent a variant of partially decoupled payments. This approach is illustrated in the following, first for domestic support in form of subsidies given to land, capital and labor, second domestic support given to intermediate inputs and finally domestic support in form of output subsidies.

The standard GTAP model allows for a differentiation between producer expenditure on factor i at market prices (VFM_{ijr}) and producer expenditure on factor i at agents prices $(EVFA_{ijr})$ used by commodity j in region r. These values are based on the linear price equation that establishes the link between agents (pfe_{ijr}) and market prices $(pmes_{ijr})$ using the percentage change of the policy variable tf_{ijr}. It holds for endowment goods[13] and captures the effect of taxation of firms' usage of primary factors (3.1)[14].

$$
\begin{aligned}
&\forall i \in ENDW \\
(3.1) \quad pfe_{ijr} = tf_{ijr} + pmes_{ijr} \quad &\forall j \in PROD \\
&\forall r \in REG
\end{aligned}
$$

pfe_{ijr}	Firms' price for endowment i in commodity j of region r
$pmes_{ijr}$	Market price of endowment i used by commodity j in region r
tf_{ijr}	Tax on primary factor i used by commodity j in region r

Adding the percentage change of the endowment quantity (qfe_{ijr}) to the respective prices yields the corresponding percentage change of values, while the difference between $pmes_{ijr}$ and pfe_{ijr} is equal to the percentage change of the power of the ad valorem tax and subsidy, respectively. To account for the representation of the homogenous (OTP, ACT, GCT) and non-homogenous (SCT) support we add the percentage change variables $tfsfp_r$, $tfsub_{irg}$, $tfsct_{ijr}$ and for the factor taxes tft_{ijr} as new policy instruments. These policy instruments are then used to establish four new price equations for the domestic support subsidies going to land, labor, and capital, which are linked to new value flow $VFMX_{ijrg}$ in the database (equation (3.2) to (3.5)).

In equation (3.2) the agent's price of endowment i used by commodity j in region r equals the price $pmesx_{ijrg}$, with g = GCT12, which already includes OTP, ACT and GCT payments plus the policy instrument for the SCT payments. Since the SCT is product specific, the policy instrument is directly related to commodities.

---

[12] The GTAP model is not suited to account for different options of the modeling of entitlements since the GTAP model includes only one representative household.

[13] In the standard GTAP model, this equation is separated into sluggish and mobile endowments.

[14] All equations that do not deviate from the standard GTAP model have a grey background.

$$(3.2) \quad pfe_{ijr} = tfsct_{ijr} + pmesx_{ijrg}$$

<div align="right">

$\forall i \in ENDW$

$\forall j \in PROD$

$\forall r \in REG$

$g = GCT12$

</div>

$pmesx_{ijrg}$	*Market price of endowment i incl. ACT, GCT and OTP subsidies used by j in region r*
$tfsct_{ijr}$	*Tax (SCT) on primary factor i used by commodity j in region r*

In contrast, equation (3.3) shows the group specific modeling of the policy instrument. The coefficient parameter $MMREG_{jrg}$ provides a mapping matrix that determines which product is allocated to a particular group. Within a group, the policy instrument *tfsub* is distributed homogenously over the products. Furthermore, the production value share $PROD\_SHR_{jrg}$ is added to the equation. It is calculated as the relation between EUROSTAT production value and the production value where some oilseeds are excluded to account for the composition of GCT groups that is deviating from the sector aggregation in GTAP.

$$(3.3) \quad \begin{aligned} pmesx_{ijrg} = {} & MMREG_{jrg} * PRODV\_SHR_{jrg} * tfsub_{irg} \\ & + pmesx_{ijrb} \end{aligned}$$

<div align="right">

$\forall i \in ENDW$

$\forall j \in PROD$

$\forall r \in REG$

$\forall g \in GROUP$

$\forall b \in BASEGROUP$

</div>

$tfsub_{irg}$	*Tax(ACT, GCT) on primary factor i in region r for group g*
$MMREG_{jrg}$	*Regional mapping matrix to allocate products to groups for commodity j in region r for group g*
$PRODV\_SHR_{jrg}$	*Relation of production values to account for deviating production values in GCT2 and GCT11 for commodity j in region r for group g*

Equations (3.4a) and (3.4b) are needed to model the OTP. In equation (3.4a) the policy instrument *tfsfp* distributes the OTP payments with a homogenous rate across sectors and factors, which is the default in GTAP. While it distributes the OTP payments in equation (3.4b) according the factor usage with a homogenous rate across primary agricultural commodities.

$$(3.4a) \quad pmesx_{ijrb} = tfsfp_r + pmest_{ijr}$$

<div align="right">

$\forall i \in ENDW$

$\forall j \in AGRI$

$\forall r \in REG$

$b = OTP$

</div>

$tfsfp_r$	*Tax (OTP/SFP) in region r*

(3.4b) $\quad pmesx_{ijrb} = tfsfp_{ir} + pmest_{ijr}$

$$\forall i \in ENDW$$
$$\forall j \in AGRI$$
$$\forall r \in REG$$
$$b = OTP$$

$tfsfp_{ir}$ *Tax (OTP/SFP) for endowment i in region r*

Due to the homogenous allocation across selected sectors, it is required to split up the equations between agricultural and non-agricultural commodities, where no OTP is included.

(3.5) $\quad pmesx_{ijrb} = pmest_{ijr}$

$$\forall i \in ENDW$$
$$\forall j \in NAGRI$$
$$\forall r \in REG$$
$$b = OTP$$

These price equations are then linked to new value flows $VFMX_{ijrg}$ in the GTAP database that include the four groups of subsidies. Equation (3.6) is built to establish the value flow $VFMT_{ijr}$ that includes the factor employment tax.

(3.6) $\quad pmest_{ijr} = tft_{ijr} + pmes_{ijr}$

$$\forall i \in ENDW$$
$$\forall j \in PROD$$
$$\forall r \in REG$$

$pmest_{ijr}$ *Market price of endowment i incl. factor tax used by j in r*

tft_{ijr} *Tax on primary factor i used by commodity j in region r*

Accordingly, pfe_{ijr} is the agents price of endowment i used by industry j in region r comprising homogenous and non-homogenous support, while $pmesx_{ijrg}$ is the market price of sluggish endowment i used by industry j in region r that includes the homogenous support. Whereas $pmest_{ijr}$ is the market price of endowment i used in industry j in region r that includes the factor tax. The corresponding percentage changes of the values are obtained by adding the percentage change of the demand for endowment i for use in commodity j in region r (qfe_{ijr}) to the respective price changes (see Figure 2). We updated the equations for *VFMT* and *VFMX*[15] using these new prices (equation (3.7) and 3.8)).

(3.7) $\quad VFMT_{ijr} = pmest_{ijr} + qfe_{ijr}$

$$\forall i \in ENDW$$
$$\forall j \in PROD$$
$$\forall r \in REG$$

(3.8) $\quad VFMX_{ijrb} = pmesx_{ijrb} + qfe_{ijr}$

$$\forall i \in ENDW$$
$$\forall j \in PROD$$
$$\forall r \in REG$$
$$\forall b \in BASEGROUP$$

qfe_{ijr} *Demand for endowment i for use in commodity j in region r*

---

[15] Where the set BASEGROUP covers OTP, ACT, GCT1, …, GCT12.

Although not explicitly defined in the model, we thereby establish that the percentage change in tf_{ijr} is equal to the sum over $tfsct_{ijr}$, $tfsub_{irg}$ and $tfsfp_r$.

Figure 2.   New endowment value flows and policy variables in the GTAP model

Value flows:	VFM	VFMT	VFMX (OTP)	VFMX (GCT12)	EVFA
Prices:	pmes	pmest	pmesx (OTP)	pmesx (GCT12)	pfe
Policy Variables:	tft	tfsfp	tfsub	tfsct	

$EVFA_{ijr}$ *Producer expenditure on factor i by sector j in region r at agent's prices*
$VFMT_{ijr}$ *VFM_{ijr} plus factor employment revenue ($FTRV_{ijr}$)*
$VFMX_{ijr}$ *$VFMt_{ijr}$ plus homogenous support from OTP, ACT and GCT*
VFM_{ijr} *Producer expenditure on factor i by sector j in region r at market prices*

Source: Authors' elaboration.

In the following, we briefly illustrate the implementation of new policy instruments for intermediate inputs. The linear price equation (3.9) establishes the link between pfd_{ijr} and pm_{jr} using the percentage change of the policy variable tfd_{ijr} and (3.10) between pfm_{ijr} and pim_{jr} for intermediate inputs in the standard GTAP model.

$$(3.9) \quad pfd_{ijr} = tfd_{ijr} + pm_{jr} \qquad \begin{matrix} \forall i \in TRAD \\ \forall j \in PROD \\ \forall r \in REG \end{matrix}$$

pfd_{ijr} *Price index for domestic purchase i by commodity j in region r*

pm_{jr} *Market price of commodity j in region r*

tfd_{ijr} *Tax on domestic i used by commodity j in region r*

$$\text{(3.10)} \quad pfm_{ijr} = tfm_{ijr} + pim_{ir} \qquad \begin{aligned} &\forall i \in TRAD \\ &\forall j \in PROD \\ &\forall r \in REG \end{aligned}$$

pfm_{ijr}	*Price index for import of i by commodity j in region r*
pim_{ir}	*Market price of composite import i in region r*
tfm_{ijr}	*Tax on imported i purchased by commodity j in region r*

In equation (3.11) the price index for domestic purchase *i* by commodity *j* in region *r* equals the price pmx_{ijrg}, with g = GCT12, which already includes ACT and GCT payments plus the policy instrument for the SCT payments. Since the SCT is product specific, the policy instrument is directly related to commodities. Subsequently, equation (3.12) shows the group specific modeling of the policy instrument.

$$\text{(3.11)} \quad pfd_{ijr} = tfdsct_{ijr} + pmx_{ijrg} \qquad \begin{aligned} &\forall i \in TRAD \\ &\forall j \in PROD \\ &\forall r \in REG \\ &g = GCT12 \end{aligned}$$

$$\text{(3.12)} \quad \begin{aligned} pmx_{ijrg} = \ &PRODV\_SHR_{jrg} * MMREG_{jrg} \\ &* tfdsub_{irg} + pmx_{ijrb} \end{aligned} \qquad \begin{aligned} &\forall i \in TRAD \\ &\forall j \in PROD \\ &\forall r \in REG \\ &\forall g \in GROUP \\ &\forall b \in BASEGROUP \end{aligned}$$

pmx_{ijrg}	*Market price for domestic i in commodity j of region r including ACT and GCT subsidies*
pmx_{ijrb}	*Market price for domestic i in commodity j of region r including OTP, ACT and GCT subsidies*
$tfdsct_{ijr}$	*Tax (SCT) on domestic i used by commodity j in region r*
$tfdsub_{irg}$	*Tax (ACT,GCT) on domestic i used by commodity j in region r*

Equation (3.11) and (3.12) show the modeling for the domestically produced intermediate imports. The price equations for imported intermediate imports are implemented accordingly. The input subsidies of the PSE do not distinguish between imported and domestically produced. Therefore, the two policy instruments are linked with the help of the variable $tfdmsct_{jr}$ to obtain a homogenous allocation over inputs for product specific support (equation 3.13). A comparable linkage structure is used for the implementation of ACT and GCT payments (equation 3.14).

$$\forall i \in INT$$

(3.13) $\quad tfdsct_{ijr} = tfmsct_{ijr} = tfdmsct_{jr}$ $\qquad \forall j \in PROD$

$$\forall r \in REG$$

$$\forall i \in INT$$

(3.14) $\quad tfdsub_{irg} = tfmsub_{irg} = tfdmsub_{rg}$ $\qquad \forall r \in REG$

$$\forall g \in GROUP$$

$tfdmsct_{jr}$	*Tax (SCT)for commodity j in region r*
$tfdmsub_{rg}$	*Tax (ACT,GCT) in region r for group g*

All subsidies related to output are given product specific. Hence, it is not necessary to further split up the following price linkage equation according the PSE categories (3.15).

(3.15) $\quad ps_{jr} = to_{jr} + pm_{jr}$ $\qquad \forall j \in TRAD$

$$\forall r \in REG$$

ps_{jr}	*Agents price of commodity j in region r*
pm_{jr}	*Market price of commodity j in region r*
to_{jr}	*Output tax for commodity j in region r*

Deviating from the standard GTAP closure (compare Figure A1 in the Appendix) the policy variables *tfsfp, tfsct, tfsub* and *tft* are defined as exogenous and hence replace *tf* in the closure. Regarding the inputs, $tfdmsub_{rg}$ and $tfdmsct_{jr}$ are exogenous with tfd_{ijr} and tfm_{ijr} endogenous, and to_{jr} exogenous for outputs.

Beyond the modifications of the price equations, it is necessary to define the shares of each category and type of support (Figure 2, 3 and 4) in the *Altertax* model and add change variables to determine the change in each category and type of support. Subsequent, the shares and new change variables are introduced.

In Figure 3 the allocation of subsidies given to land, labor, and capital are illustrated according to their categories SCT, GCT, ACT, and OTP. The initial factor employment tax revenue ($FTRV_{ijr}$) of the GTAP database is given by the difference of VFM_{ijr} and $VFMT_{ijr}$. The newly introduced OTP is equal to the margin between $VFMT_{ijr}$ and $VFMX_{ijrg}$ with g = otp. ACT and GCT subsidies to land, labor and capital are specified by the difference between $VFMX_{ijrg}$ with g = otp and $VFMX_{ijrg}$ with g = gct12 while the product specific SCT is located between $VFMX_{ijrg}$ with g = gct12 and $EVFA_{ijr}$. In the standard GTAP database, the value of all domestic support payments is reported as $FBEP_{ijr}$ that is equal to the difference between $VFMT_{ijr}$ and $EVFA_{ijr}$. Hence, $FBEP_{ijr}$ is equal to the sum of OTP/SFP, GCT and ACT, and SCT payments.

Figure 3. Homogenous and non-homogenous support in GTAP allocated to land, capital, and labor
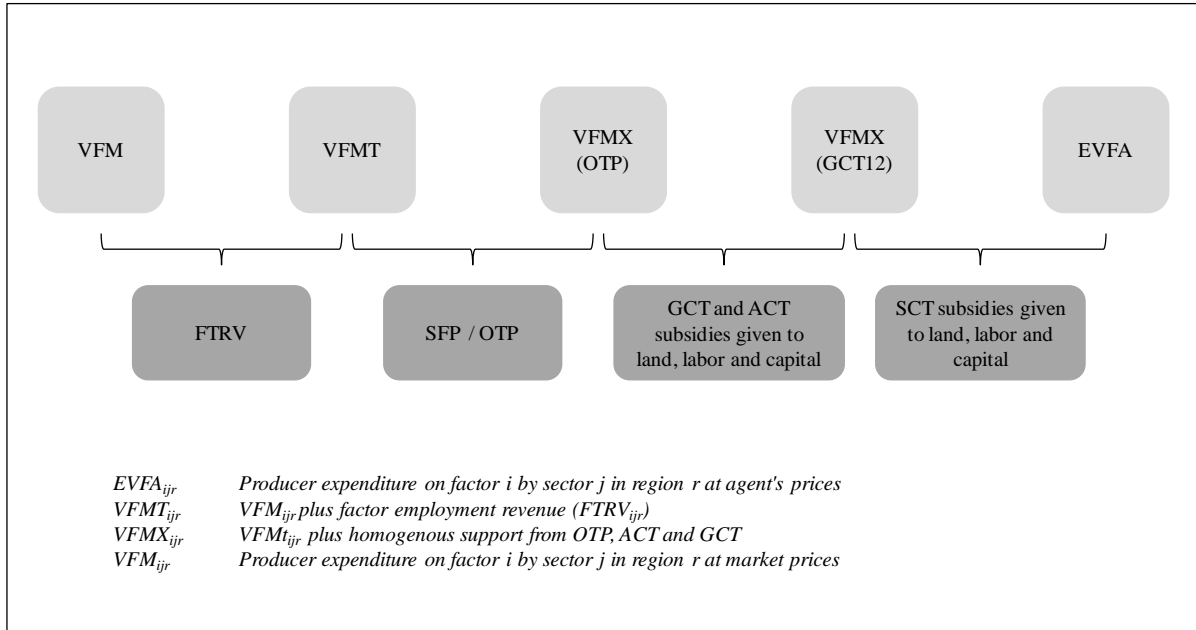
Source: Authors' elaboration.

For the implementation of e.g., the homogenous OTP payments, we use the change variable $del\_otp\_shr_r$ that determines the change in the share of OTP support. The OTP share is calculated in relation to the value of output (equation (3.15)). The change variable of OTP share is then shocked to update OTP_SHR_r using equation (3.16).

$$(3.15) \qquad SH\_OTP_r = \frac{\sum_{j \in AGRI} \sum_{i \in NNATDIS} VFMT_{ijr} - VFMX_{ijrb}}{\sum_{j \in AGRI} VOM_{jr}} \qquad \begin{array}{l} \forall r \in REG \\ \forall b \in OTP \end{array}$$

$$(3.16) \qquad \begin{array}{l} 100 * \sum_{j \in AGRI} VOM_{jr} * del\_otp\_shr_r \\[2mm] + \ SH\_OTP_r * \sum_{j \in AGRI} \left(VOM_{jr} * \left(pm_{jr} + qo_{jr} \right) \right) \\[2mm] = \sum_{i \in NNATDIS} \sum_{j \in AGRI} VFMT_{ijr} * \left(pmest_{ijr} + qfe_{ijr} \right) \\[2mm] - \sum_{i \in NNATDIS} \sum_{j \in AGRI} VFMX_{ijrb} * \left(pmesx_{ijrb} + qfe_{ijr} \right) \end{array} \qquad \begin{array}{l} \forall r \in REG \\ \forall b \in OTP \end{array}$$

OTP_SHR_r	*Share of OTP support in region r*
$del\_otp\_shr_r$	*Change in share of OTP support in region r*
pm_{jr}	*Market price of commodity j in region r*
qo_{jr}	*Output of commodity j in region r*

The share of domestic support allocated to ACT and the 12 GCT subsidies on land, labor and capital (SHR_ACT_{ir}, SHR_GCT1_{ir}, …, SHR_GCT12_{ir}) is updated with the change variable of that share ($del\_shrendw_{jrg}$) using equation (3.18). In equation (3.18) only GCT1 is shown exemplary for all the other groups.

$$(3.17) \quad SHR\_GCT1_{ir} = \frac{\sum_{j \in AGRI} VFMX_{ijrb} - VFMX_{ijrg}}{\sum_{j \in AGRI} VOM_{jr}}$$

<div align="right">

$\forall i \in NNATDIS$

$\forall b \in ACT$

$\forall r \in REG$

$\forall g \in GCT1$

</div>

SHR_GCT1_{ir}	*Share of GCT1 domestic support allocated to land, labor, and capital subsidies in GTAP in region r*

$$(3.18) \quad \begin{aligned} &100*\Big[\sum_{j \in GCT1} VOM_{jr}*del\_shrendw_{jrg} \\ &+ SHR\_GCT1_{ir}*\sum_{j \in GCT1} VOM_{jr}*\big(pm_{jr}+qo_{jr}\big)\Big] \\ &= \sum_{j \in GCT1} VFMX_{ijrg-1}*\big[pmesx_{ijrg-1}+qfe_{ijr}\big] \\ &- VFMX_{ijrg}*\big[pmesx_{ijrg}+qfe_{ijr}\big] \end{aligned}$$

<div align="right">

$\forall r \in REG$

$\forall i \in NNATDIS$

</div>

The share of domestic support allocated to ACT and the 12 GCT on input subsidies (*SHR_INTACT_r, SHR_INTGCT1_r, …, SHR_INTGCT12_r*) is updated with the change of that share (*del_shrint_rg*) using equation (3.20). In equation (3.20) the example for GCT1 is shown, the equations for the remaining groups are written in the same way.

$$(3.19) \quad \begin{aligned} SHR\_INTGCT1_r = &\Big[\sum_{j \in AGRI}\sum_{k \in INT} VDFMX_{kjrb} - VDFMX_{kjrg} \\ &+ \sum_{j \in AGRI}\sum_{k \in INT} VIFMX_{kjrb} - VIFMX_{kjrg}\Big] / \sum_{j \in AGRI} VOM_{jr} \end{aligned}$$

<div align="right">

$\forall r \in REG$

$\forall b \in ACT$

$\forall g \in GCT1$

</div>

$SHR\_INTGCT1_r$	*Share of GCT1 domestic support allocated to input subsidies in GTAP in region r*

$$(3.20) \quad \begin{aligned} &100*\Big[\sum_{j \in GCT1} VOM_{jr}*del\_shrint_{jrg} \\ &+ SHR\_INTGCT1_{ir}*\sum_{j \in GCT1} VOM_{jr}*\big(pm_{jr}+qo_{jr}\big)\Big] \\ &= \sum_{k \in INT}\sum_{j \in GCT1} VDFMX_{kjrg-1}*\big(pmx_{kjrg-1}+qfd_{kjr}\big) - VDFMX_{kjrg}*\big(pmx_{kjrg}+qfd_{kjr}\big) \\ &+ \sum_{k \in INT}\sum_{j \in GCT1} VIFMX_{kjrg-1}*\big(pimx_{kjrg-1}+qfm_{kjr}\big) - VIFMX_{kjrg}*\big(pimx_{kjrg}+qfm_{kjr}\big) \end{aligned}$$

<div align="right">

$\forall r \in REG$

</div>

The allocation of intermediate inputs according the categories ACT and GCT as well as SCT are illustrated in Figure 4.

Following a modified procedure[16], the power of support tax of the SCT payments can be adjusted in the GTAP database. In equation (3.21) the initial value of domestic support in GTAP is defined.

---

[16] For the categories OTP, ACT, and GCT, we calculated the shares in relative to the value of output. Here, the category SCT comprise subsidies that needs to be allocated to output. Thus, the method used beforehand would create a bias, so that we slightly adjusted it.

$$VOTAX\_SCT_{ir} = VOA_{ir} - VOM_{ir}$$

$$+ \left(\sum\nolimits_{j \in ENDW\_COMM} VFA_{ijr} - VFMX_{ijrg} \right)$$

$$+ \left(\sum\nolimits_{j \in INT\_COMM} VDFMX_{ijrg} - VDFA_{ijr} \right)$$

$$+ \left(\sum\nolimits_{j \in INT\_COMM} VIFMX_{ijrg} - VIFA_{ijr} \right)$$

(3.21)

$\forall i \in TRAD$

$\forall r \in REG$

$\forall g \in GCT12$

$VOTAX\_SCT_{ir}$ *Initial value of domestic support for commodity i in region r*

Figure 4. Homogenous and non-homogenous support in GTAP allocated to intermediate goods
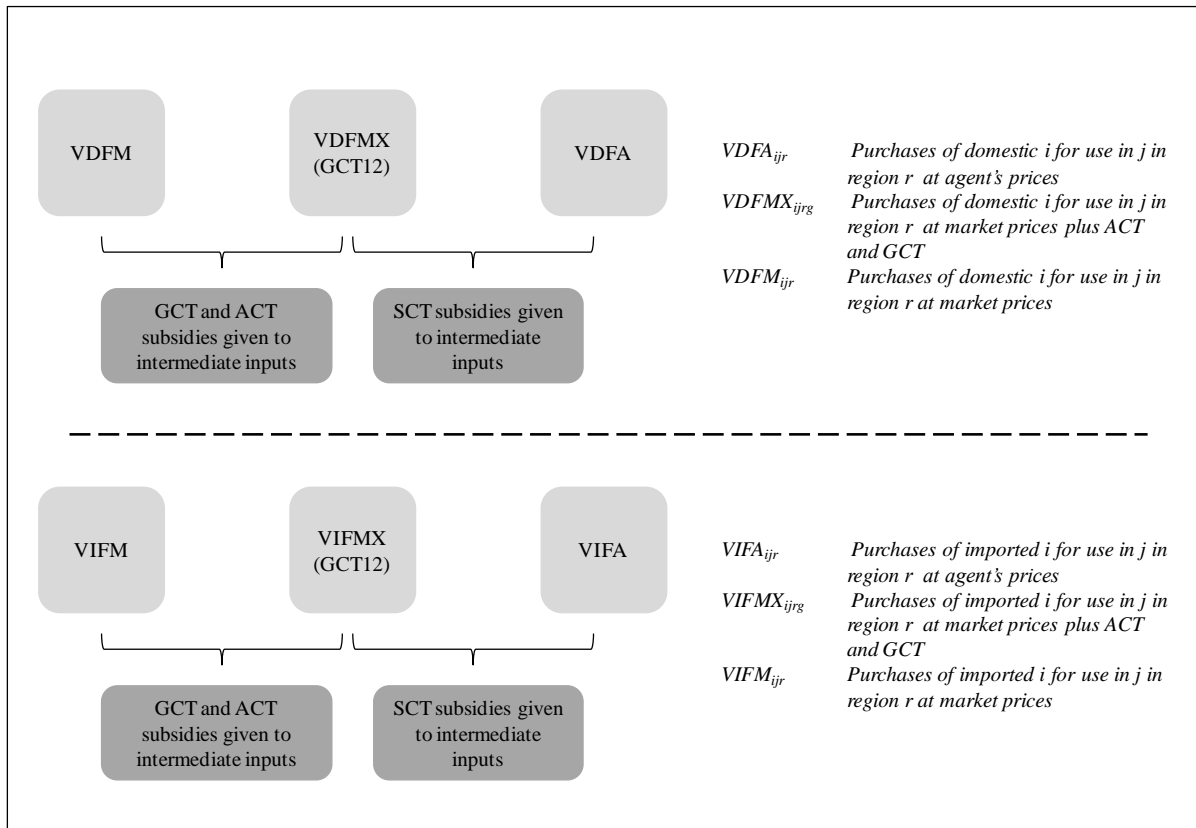
Source: Authors' elaboration.

In equation (3.22) the initial power of tax levels is given.

$$PO\_TAX\_SCT_{ir} = 1 + \big[\left(VOA_{ir} - VOM_{ir} \right)$$

$$+ \left(\sum\nolimits_{j \in ENDW\_COMM} VFMX_{ijrg} - VFA_{ijr} \right)$$

$$+ \left(\sum\nolimits_{j \in INT\_COMM} VDFMX_{ijrg} - VDFA_{ijr} \right)$$

$$+ \left(\sum\nolimits_{j \in INT\_COMM} VIFMX_{ijrg} - VIFA_{ijr} \right) \big]$$

$$/ VOM_{ir}$$

(3.22)

$\forall i \in TRAD$

$\forall r \in REG$

$\forall g \in GCT12$

$PO\_TAX\_SCT_{ir}$ *Initial power of SCT subsidy levels for commodity i in region r*

20

The initial change in the power of SCT subsidy levels is calculated with the help of equation (3.23).

$$
\begin{aligned}
(3.23) \quad & 100*\Big[PO\_TAX\_SCT_{ir}*VOM_{ir} + \big(pm_{ir} + qo_{ir}\big) \\
& + VOM_{ir}*del\_potax\_sct_{ir}\Big] \\
& = VOA_{ir}*\big(ps_{ir} + qo_{ir}\big) - VOM_{ir}*\big(pm_{ir} + qo_{ir}\big) \\
& + \sum_{j\in ENDW\_COMM} VFMX_{jirg}*\big(pmesx_{ijrg} + qfe_{ijr}\big) \\
& - VFA_{jir}*\big(pfe_{ijr} + qfe_{ijr}\big) \\
& + \sum_{j\in INT\_COMM} VDFMX_{jirg}*\big(pmx_{ijrg} + qfd_{ijr}\big) \\
& - VDFA_{jir}*\big(pfd_{ijr} + qfd_{ijr}\big) \\
& + \sum_{j\in INT\_COMM} VIFMX_{jirg}*\big(pimx_{ijrg} + qfm_{ijr}\big) \\
& - VIFA_{jir}*\big(pfm_{ijr} + qfm_{ijr}\big)
\end{aligned}
\qquad
\begin{aligned}
& \forall i \in TRAD \\
& \forall r \in REG \\
& g = GCT12
\end{aligned}
$$

This initial change in the power of tax is then updated using the OECD power of tax, which is calculated in equation (3.22).The initial value of domestic support uses the change in total tax (del_votax_{ir}) defined in equation (3.24).

$$
\begin{aligned}
(3.24) \quad & 100*del\_votax\_sct_{ir} \\
& = PO\_TAX_{ir}*VOM_{ir}*\big(pm_{ir} + qo_{ir}\big) \\
& + VOM_{ir}*potax\_sct_{ir} - VOM_{ir}*\big(pm_{ir} + qo_{ir}\big)
\end{aligned}
\qquad
\begin{aligned}
& \forall i \in TRAD \\
& \forall r \in REG
\end{aligned}
$$

After the update of the SCT, the values are allocated to output, inputs, land, labor, and capital. For example, the share of domestic support allocated to output subsidies ($SHR\_OUT\_SCT_{ir}$) is updated with the change in the share of output subsidy ($del\_shrout\_sct_{ir}$) using equation (3.26).

$$
\begin{aligned}
(3.25) \quad SHR\_OUT_{ir} = & \big[VOA_{ir} - VOM_{ir}\big] \\
& / \big[VOA_{ir} - VOM_{ir} \\
& + \sum_j VFMX(GCT12)_{jir} - VFA_{jir} \\
& + \sum_k VDFMX(GCT12)_{kir} - VDFA_{jir} \\
& + \sum_k VIFMX(GCT12)_{kir} - VIFA_{jir}\big]
\end{aligned}
\qquad
\begin{aligned}
& \forall i \in AGRI \\
& \forall r \in REG \\
& \forall j \in ENDW \\
& \forall k \in INT
\end{aligned}
$$

SHR_OUT_{ir}	Share of domestic support allocated to output subsidies in GTAP for commodity i in region r

$$
\begin{aligned}
(3.26) \quad & 100*\Big[VOTAX\_SCT_{ir}*del\_shrout\_sct_{ir} \\
& + SHR\_OUT\_SCT_{ir}*del\_votax\_sct_{ir}\Big] \\
& = VOA_{ir}*\big(ps_{ir} + qo_{ir}\big) - VOM_{ir}*\big(pm_{ir} + qo_{ir}\big)
\end{aligned}
\qquad
\begin{aligned}
& \forall i \in TRAD \\
& \forall r \in REG
\end{aligned}
$$

The share of SCT payments allocated to output is shown in Figure 5. The remaining SCT payments are distributed accordingly to intermediate inputs as depicted in Figure 4 and the factors land, labor, and capital as displayed in Figure 3.

Figure 5. Product specific support in GTAP allocated to output

VOA_{jr}	Value of output of commodity j in region r at agent's prices	
VOM_{jr}	Value of output of commodity j in region r at market prices	
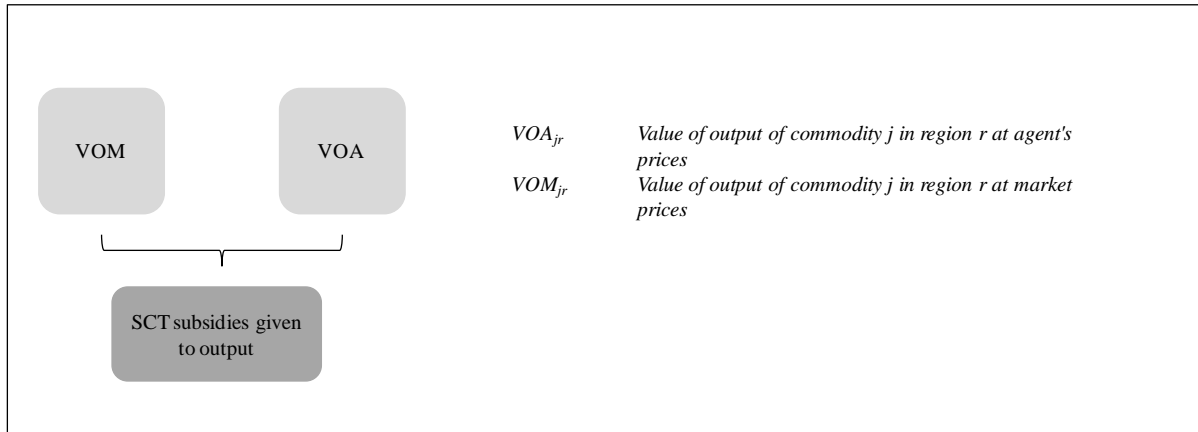
Source: Authors' elaboration.

3.2 Extended standard GTAP model

We adjusted the structure of value flow and the corresponding price linkage equations in the standard GTAP model in a similar way we extended them in the *Altertax* model, but we relaxed some of the equations regarding the implementation of ACT and GCT payments and the distribution with homogenous rates[17].

Equation (3.27) shows the group specific modeling of the policy instrument, but deviates from the equation (3.3) in the *Altertax* model. Using the *Altertax* model ACT and GCT payments are allocated with a homogenous rate across all commodities belonging to the defined groups. As long as the tax rates are exogenous in the model, they can be modeled using a simplified equation (3.27).

$$(3.27) \quad pmesx_{ijrg} = tfsub_{ijrg} + pmesx_{ijrb}$$

$$\forall i \in ENDW$$
$$\forall j \in PROD$$
$$\forall r \in REG$$
$$\forall g \in GROUP$$
$$\forall b \in BASEGROUP$$

$tfsub_{ijrg}$ *Tax(ACT, GCT) on primary factor i used for commodity j in region r for group g*

Equation (3.28) shows the modeling for the domestic imports simplified according to equation (3.27), the price equations for imported imports are modified likewise.

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[17] The GTAP model is applied using the update database where domestic support is allocated accounting for the requirements of the different categories of support. As long as the policy instruments are exogenous in the closure, there is no need to implement the equations in such a detailed and complicated way. In case the value of domestic support needs to be constant in the model, it is necessary to apply change variables in order to endogenize the policy instruments. Therefore, the price equations used in the GTAP model need to be replaced by the more detailed ones used in the Altertax model presented in the previous paragraph.

$$\forall i \in TRAD$$
$$\forall j \in PROD$$
$$(3.28) \qquad pmx_{ijrg} = tfdsub_{ijrg} + pmx_{ijrb} \qquad\qquad \forall r \in REG$$
$$\forall g \in GROUP$$
$$\forall b \in BASEGROUP$$

pmx_{ijrg}	*Market price for domestic i in commodity j of region r including ACT and GCT subsidies*
pmx_{ijrb}	*Market price for domestic i in commodity j of region r including OTP, ACT and GCT subsidies*
$tfdsub_{ijrg}$	*Tax (ACT,GCT) on domestic i used by commodity j in region r for group g*

In the closure (see Figure A2) the policy variables to_{jr}, $tfsfp_r$, $tfsct_{ijr}$, $tfsub_{ijrg}$ and tft_{ijr} are again defined as exogenous. However, regarding the inputs now $tfdsub_{ijrg}$ and $tfdsct_{ijr}$ as well as $tfmsub_{ijrg}$ and $tfmsct_{ijr}$ are exogenous. To allow for variation of this standard closure we add change variables, which accounts for the different payments types in the extended GTAP model.

4 Empirical analysis

4.1 Mapping of the OECD PSE tables and the GTAP aggregation

The agricultural domestic support in version 8 of the GTAP database originates from the OECD's PSE tables of the year 2007 for the EU, which can be downloaded from the OECD website[18]. This database is a complement to the OECD report "Agricultural Policies in OECD Countries: Monitoring and Evaluation − At a Glance 2010". The PSE concept contains market price support and budgetary transfers. Since market price support also includes border measures, it is not included in the GTAP database to avoid double counting with other policy measures, e.g., tariffs. To represent domestic support we implement PSE budgetary transfers in the GTAP database[19].

The OECD support categories (A2 to E) introduced in Chapter 2 are grouped into five GTAP support categories:

- Output subsidies
- Intermediate input subsidies
- Land-based subsidies
- Labor-based subsidies
- Capital-based subsidies

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[18] http://www.oecd.org/document/59/0,3746,en_2649_33797_39551355_1_1_1_1, 00.html.

[19] More information about the PSE concept and the classification of budgetary transfer is available at the website www.oecd.org and in the PSE manual (OECD, 2010).

The OECD support categories F and G are not included in the GTAP database because they are either not related to any production (based on non-commodity criteria as e.g., long-term resource retirements comprising payments for afforestation) or are miscellaneous.

The PSE data of the OECD is only available for the EU as a whole. Consequently, we had to divide this data to create individual PSE tables for all 27 member states. Thereby, additional information provided by the OECD, the Financial Plan of the EU Commission as well as the European Agricultural Guarantee Fund (EAGF) and the European Agricultural Fund for Rural Development (EAFRD) are employed.

In general, the allocation of payments to the EU member states follows the method also used by the OECD at the aggregated level[20]. Beyond, the disaggregation of EU PSE support to member state level comprises the following steps. First, the PSE payment items have to match with the corresponding payments in the EAGF of the financial year 2008[21], where the payments are given by member country. Second, using additional information from the OECD, national payments found in the PSE tables are differentiated into individual member country payments. Third, for the allocation of payments belonging to the EAFRD the national co-financing rate is used[22].

In the newly created individual domestic support tables for the 27 EU member states the total support is grouped into SCT, GCT, ACT, and OTP for the EU by member states and by PSE type of support. In Table A3 in the Appendix, the reallocation of the more detailed PSE types of support to the five aggregated GTAP support categories for the payment groups SCT, GCT, and ACT is presented[23]. Thus, we obtain subsidy payments given to output, input, land, labor, and capital for each of the payment groups SCT, ACT, and GCT.

The SCT payments are attached to specific sectors in the PSE tables that are aggregated to match the 12 primary agricultural commodities in the GTAP database. The ACT payments are distributed by PSE type of support to the group of all primary agricultural commodities, while the GCT payments are given to 12 defined groups of commodities. The OTP payments are assigned based on entitlements. Thus, they are not related to commodities and the different types of support in the PSE tables (shown in Table A3, Appendix).

For the groups other than SCT an allocation mechanism is required to incorporate them into the GTAP database since ACT and OTP payments are given to all commodities, while GCT is given to defined groups of commodities and are thus not linked to specific sectors.

4.2   Re-allocation of PSE data according to GTAP aggregation

Considering the explanations of Section 4.1, some re-allocation of PSE data according to the GTAP aggregation is required to enable the incorporation into the GTAP model and database.

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[20] Explanations can be found in the composition of OECD PSE tables (http://www.oecd.org/agriculture /agriculturalpoliciesandsupport/producerandconsumersupportestimatesdatabase.htm.).

[21] The financial year 2008 covers the period from July 2007 until June 2008.

[22] For more information that is detailed, compare the documentation of PSE domestic support payments in the GTAP Version 7 database for 2004 provided by Jensen (2008, 2010).

[23] Please note, that the PSE concept determines to which GTAP category payments have to be allocated.

Since the OTP are given in the PSE tables as one number for each member state, it is necessary to generate some redistribution methods before implementing the OTP into GTAP. In Section 3, we introduced different options to model OTP (see equations 3.4a and b). Now, the initial PSE data is prepared accordingly as shown in the upper part of Figure 6.

Figure 6.   Transferring OECD domestic support to the GTAP database
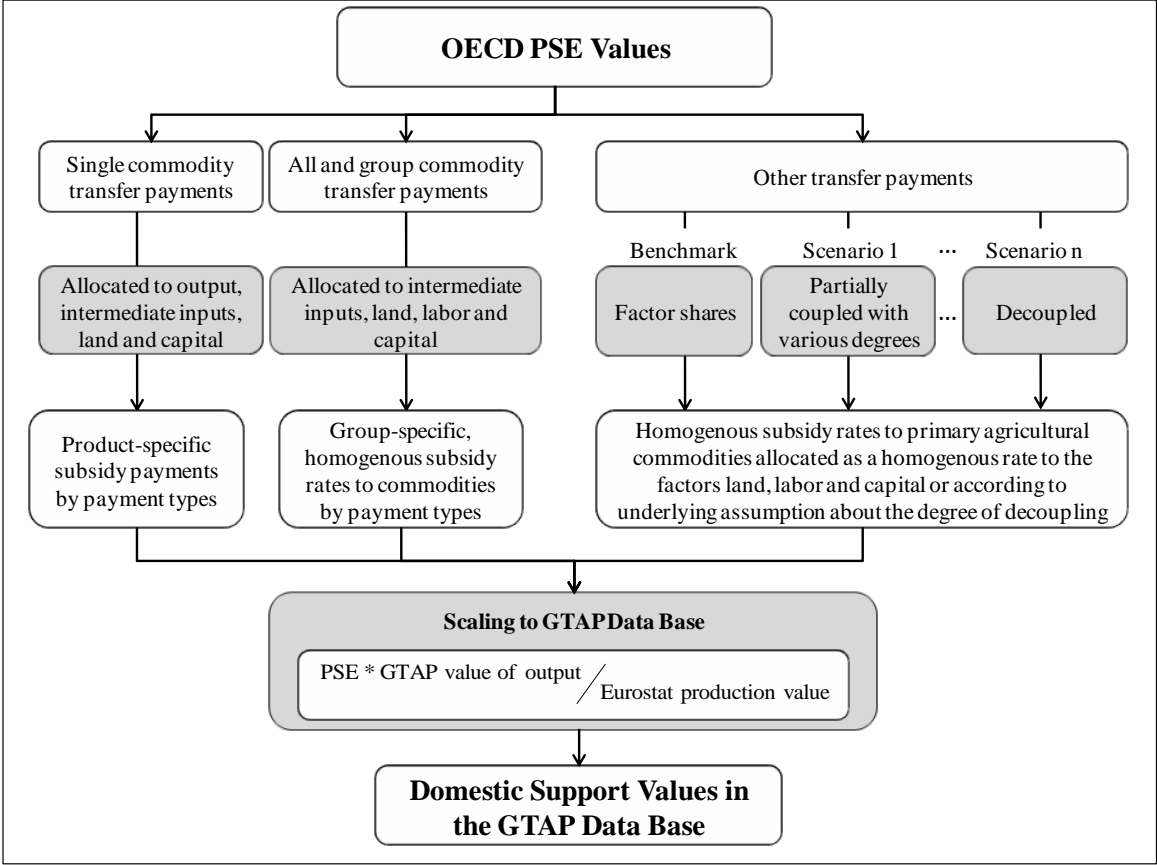
Source: Authors' elaboration.

We start with the allocation according to the factor usage in each agricultural sector. To be able to distribute the OTP payments of the OECD in this way, additional information on factor shares is required. This information is taken from the initial GTAP database and is used to calculate the GTAP factor usage share ($TVFMSHR_{ir}$)[24]. According to equation (4.1), it is given by the sum of firms' purchases at market prices for land, labor and capital taking the sum over all agricultural sectors $(TVFM_{ijr})$ divided by the sum of $TVFM_{ijr}$ over land, labor, and capital and all agricultural sectors[25]. The coefficient $TVFM_{ijr}$ equals $EVFA_{ijr}$[26] with unskilled and skilled labor aggregated to a single factor labor as shown in Figure 7. This factor share is then multiplied with the amount of PSE OTP payments that equals $OTPH_r$

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[24] The factor shares are utilized in the simulations are exogenous. In an ideal situation, the factor shares would be updated based on other information. However, this information is not available to us.

[25] For the description of all sets please refer to table A5 and for the descriptions of coefficients to table A6 in the Appendix.

[26] We use the EVFA aggregated shares of land, labor, capital employed in primary agriculture to allocate the homogenous SFP support rate in each country, because the EVFA share corresponds to the initial factor shares calibrated into the database, which are linked back to published econometric studies.

(equation 4.2). This leads to OTP payments allocated according to the factor usage in each region shown in Figure 8.

Figure 7.   Factor mapping
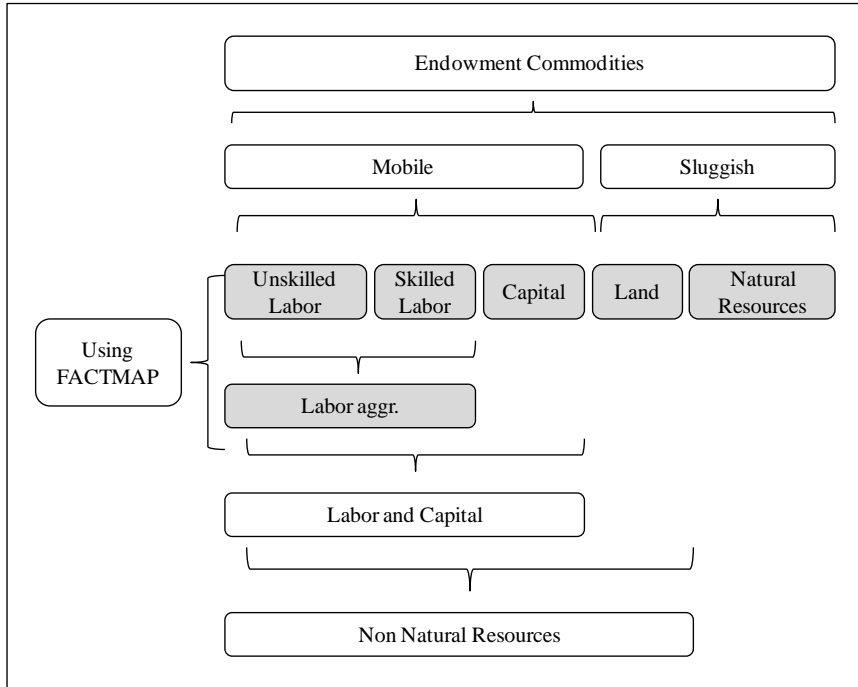
Source: Authors' elaboration.

$$(4.1) \qquad TVFMSHR_{ir} = \frac{\sum_j TVFM_{ijr}}{\sum_i \sum_j TVFM_{ijr}} \qquad \begin{aligned} &\forall i \in NNAT \\ &\forall r \in REG \end{aligned}$$

TVFMSHRir	*Factor usage share for endowment i in region r*
TVFMijr	*Factor usage for endowment i used in commodity j in region r*

$$(4.2) \qquad OTRAN_{ir} = TVFMSHR_{ir} \times OTPH_r \qquad \begin{aligned} &\forall i \in NNAT \\ &\forall r \in REG \end{aligned}$$

OTRAN_{ir}	*Other transfer to producers by factor usage for endowment i in region r*
OTPH_r	*Other transfer payments to producers in region r*

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Figure 8.   EU OTP payments by factor share (EURO Mio.)
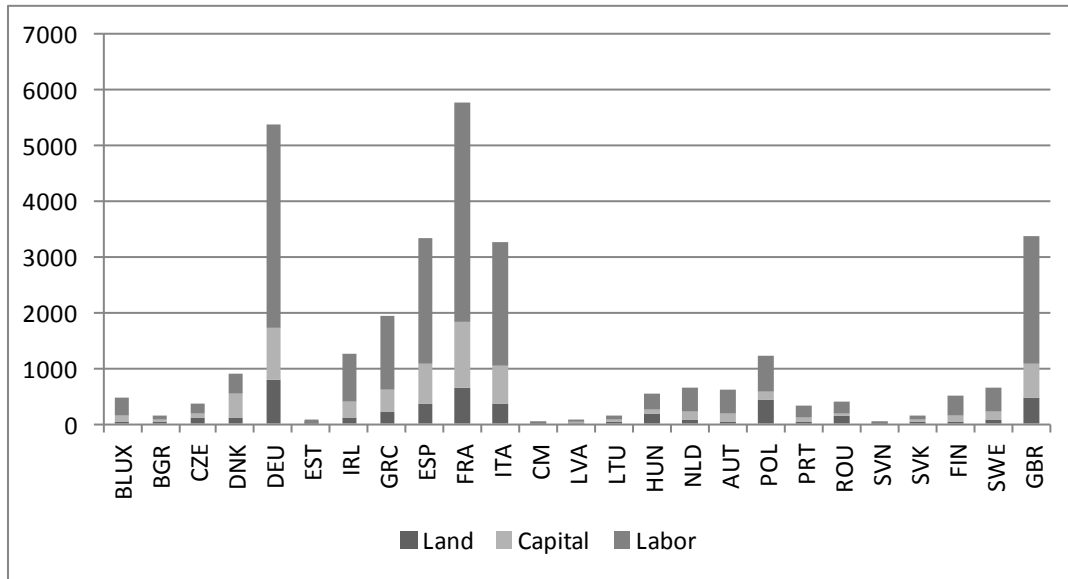
Source: Own calculations.

Beside the default allocation, we discuss in this paper the allocation of OTP according to deviating degrees of decoupling. To allow for the modification of such a degree it is required to introduce a new coefficient that enables the change of the extent of the distribution of OTP to each of the factors used without affecting each sector's factor usage.

Therefore, we introduce the coefficient $SHIFTFCT_i$ that determines by how much the distribution varies from the distribution according the factor usage. $SHIFTFCT_i$ is specified manually according to own assumptions about the degree of decoupling of OTP. In equation (4.4) the share of decoupling ($DECOUPSHR_{i,r}$) – referred to as degree of decoupling – is obtained through first multiplying the factor usage share for labor and capital with the coefficient $SHIFTFCT_i$ and second substracting the sum over labor and capital of the obtained share from 1 to achieve the share given land. Using equation (4.4) and (4.5) we are able to deviate from the factor usage by a successively decrease share of a chose percentage. As example, we choose here 10%. Equation (4.4) reduces the share given to labor and capital (FCAP) by 10% each. This is then both shifted to the factor land as shown in equation (4.5). In so doing we obtain a coefficient that determines the degree of decoupling which can then be used to distribute the OTP according own assumptions about the decoupling (equation (4.6)) deviating from the default in GTAP.

$$(4.4) \qquad DECOUPSHR_{ir} = TVFMSHR_{ir} \times SHIFTFCT_i \qquad \begin{aligned} &\forall i \in FCAP \\ &\forall r \in REG \end{aligned}$$

$DECOUPSHR_{ir}$ — Degree of decoupling for endowment i in region r

$SHIFTFCT_i$ — Predetermined coefficient to vary from the distribution according factor usage for endowment i

$$(4.5) \qquad DECOUPSHR_{ir} = 1 - \sum_{k=FCAP} DECOUPSHR_{kr} \qquad \begin{aligned} &\forall i \in LAND \\ &\forall r \in REG \end{aligned}$$

$$(4.6) \qquad OTRAN_{ir} = DECOUPSHR_{ir} \times OTPH_{r} \qquad \begin{array}{l} \forall i \in NNAT \\ \forall r \in REG \end{array}$$

The ACT payments are activity-generic implying that they are given to all primary agricultural commodities without any restrictions on the commodity produced as long as some are produced. For the distribution of ACT payments over agricultural products in GTAP the power of ACT support ($ACTPOWER_{ir}$) is calculated (equation (4.7)). This is done by dividing the PSE category ACT, reallocated according to GTAP types of support, by the sum over all EUROSTAT production values of agricultural commodities. This relation is then multiplied with the EUROSTAT production value for each agricultural GTAP sector to obtain the ACT payments given to each GTAP sector as well as to input, land, labor or capital ($ACTTRAN_{ijr}$) (equation (4.8)).

$$(4.7) \qquad ACTPOWER_{ir} = \frac{ACPM_{ir}}{\sum_{j \in AGRI} PRODN_{jr}} \qquad \begin{array}{l} \forall i \in NOPT \\ \forall r \in REG \end{array}$$

$$(4.8) \qquad ACTTRAN_{ijr} = ACTPOWER_{ir} \times PRODN_{jr} \qquad \begin{array}{l} \forall i \in NOPT \\ \forall j \in AGRI \\ \forall r \in REG \end{array}$$

$ACTPOWER_{ir}$	*ACT power of support by payment type i and region r*
$ACPM_{ir}$	*All commodity transfer payments (OECD) by payment type i and region r*
$PRODN_{jr}$	*Value of agricultural production (EUROSTAT) by commodity j and region r*
$ACTTRAN_{ijr}$	*All commodity transfer payments by payment type i, commodity j and region r*

In Table 1 the ACT payments, distributed with a homogenous rate (ACTPOWER) over the 12 GTAP agricultural commodities in the EU, are shown.

Table 1. ACT payments in the EU (EURO Mio.)

ACT payments	pdr	wht	gro	v_f	osd	c_b	pfb	ocr	ctl	oap	rmk	wol	Total
Output	0	0	0	0	0	0	0	0	0	0	0	0	0
Input	17	351	371	1.040	202	48	4	957	523	815	646	2	4.974
Land	17	402	552	1.258	236	65	19	1.159	829	1.125	1.170	2	6.833
Capital	27	310	410	1.354	246	49	14	963	499	948	683	2	5.505
Labor	3	32	32	107	21	4	0	106	46	71	59	0	481
Total	63	1.095	1.365	3.759	704	166	38	3.185	1.897	2.959	2.557	6	17.792

Source: Own calculations.

The GTAP database differentiates between 12 primary agricultural sectors, which can be assigned to 12 commodity groups as defined by the OECD (compare Table 2). Some PSE payments are given to farmers for the production of commodities according to their belonging to one or more of those 12 GCT groups. In order to receive such group specific payments, agricultural producers need to produce at least one commodity of the defined group.

Table 2. Allocation of GTAP sectors to different groups[27]

	All commo-dities	All crops	All arable crops	Grains	Oil-seeds	Other crops	Vege-tables and fruits	Live-stock	Rumin-ants	Non-rumi-nants	Protein crops	Cereals oilseeds protein crops	Milk and beef
pdr			GCT2	GCT3									
wht			GCT2	GCT3								GCT11	
gro			GCT2	GCT3								GCT11	
v_f		GCT1				GCT5	GCT6						
osd			GCT2		GCT4							GCT11	
c_b	ACT		GCT2										
pfb			GCT2										
ocr						GCT5					GCT10	GCT11	
ctl									GCT8				GCT12
oap								GCT7					
rmk									GCT8	GCT9			GCT12
wol													

Source: Authors' elaboration.

Consequently, the payments of a specific group need to be distributed homogenously across all products covered by that group. In equation (4.9) and (4.10), the computation of GCT1 payments is exemplary shown using a similar approach as used for the ACT payments. First, the share of GCT1 payments is calculated in relation to the sum of the EUROSTAT production value over the commodities belonging to group GCT1 (pdr, wht, gro, v_f, osd, c_b, pfb, ocr). This share is then used to distribute the subsidy to all sectors included in group GCT1 according to the value of production. The remaining 11 GCT payments are allocated accordingly. The allocation to the different groups is shown in Table 3 and the distribution across the commodities within GCT1 is presented in Table 4.

$$(4.9) \qquad GCT1POWER_{ir} = \frac{GCT1P_{ir}}{\sum_{j \in GCT1} PRODN_{jr}} \qquad \begin{array}{l} \forall i \in NOPT \\ \forall r \in REG \end{array}$$

$$(4.10) \qquad GCT1PAY_{ijr} = GCT1POWER_{ir} \times PRODN_{jr} \qquad \begin{array}{l} \forall i \in NOPT \\ \forall j \in GCT1 \\ \forall r \in REG \end{array}$$

$GCT1POWER_{ir}$ *GCT1 power of support by payment type i and region r*

$GCT1P_{ir}$ *GCT1 payments (OECD) by payment type i and region r*

$GCT1PAY_{ijr}$ *GTAP activity-specific GCT1 payments by payment type i, commodity j and region r*

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[27] All primary agricultural sectors covered by a specific group are highlighted using a grey colored background.

Table 3. Allocation of GCT payments in the EU (EURO Mio.)

GCT payments	GCT1	GCT2	GCT3	GCT4	GCT5	GCT6	GCT7	GCT8	GCT9	GCT10	GCT11	GCT12	Total
Output	0	0	0	0	0	0	0	0	0	0	0	0	0
Input	130	0	0	0	0	0	938	136	0	0	0	0	1.204
Land	1.125	35	0	0	478	19	0	0	0	43	2.096	0	3.796
Capital	146	0	0	0	6	0	434	148	0	0	0	5	739
Labor	1	0	0	0	0	0	0	0	0	0	0	0	1
Total	1.402	35	0	0	484	19	1.373	284	0	43	2.096	5	5.740

Source: Own calculations.

Table 4. Allocation of GCT1 payments in the EU (EURO Mio.)

GCT1 payments	pdr	wht	gro	v_f	osd	c_b	pfb	ocr	ctl	oap	rmk	wol	Total
Output	0	0	0	0	0	0	0	0	0	0	0	0	0
Input	0	15	20	42	8	2	0	43	0	0	0	0	130
Land	5	109	191	396	68	14	5	337	0	0	0	0	1.125
Capital	1	11	16	64	8	1	1	45	0	0	0	0	146
Labor	0	0	0	0	0	0	0	0	0	0	0	0	1
Total	6	135	227	503	84	17	6	425	0	0	0	0	1.402

Source: Own calculations.

GCT2 and GCT11 have to be treated differently for oilseeds and protein crops. In both groups, the production values for oilseeds have to be reduced by the olive oil production value, because payments to olive oil are not included. Furthermore, GCT11 contains only protein crops. Protein crops are aggregated with other crops in the sector OCR. Therefore, deviating value flows from EUROSTAT are calculated considering the excluded products. When updating the GTAP database, the support rate for OCR and OSD in GCT11 as well as for OSD in GCT2 is weighted with the share of the production values.

The SCT is distributed according to the GTAP sectors. There is no particular distribution method required, because the SCT is allocated specifically to sectors as already mentioned (see Table 5)[28].

Table 5. Allocation of SCT of the EU across GTAP sectors (EURO Mio.)

SCT payments	pdr	wht	gro	v_f	osd	c_b	pfb	ocr	ctl	oap	rmk	wol	Total
Output	9	-2	6	382	2	0	0	307	0	7	215	1	927
Input	0	0	0	0	0	0	0	-2	16	20	-1	0	32
Land	168	125	1	212	118	30	248	302	0	0	0	0	1.203
Capital	0	0	0	0	0	0	0	242	2.376	120	78	0	2.817
Labor	0	0	0	0	0	0	0	0	0	0	0	0	0
Total	178	123	6	594	120	30	248	848	2.393	147	293	1	4.978

Source: Own calculations.

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[28] Several EU member states (deu, irl, fra, ita, ndl) had to refund agri-monetary aid to the EU. The negative domestic support payments lead to problems when calculating payment shares and shocks. Since the negative payments is marginal compared to the total amount of SCT, we omit such payments.

Finally, the total value of support for each primary agricultural commodity is found by adding up the support allocated to each commodity in the four types of support (SCT, GCT, ACT and OTP).

So far, we only manipulated the OECD PSE data of support with additional information from EUROSTAT and the GTAP database. Since the underlying production values of the GTAP database differ from the one used in the OECD PSE tables that are based on EUROSTAT production values, we implement the new data or update the GTAP database using the scaling mechanism demonstrated in the lower part of Figure 6 to get finally domestic support into the GTAP database. We apply this scaling mechanism by calculating the relation of the different PSE payment types to the EUROSTAT production value[29]. This share can then be used to shock the comparable relation of the difference between GTAP value flows in relation to the GTAP value of output to our target share. In so doing, we bring the GTAP data in accordance with the PSE database.

The share of support for the different payment types is defined by the total value of domestic support of ACT, GCT, OTP and SCT divided by the total value of production (EUROSTAT) (see Figure 6). Equation (4.11) and (4.12) show that subsidy payments related to SCT payments are distributed with a non-homogenous rate across agricultural sectors. First, the power of the subsidy equal to one plus the subsidy rate is calculated. The subsidy rate equals SCT per commodity divided by the production value (EUROSTAT). In the second equation, the allocation to output, input, land, labor, and capital is determined by computing the share of SCT payments going to each payment type.

$$(4.11) \qquad SCTPAYPOS_{jr} = 1 + \frac{\sum_{i=ALLPAYT} SCPM_{ijr}}{PRODN_{jr}} \qquad \begin{array}{l} \forall j \in AGRI \\ \forall r \in REG \end{array}$$

$$(4.12) \qquad SCT\_PVS_{ijr} = \frac{\left[100 * \dfrac{SCPM_{ijr}}{\sum_{k \in ALLPAYT} SCPM_{kjr}} \right]}{100} \qquad \begin{array}{l} \forall i \in ALLPAYT \\ \forall j \in AGRI \\ \forall r \in REG \end{array}$$

$SCTPAYPOS_{jr}$	*SCT payment power related to the production value by commodity j and region r*
$SCPM_{ijr}$	*SCT by payments by type i, commodity j and region r*
SCT_PVS_{ijr}	*Share of SCT by payment type i, commodity j and region r*

The total amount of group specific homogenous payments over all payment categories ($TOTPAYM_{ijrg}$) is then calculated by summing up the 12 GCT payments and ACT payments.

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[29] The OECD calculates the PSE with the help of the production values provided by Eurostat. Since the production values used in GTAP differs from the one of Eurostat, we first calculate the relation of the PSE values to the production values provided by Eurostat and pass these shares on the to GTAP, where we multiply them with the GTAP production values. Applying these steps we achieve approximately the same relation of domestic support payments to the production value in GTAP as calculated before using PSE data and Eurostat production values (see Table 12).

Furthermore, the share going to each payment type (HOM_PVSijr) is given by the total payments divided by the sum over all agricultural commodities of the total value of production (see equation (4.13)).

$$(4.13) \qquad HOM\_PVS_{irg} = 100 \times \frac{\sum_{j \in AGRI} TOTPAYM_{ijrg}}{\sum_{j \in AGRI} PRODN_{jr}} \qquad \begin{array}{c} \forall i \in ALLPAYT \\ \forall r \in REG \\ \forall g \in GROUP \end{array}$$

HOM_PVS_{irg} *Homogenous ACT and GCT production value shares by payment type i, region r and group g*

$TOTPAYM_{ijrg}$ *Total group specific payments of all categories by payment type i, commodity j, region r and group g*

To determine the share of OTP payments (equation (4.14)), the subsidy payments resulting from OTP are set in relation to the production value of EUROSTAT (see Figure 6).

$$(4.14) \qquad OTP\_PVS_{ir} = \frac{OTRAN_{ir}}{\sum_{j=AGRI} PRODN_{jr}} \qquad \begin{array}{c} \forall i \in NNAT \\ \forall r \in REG \end{array}$$

OTP_PVS_{ir} *OTP share of the production value for endowment i in region r*

In contrast to the SCT payments, the subsidy payments related to OTP, ACT and GCT are distributed across sectors using homogenous support. To mirror this difference in the GTAP database, the difference between the producer expenditure at agent's prices (*EVFA*) and the producer expenditure at market prices (*VFM*) is subdivided into homogenous and non-homogenous support categories as introduced in Section 3 (Figure 3). Comparatively Figure 4 and 5 illustrate the changes in value flows for intermediate inputs and for output.

4.3 Experiment design

The literature review depicted the importance of an evaluation of the effects of modeling decoupled payments in CGE models according to deviating underlying assumptions. Hence, the objective of our analysis is to examine the implications of different degrees of decoupling in a CGE framework and provide a tool to alter the implementation of decoupled payments in the model. Given the magnitude of coupling channels affecting the impact of the SFP on production decisions, it seems reasonable to prioritize the implementation of the SFP in our analysis that is based on the GTAP model. There are other issues, which have to be kept in mind, but they are beyond the scope of this paper. At present, the total SFP payments are distributed according to factor shares in the GTAP database and allocated across sectors using a homogenous rate for each factor. Varying this representation of the SFP in the GTAP database and extending the GTAP model appropriately, enable us to identify the effects of different degrees of decoupling.

In this paper, we compare the default implementation of the SFP in the GTAP framework with a set of different SFP distribution options based on deviating underlying assumptions about the supposed degree of decoupling. The default option to allocate the OTP payments of the OECD is based on the factor usage in each sector that is the default approach in the standard GTAP model. Since the factor land is only used in agricultural sectors in the

standard GTAP model and its supply is pre-determined, a uniform subsidy to all agricultural land is effectively fully decoupled (Frandsen et al., 2003). They stated in their analysis that a uniform subsidy given to all agricultural land, irrespective of its use, would result in the same supply response as would occur if the subsidy were eliminated, beside some minor budgetary effects of eliminating the subsidy.

We start from the default in the GTAP database and gradually move the support onto the factor land. In so doing, we stepwise lower the share given to the factors labor and capital in equal proportions until we reach a 100% allocation to the factor land that reflects fully decoupling in our analysis as suggested by Frandsen et al. (2003)[30].

According to the alternative ways of distributing the OTP, we create "N" alternative GTAP databases, indexed over i = 1… N (see Figure 9) ranging from the benchmark to fully decoupled.

1) BENCHMARK: OTP implemented with a homogenous rate across factors and agricultural commodities (according factor usage).

2) PARTIAL-DECOUPLED: OTP allocated with a homogenous rate across primary agricultural commodities to the factors land, capital, and labor according to pre-determined shares based on varying assumptions. Such a set of deviating underlying degrees of decoupling is obtained by gradually diluting the share of the factors labor and capital in equal proportions and loading this onto the factor land.

…

N) EFFECTIVELY FULLY DECOUPLED: OTP allocated with a homogenous rate across primary agricultural commodities to the factor land.

These alternative databases are then used as starting points to run simulations respectively where the OTP subsidy payments are always completely removed.

In our empirical example we use a regional disaggregation of the GTAP database that separates all EU27 member states, but aggregates Malta and Cyprus as well as Luxembourg and Belgium to avoid computational problems related to very small countries (for detail see Table A1 and A2, Appendix). Furthermore, we consider the agricultural commodities as disaggregated as possible. The analysis is conducted with the extended version of the GTAP model introduced in Section 3.

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[30] We have been working with version 8 of the GTAP database, where the method used to calibrate OTP payments into the database is equal to our first experiment – the allocation based on the factor usage. Nevertheless, we start by recalibrating the standard approach into the database using the same method as we use to make alternative databases. In so doing, we make our comparison of databases more consistent by using the same program to calibrate all databases.

Figure 9. Experiment design

	Scenarios (i = 1, .., N)			
	Increasing degree of decoupling			
Distribution of OTP in the GTAP data base according to:	**1 BENCHMARK** Factor shares	**2 PARTIALLY COUPLED** Lowering capital and labor in equal proportions	**…**	**N FULLY DECOUPLED** 100% allocated on land
Policy simulation	**100% removal of OTP**			
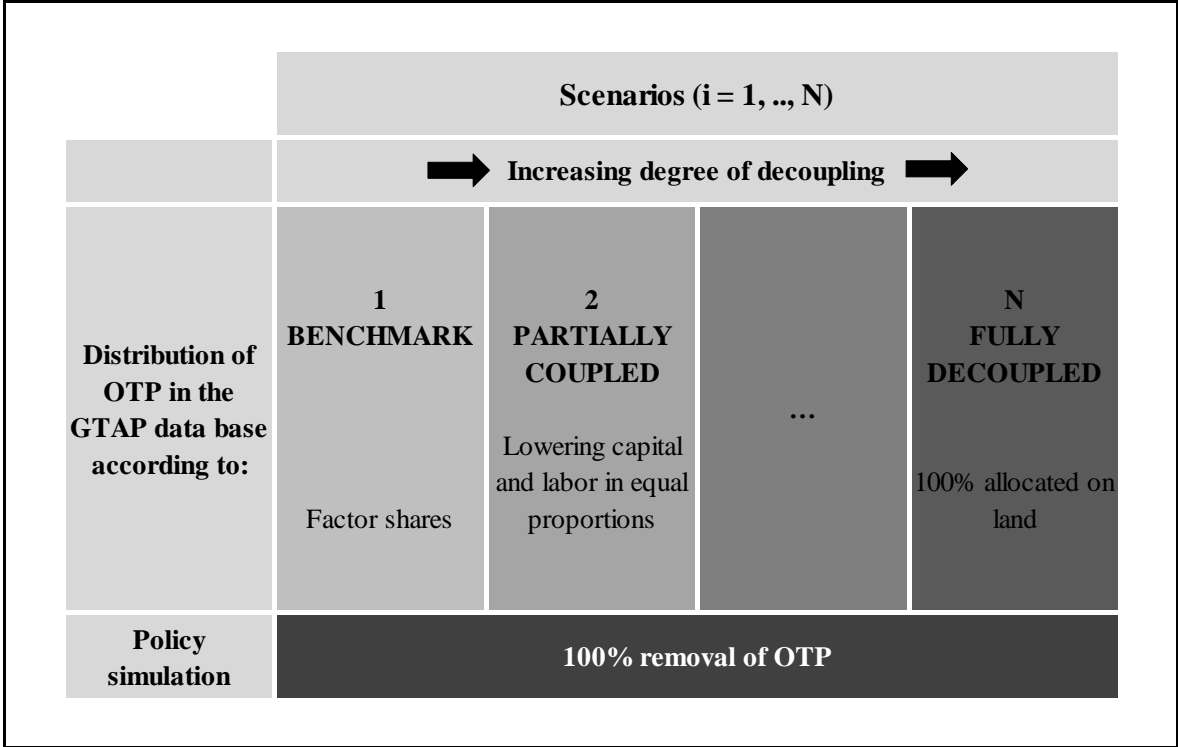
Source: Authors' elaboration.

4.4   Calculation of domestic support shocks

In Section 3.1, we described the *Altertax* model that is used to implement domestic support into the GTAP database. Recap that we divided e.g., the difference of EVFA and VFM into 4 parts (Figure 3). In the *Altertax* program, we modeled the shares of domestic support payments in relation to the value of production (VOM in the GTAP database) for each payment category and type. Then, in Section 4, we so far described the manipulation of the OECD PSE data to match the GTAP database and determined the shares of domestic support in relation to the value of production (Eurostat). Subsequent, the next step further imposes this scaling mechanism to implement the PSE domestic support payments in the GTAP database by introducing the still missing part on how the shocks employed to change the GTAP database are calculated.

The initial share of OTP in the GTAP database needs to be shocked to the value obtained by the OECD PSE data in relation to the EUROSTAT production value. The new value is calculated by building the sum of the difference between $VFMT_{ijr}$ and $VFMX_{ijrg}$ with g = base over all agricultural commodities and dividing this value by the sum of VOM_{jr} over all agricultural commodities (equation (4.11)). Thereafter the shock to OTP can be introduced by taking the difference between OTP_PVS_r (see equation (4.10)), which was calculated in ds_eu.tab (OECD) and the newly calculated GTAP OTP_SHR_r. In the initial situation, this share is equal to zero (see equation (4.12)). Using this shock, the share of domestic support allocated to OTP adjusts to the share calculated using the PSE values.

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$$(4.11) \qquad OTP\_SHR_r = \frac{\sum_{j \in AGRI} \sum_{i \in NNATDIS} VFMT_{ijr} - VFMX_{ijrg}}{\sum_{j \in AGRI} VOM_{jr}} \qquad \begin{matrix} \forall r \in REG \\ g = base \end{matrix}$$

$$(4.12) \qquad SHOTP_r = \sum_{i \in NNAT} OTP\_PVS_{ir} - OTP\_SHR_r \qquad \forall r \in REG$$

      OTP_SHR_r *Share of domestic support allocated to OTP/SFP in GTAP by region r*

      VOM_{jr} *Value of output at market prices by commodity j and region r*

      $SHOTP_r$ *Shock to OTP/SFP in GTAP by region r*

      OTP_PVS_r *Share of domestic support allocated to OTP/SFP (OECD) by region r*

The scaling mechanism and the related shocks to GCT and ACT subsidies are applied in a similar way. In this part ACT and GCT payments are implemented at once, but the related value flows consider an additional index. This index includes the different payment groups (ACT, GCT1, …, GCT12) so that this value flow is established like a chain. Due to this chain, we are able to implement group specific policy instruments (see Section 3.1). The endowment share for ACT, e.g., is calculated by the difference between $VFMX_{ijrg}$ with g = base and $VFMX_{ijrg}$ with g = gct1 summed over agricultural commodities divided by the sum over agricultural commodities of VOM_{jr}. Subtracting this initial GTAP share based on from the share obtained by the PSE data in relation to Eurostat production values, we get the shock to ACT payments allocated to land, labor, and capital in GTAP (equation (4.13) and (4.14)).

$$(4.13) \qquad SHR\_ENDW_{irg} = \frac{\sum_{j \in AGRI} VFMX_{ijrb} - VFMX_{ijrg}}{\sum_{j \in AGRI} VOM_{jr}} \qquad \begin{matrix} \forall i \in NNATDIS \\ \forall r \in REG \\ \forall g \in GROUP \\ \forall b \in BASEGROUP \end{matrix}$$

$$(4.14) \qquad SHK\_ENDW_{irg} = HOM\_PVS_{irg} - SHR\_ENDW_{irg} \qquad \begin{matrix} \forall i \in NNATDIS \\ \forall r \in REG \\ \forall g \in GROUP \end{matrix}$$

      SHR_ENDW_{irg} *Share of all and group commodity domestic support allocated to land, labor and capital subsidies in GTAP in region r for group g*

      SHK_ENDW_{irg} *Shock to all and group commodity payments allocates to land, labor and capital in GTAP in region r for group g*

      HOM_PVS_{irg} *Share of all and group commodity domestic support allocated to land, labor and capital (OECD) in region r for group g*

The implementation of ACT and GCT payments allocated to intermediate inputs involves more consideration. In the GTAP model, inputs are differentiated according to their origin. In contrast, in the PSE tables, there is no distinction made between imported and domestically produced intermediate inputs. Therefore, the share in GTAP is determined by summing up both the share for domestically produced intermediate inputs and the imported one (equation (4.15)). The calculation of the shocks is analogous to the one for endowments and can be retraced from equation (4.16) that yields in a shock for both value flows together.

$$4.15) \quad SHR\_INT_{rg} = \left[\sum_{j \in AGRI} \sum_{k \in INT} VDFMX_{kjrb} - VDFMX_{kjrg} \right. \qquad \begin{array}{l} \forall r \in REG \\ \forall g \in GROUP \end{array}$$

$$+ \sum_{j \in AGRI} \sum_{k \in INT} VIFMX_{kjrb} - VIFMX_{kjrg} \left. \right] / \sum_{j \in AGRI} VOM_{jr} \quad \forall b \in BASEGROUP$$

$$(4.16) \quad SHK\_INT_{rg} = HOM\_PVS_{irg} - SHR\_INT_{rg} \qquad \begin{array}{l} \forall r \in REG \\ \forall g \in GROUP \\ \forall i \in INPUT \end{array}$$

SHR_INT_{rg} — *Share of all and group commodity domestic support allocated to input subsidies in GTAP in region r for group g*

SHK_INT_{rg} — *Shock to all and group commodity payments allocated to inputs in GTAP in region r fro group g*

HOM_PVS_{irg} — *Share of all and group commodity domestic support allocated to inputs (OECD)in region r for group g*

The product specific support is calculated differently, because those payments are directly related to one special commodity. The SCT is allocated to inputs, land and capital as well as output. Output subsidies are given only as commodity specific support. Due to the consideration of output subsidies, VOM_{jr} has to be included in the procedure. Consequently, we need to deviate from the procedure applied before, where all shares are determined in relation to VOM_{jr} to avoid a bias.

The deviating approach to implement SCT is presented in equation (4.17) to (4.20). We first calculate the power of tax, by calculating the relation between the SCT value and VOM_{jr} and add 1 (4.17.). Beforehand, we computed the power of *SCTPAYPOS* (compare equation (4.7)). This power is now divided by initial PO_TAX_{ir} (compare equation (4.18)) to determine the shock. Additionally, it is essential to calculate shares of SCT going to output, inputs, land, and capital. In equation (4.19) and (4.20) the calculation is shown for output subsidies as an example, the equations for the other subsidies can be found in the attached file containing the shock calculations.

$$(4.17) \quad \begin{aligned} PO\_TAX_{ir} = 1 + \Big[& VOA_{ir} - VOM_{ir} \\ & + \sum_j VFMX(GCT12)_{jir} - VFA_{jir} \\ & + \sum_k VDFMX(GCT12)_{kir} - VDFA_{kir} \\ & + \sum_k VIFMX(GCT12)_{kir} - VIFA_{kir} \Big] \\ & / VOM_{ir} \end{aligned} \qquad \begin{array}{l} \forall i \in AGRI \\ \forall r \in REG \\ \forall j \in ENDW \\ \forall k \in INT \end{array}$$

PO_TAX_{ir} — *Power of tax in GTAP for commodity i in region r*

$$(4.18) \quad POSCT_{jr} = 100 * \left[\left(\frac{SCTPAYPOS_{jr}}{PO\_TAX_{jr}} \right) - 1 \right] \qquad \begin{array}{l} \forall j \in AGRI \\ \forall r \in REG \end{array}$$

$POSCT_{jr}$ — *Power of tax shock in GTAP for commodity j in region r*

$SCTPAYPOS_{jr}$ — *Power of SCT (OECD) for commodity j in region r*

$$(4.19) \quad SHR\_OUT_{ir} = \left[VOA_{ir} - VOM_{ir}\right]$$
$$/ \left[VOA_{ir} - VOM_{ir}\right.$$
$$+ \sum_j VFMX(GCT12)_{jir} - VFA_{jir}$$
$$+ \sum_k VDFMX(GCT12)_{kir} - VDFA_{jir}$$
$$+ \left. \sum_k VIFMX(GCT12)_{kir} - VIFA_{jir}\right]$$

$\forall i \in AGRI$

$\forall r \in REG$

$\forall j \in ENDW$

$\forall k \in INT$

SHR_OUT_{ir} *Share of domestic support allocated to output subsidies in GTAP for commodity i in region r*

$$(4.20) \quad SHK\_OUT_{ir} = SCT\_PVS_{ijr} - SHR\_OUT_{jr}$$

$\forall i \in OUTPUT$

$\forall r \in REG$

$\forall j \in AGRI$

SHK_OUT_{ir} *Shock to payments allocates to output in GTAP for commodity i in region r*

5   Iterative procedure to integrate domestic support into the GTAP database

In this Section, we explain the technical procedure utilized to implement domestic support payments. Since the technical steps are tightly intertwined, we provide here a systematic description of how to incorporate or alter domestic support in the GTAP database applying the models introduced in Section 3, the created databases described in Section 4.1 and 4.2 and the shocks specified in Section 4.4.

As introduced in Section 4 the PSE values are re-allocated according the GTAP aggregation. After this re-allocating according to the GTAP sectors and payment categories (compare file EU_pse.xlsx)[31] it is necessary to transfer the domestic support data into the GTAP database. Therefore, the OECD PSE data are copied into a header array (har)-file (compare pse_eu.har) which is read into a program called ds.tab. In this file, our exemplary region, the EU, is disaggregated at member state level[32]. For the implementation procedure of domestic support, additional set definitions are needed. The file sets.har contains the standard GTAP set definitions, while the file ds_sets.har comprises the additional set definitions required for the domestic support calculations.

The PSE payments can be differentiated into 4 payment groups. As introduced in Section 4.2, the SCT payments are product specific and are therefore directly allocated to products and payment categories. The ACT and GCT payments are not product specific, but bound on production of commodities belonging to a defined group. These payments are allocated by payments types, but with a group-specific homogenous subsidy rate to commodities. The remaining OTP is the focal point of this analysis. As introduced in Section 4.3, we applied different allocation options shown in Figure 8. This operation is conducted applying the tab-file ds.tab using the mentioned input files. Beyond, in the file ds.tab the share of product specific support going to the categories output, input, land, labor and capital is calculated. For the incorporation into the GTAP database the application of the scaling mechanism, as already mentioned, is required. Therefore, we calculate the share of PSE values in relation to the Eurostat production value and multiply this share with the value of output in the GTAP database. This procedure was more precisely explained in Section 4.2. Consequently, the output obtained by running ds.tab is PSE payments that are manipulated in order to fit with the GTAP database. The output is written to ds_gtap.har.

In Figure 10, the implementation procedure is shown starting with the scaling of PSE data to the GTAP level up to the application of the extended standard GTAP model. To correctly implement domestic support in the GTAP database all support rates need to be updated, but particularly, the OTP needs to be allocated either with the help of a homogenous rate across sectors to land, labor and capital (default in GTAP) or with an allocation to the factor land according an assumed degree of decoupling. Therefore, it is necessary to determine shocks (refer to Section 4.4) to adjust the GTAP database. These shocks are computed in ds_shk.tab.

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[31] Refer to table A4 in the Appendix for the description of files. Please note that all required files will be provided via www.gtap.org.

[32] In case a higher aggregation of the EU member states is required, the tablo- (tab) file regions_mapping.tab is provided to change the OECD PSE data according to the selected aggregation of the EU member states. This tab-file delivers an updated har-file named pse_eu_agg.har, which is then used to replace pse_eu.har.

Figure 10. Structure of the implementation procedure IV
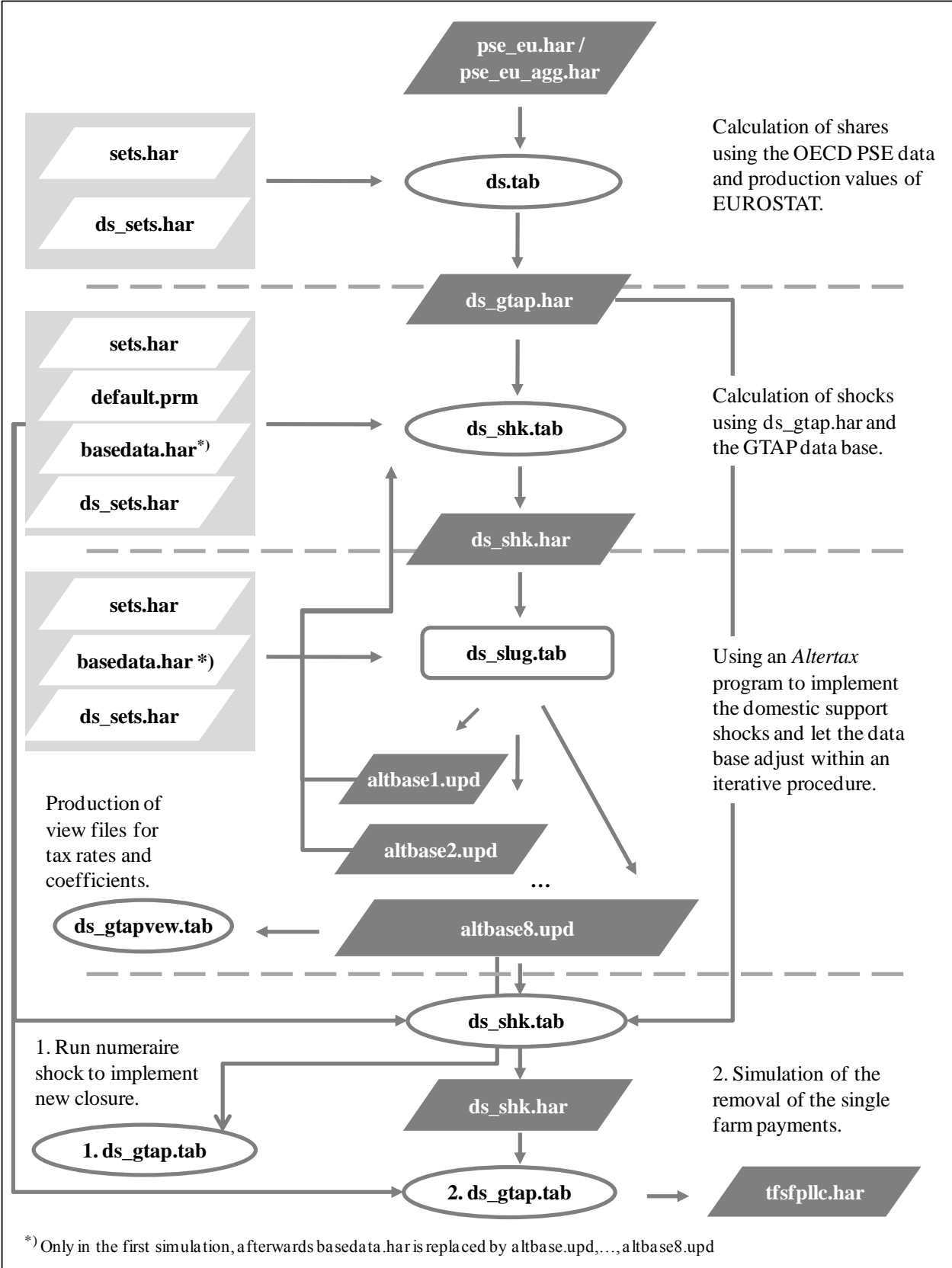
Source: Authors' elaboration.

As shown in Figure 10 additional input files are required for this program, which are the standard GTAP input files (sets.har, default.prm, basedata.har) plus the required files for domestic support (ds_sets.har and ds_gtap.har). In the next step of the implementation process, the *Altertax* program developed by Gerard Malcolm (Malcolm, 1998) is applied to shock the domestic support variables and adjust the database within an iterative procedure. Specifically, ds_slug.tab is needed to calibrate the homogenous subsidy rate for land; labor and capital depending on the chosen distribution method (compare Section 3 and 4). Therefore, the ds_slug.tab is adjusted to accommodate the needs to implement domestic support. The target is to achieve only minimal changes to all other variables in the database, when implementing domestic support.

To run this *Altertax* program nine Gempack command-files (compare alterdo.cmf, alterdo1.cmf, ..., alterdo8.cmf) are applied to impose the closure shown in (Figure A1)[33]. In so doing, the shocks and swaps are introduced stepwise. The output is written to an updated GTAP database file (compare altbase.upd, alterbase1.upd …, alterbase8.upd).

How does this procedure work? We swap for example the exogenous (compare Figure A1) policy variable $tfsfp_r$ with $DEL\_OTP\_SHR_r$ to become endogenous in the model. The change variable $DEL\_OTP\_SHR_r$ is then shocked with $SHOTP_{ir}$ calculated in ds_shk.tab (compare equation (4.12) in Section 4.4). Following the method for $tfsfp_r$ the other policy variables (tfs_r, to_r, $tfdmsct_{r,...}$) are likewise made endogenous using a swap. In the next step, the related change variables are shocked using shocks calculated in ds_shk.tab. For domestic support excluding OTP the shocks and swaps are subdivided into the different categories of support. The swaps and shocks required for the domestic support update are implemented stepwise to enable the GTAP *Altertax* model to solve as accurately as possible and achieve only minimal changes in other variables in the database.

Finally, the ds_gtap.tab, adapted from the standard file gtap.tab to include the domestic support as explained in Section 3.2, is used for an initial run to establish the adjusted standard GTAP closure (compare Figure A2) and perform the price homogeneity test. After doing these steps domestic support is implemented in the GTAP database and can be used for simulations e.g., the 100% reduction of OTP as shown in Section 4.3 of this paper (compare Figure 10).

After that, the tab-file ds_gtpvew.tab, a modification of the standard gtpvew.tab to capture the details of domestic support payments is applied to calculate additional tax rates for the newly implemented allocation of domestic support subsidies together with some other summary values used to demonstrate how successful the implementation procedure was (Section 6).

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[33] A onetime solution results only in rough estimates, whereas the sequential steps are necessary for the fine-tuning. Users have the ability to vary the number of iterations by reducing the number of alterdo.cmf-files and adjusting the batch-file accordingly, if they prefer shorter solution time over the fine tuning.

6   Results

6.1   Output of database update

In Table 6, the default allocation of OTP across sectors and factors is shown, displayed as a homogenous percentage support rate across factors and sectors using Germany as an example.

Table 6. Homogenous allocation of OTP across factors and sectors in Germany (%)

RTFSFP	PDR	WHT	GRO	V_F	OSD	C_B	PFB	OCR	CTL	OAP	RMK	WOL
Land	-18	-18	-18	-18	-18	-18	-18	-18	-18	-18	-18	-18
Unskilled Labor	-18	-18	-18	-18	-18	-18	-18	-18	-18	-18	-18	-18
Skilled Labor	-18	-18	-18	-18	-18	-18	-18	-18	-18	-18	-18	-18
Capital	-18	-18	-18	-18	-18	-18	-18	-18	-18	-18	-18	-18
Natural Resources	0	0	0	0	0	0	0	0	0	0	0	0
Total	-72	-72	-72	-72	-72	-72	-72	-72	-72	-72	-72	-72

Source: Own calculations.

In contrast, Table 7 depicts the product specific rates for the SCT by type of support.

Table 7. Product specific allocation of SCT in Germany (%)

RTFSCT	PDR	WHT	GRO	V_F	OSD	C_B	PFB	OCR	CTL	OAP	RMK	WOL
Land	0	0	0	-0,02	0	0	0	-0,99	0	0	0	0
Unskilled Labor	0	0	0	0	0	0	0	0	0	0	0	0
Skilled Labor	0	0	0	0	0	0	0	0	0	0	0	0
Capital	0	0	0	0	0	0	0	-0,64	-0,07	0	0	0
Natural Resources	0	0	0	0	0	0	0	0	0	0	0	0
Total	0	0	0	-0,02	0	0	0	-1,63	-0,07	0	0	0

Source: Own calculations.

While in Table 8 the homogenous distribution of ACT payments over all commodities by type of support is presented.

Table 8. Factor specific homogenous allocation of ACT in Germany (%)

RTFACT	PDR	WHT	GRO	V_F	OSD	C_B	PFB	OCR	CTL	OAP	RMK	WOL
Land	-13	-13	-13	-13	-13	-13	-13	-13	-13	-13	-13	-13
Unskilled Labor	0	0	0	0	0	0	0	0	0	0	0	0
Skilled Labor	0	0	0	0	0	0	0	0	0	0	0	0
Capital	-4	-4	-4	-4	-4	-4	-4	-4	-4	-4	-4	-4
Natural Resources	0	0	0	0	0	0	0	0	0	0	0	0
Total	-17	-17	-17	-17	-17	-17	-17	-17	-17	-17	-17	-17

Source: Own calculations

Table 9 illustrates the special case for the group commodity transfer payments in Germany. Here, it becomes obvious that only products belonging to the group GCT1 are receiving subsidies. These subsidies are allocated with a homogenous rate across these commodities. In Germany GCT1 payments are only given to the factor land.

Table 9. Group and factor specific homogenous allocation of GCT1 in Germany (%)

RTFGCT1	PDR	WHT	GRO	V_F	OSD	C_B	PFB	OCR	CTL	OAP	RMK	WOL
Land	-2	-2	-2	-2	-2	-2	-2	-2	0	0	0	0
Unskilled Labor	0	0	0	0	0	0	0	0	0	0	0	0
Skilled Labor	0	0	0	0	0	0	0	0	0	0	0	0
Capital	0	0	0	0	0	0	0	0	0	0	0	0
Natural Resources	0	0	0	0	0	0	0	0	0	0	0	0
Total	-2	-2	-2	-2	-2	-2	-2	-2	0	0	0	0

Source: Own calculations.

Table 10 highlights the deviating allocation mechanism for GCT2 and GCT11 concerning oilseeds and protein crops.

Table 10. Group and factor specific homogenous allocation of GCT11 in Germany (%)

RTFGCT11	PDR	WHT	GRO	V_F	OSD	C_B	PFB	OCR	CTL	OAP	RMK	WOL
Land	0	-2.68	-2.68	0	-2.68	0	0	-0.01	0	0	0	0
Unskilled Labor	0	0	0	0	0	0	0	0	0	0	0	0
Skilled Labor	0	0	0	0	0	0	0	0	0	0	0	0
Capital	0	0	0	0	0	0	0	0	0	0	0	0
Natural Resources	0	0	0	0	0	0	0	0	0	0	0	0
Total	0	-2.68	-2.68	0	-2.68	0	0	-0.01	0	0	0	0

Source: Own calculations.

In the case of Germany the sectors for wheat, other grains and oilseeds receive a homogenous tax rate, while in the remaining sector other crops (OCR) only the commodity protein crops is eligible for subsidies. Therefore, the subsidy rate is reduced compared to the other three commodities. In addition, the oilseeds sector in other EU member states, e.g., Greece, Spain and Italy, has a more varying rate due to excluded olive oil payments, which is not relevant for Germany.

Table 11 and 12 provide a summary of the domestic support update of the GTAP database.

Table 11. Total domestic support value of the EU27 (USD Mio.)

	OTP	ACT	GCT	SCT	Total
Output	0	0	0	1384	1384
Input	0	0	0	0	0
Land	8775	9507	5236	2557	26075
Capital	9680	7782	965	3587	22015
Unskilled Labor	24789	635	2	0	25426
Skilled Labor	1688	44	0	0	1732
Total	44933	24635	6757	7576	83901

Source: Own calculations.

The file ds_gtpvew.tab contains the calculation of total domestic support in GTAP by product, payment category, and region. Furthermore, the share of each domestic support payment type related to the total value of domestic support as well as the value of production

is computed. The herewith-determined value of 83,820 USD Million in the GTAP database corresponds to 102%[34] of the initial domestic support given by the OECD.

The domestic support share of the production value is also close. The share in the GTAP database is equal to 5.11 while the PSE share in relation to the EUROSTAT production value accounts for 5.2.

Table 12. Comparison of the information on domestic support in the OCED PSE tables and the GTAP database

|	OECD PSE payments related to Eurostat production values					Domestic support payments related to production values in the GTAP database				
	SCT	ACT	GCT	OTP	Total	SCT	ACT	GCT	OTP	Total
Output	0.00	0.00	0.00	0.10	0.10	0.00	0.00	0.00	0.11	0.11
Input	0.00	0.31	0.16	0.00	0.48	0.00	0.31	0.06	0.00	0.37
Land	0.46	0.77	0.45	0.11	1.78	0.63	0.77	0.44	0.14	1.97
Capital	0.48	0.38	0.16	0.27	1.29	0.52	0.38	0.15	0.24	1.29
Unskilled Labor	1.48	0.03	0.00	0.00	1.51	1.28	0.03	0.00	0.00	1.31
Skilled Labor	0.08	0.00	0.00	0.00	0.08	0.07	0.00	0.00	0.00	0.07
Total	2.50	1.49	0.77	0.49	5.25	2.50	1.49	0.64	0.49	5.11

Source: Own calculations.

6.2   Sensitivity analysis results

In the course of this Section, we present selected results of the conducted sensitivity analysis. To carry out the sensitivity analysis we stepwise increased the degree of decoupling through gradually diluting the allocation to the factors capital and labor while shifting it onto the factor land until the OTP is distributed completely to the factor land. The intention of our comparison is twofold. First, we show the development of the effects due to an elimination of OTP depending on the underlying degree of decoupling. Second, we contrast the results of the scenario, in which we implemented the OTP as an effectively fully decoupled payment, with the default implementation in GTAP.

The production effects are illustrated by the percentage changes in output quantity in Figures 11 to 14 using different selections of countries and primary agricultural sectors. These graphs clearly depict that the effect of an elimination of OTP decreases with an increase in the degree of decoupling. It can be seen that there are no production changes in the scenario "decoupled" exposed by a degree of decoupling equal to one. The reason for this is of course, the distribution with a homogenous subsidy rate across primary agricultural commodities given to the factor land, which is used only by agricultural sectors.

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[34] To obtain a closer match of OECD and GTAP domestic support data more iterations of the update procedure would be required. In complex simulation models, we always face a trade-off fine-tuning versus solution time. Users of this implementation procedure can adjust the iterations and hence the accuracy according their needs.

Figure 11. Production effects in the wheat sector for selected EU member states
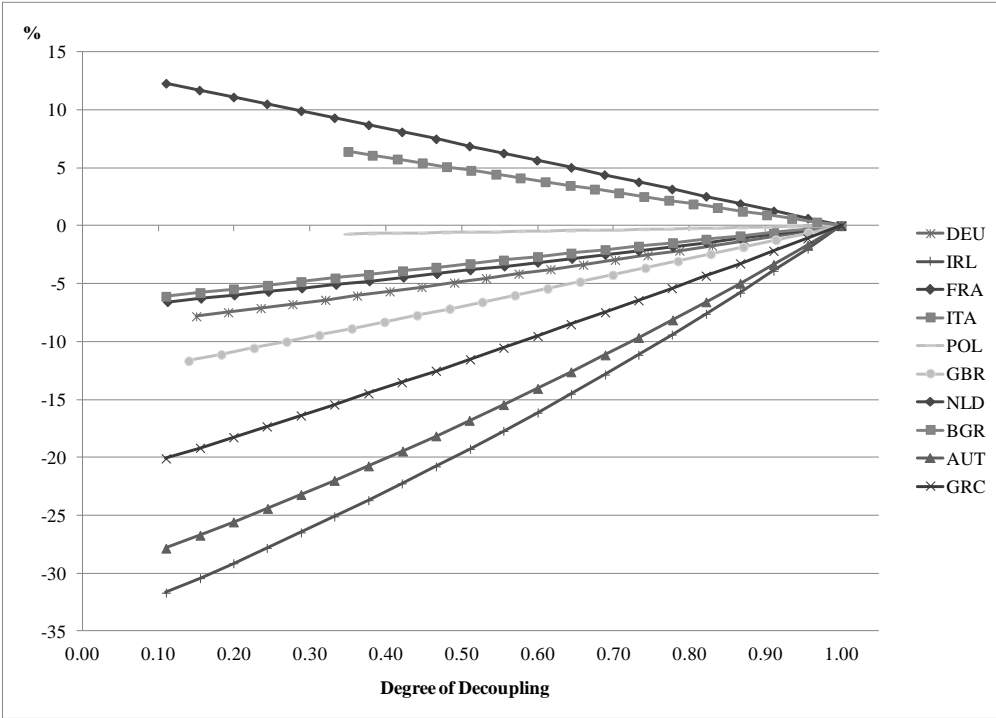
Source: Authors' elaboration.

The graphs 11 to 14 show that OTP distributed only to the factor land causes no production effects in all EU member states and in all primary agricultural sectors. Hence, the Figures 11 to 14 approve that this way of implementation and modeling reflects effectively fully decoupled payments in the GTAP database and model. This method of distributing the OTP in the GTAP database should be selected, when one assumes that the subsidies create no incentives to produce. Beyond, this supports our presumption that the effects are smaller the higher the share of OTP allocated to land is. Thinking about the removal of subsidies one generally would expect negative effects on output. However, Figure 11 reveals that the abolishment of OTP in the EU leads to a rise in wheat production in the Netherlands and in Bulgaria. Of course, this effect is decreasing with an increase in the degree of decoupling. The cattle sector shown in Figure 12 has positive output effects in Italy, Poland and slightly positive in Estonia.

In general, the range of the effects is much smaller in the EU member states that joined the EU in 2004. Beyond a significantly lower value of output in primary agricultural sectors of the EU, the main reason is that they receive OTP counting only for 3 to 5 percent of the value of output except for Estonia and Latvia (8%), Czech Republic (7%) and Hungary and Lithuania (6%). Most of the EU15 member states hold share higher than 8% except some of the Mediterranean countries (Italy and Spain (6%), Portugal (4%) and France (7%)) and, in particular, the Netherlands with only 2%.

Figure 12. Production effects in the cattle sector for selected EU member states
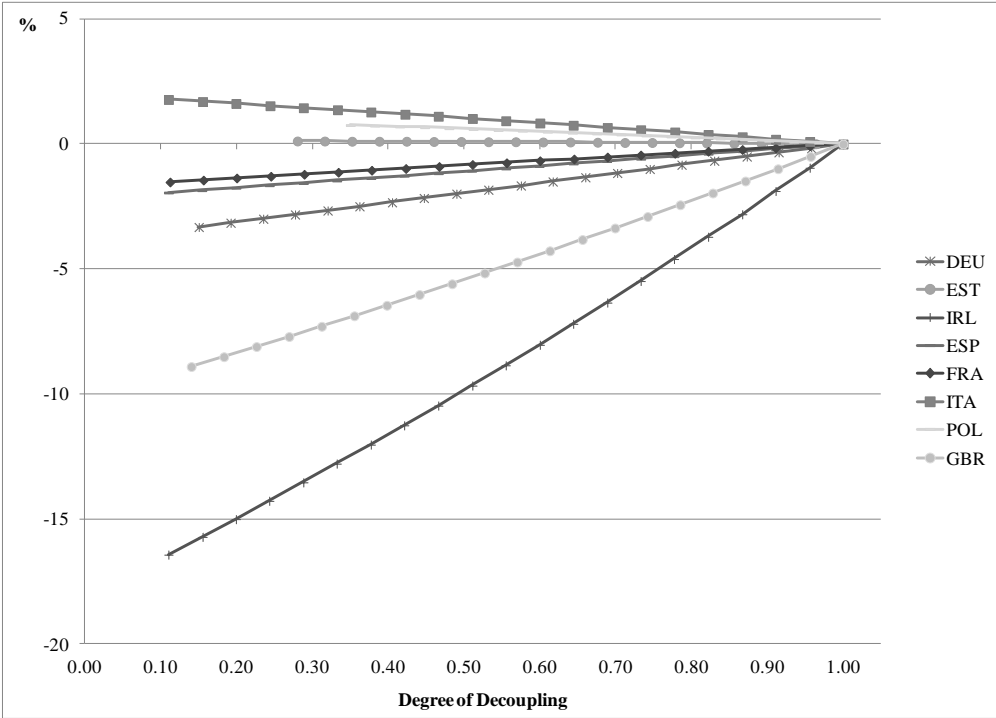
Source: Authors' elaboration.

From both graphs, it becomes obvious that Ireland faces in both sectors the highest effect on output. Figure 13 confirms those high effects, in particular, for the sectors oilseeds, wheat as well as vegetables and fruits, while the livestock and other meat sectors together with other grains and other crops are less affected.

A closer look at agricultural production in Ireland reveals that meat and dairy products comprise the major shares of Irish agriculture, while plant breeding plays only a minor role. Nevertheless, this does not explain why Ireland observes the highest negative effect on cattle production in comparison to all other EU member states. The value of output in the Irish cattle sector is comparatively low, relative to the other EU 15 member states. Beyond this, the OTP counts for almost 16% of the total value of primary agricultural output, while countries as France, Germany, or Italy face numbers between 6 and 9%. In Ireland the elimination of the OTP leads to a shift of the production factors capital and labor from primary agricultural and food processing sectors to manufacturing and services, while the factor land migrates from less competitive sectors as wheat, vegetables and fruits, and oilseeds into sectors as livestock and other crops. This factor movement explains the negative production effects and, in particular, why they are less negative for some of the sectors.

In contrast, Figure 14 shows the primary agricultural sectors of the Netherlands. Here, we see a picture that is split-up into two pieces. The ruminant livestock and dairy sectors and, in particular, the oilseeds sector experience slightly negative influences due to the elimination of OTP, while all other plant breeding sectors and other animal production are positively affected, clearly led by the wheat sector.

Figure 13. Production effects in selected sectors in Ireland
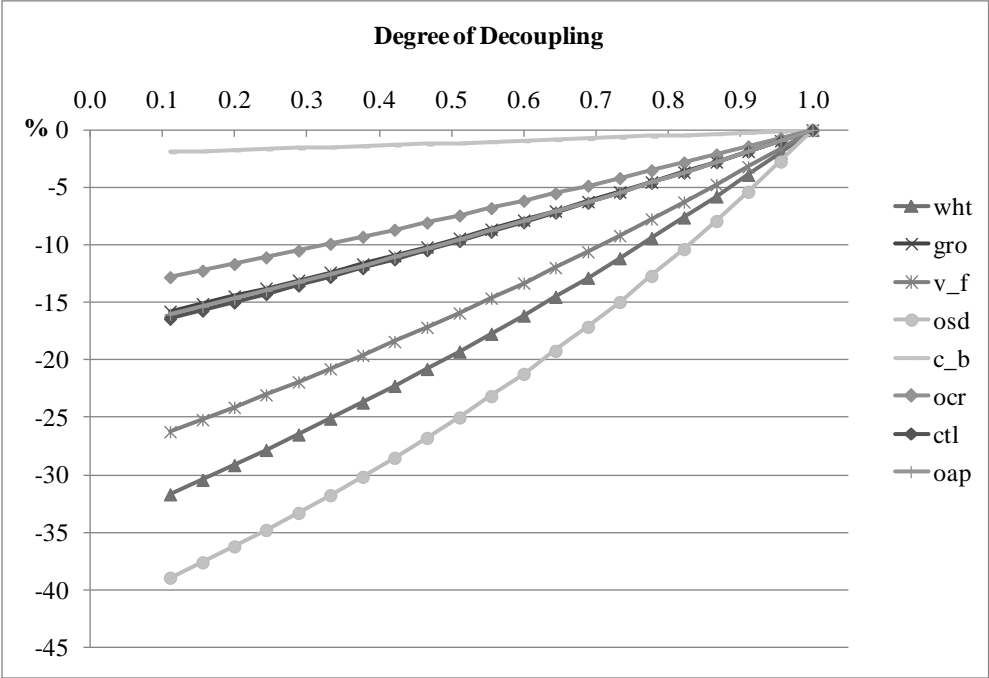
Source: Authors' elaboration.

Agriculture in the Netherlands is dominated by the production of other crops, e.g., flowers, seeds and fodder, and vegetables and fruits as well as livestock and dairy products.

Figure 14. Production effects in selected sectors in the Netherlands
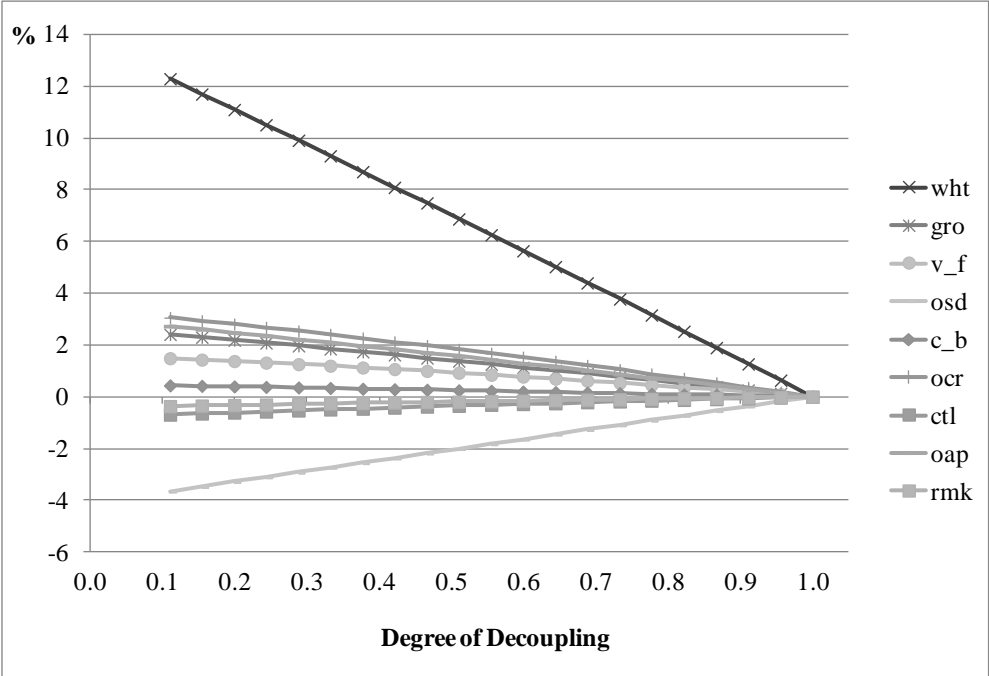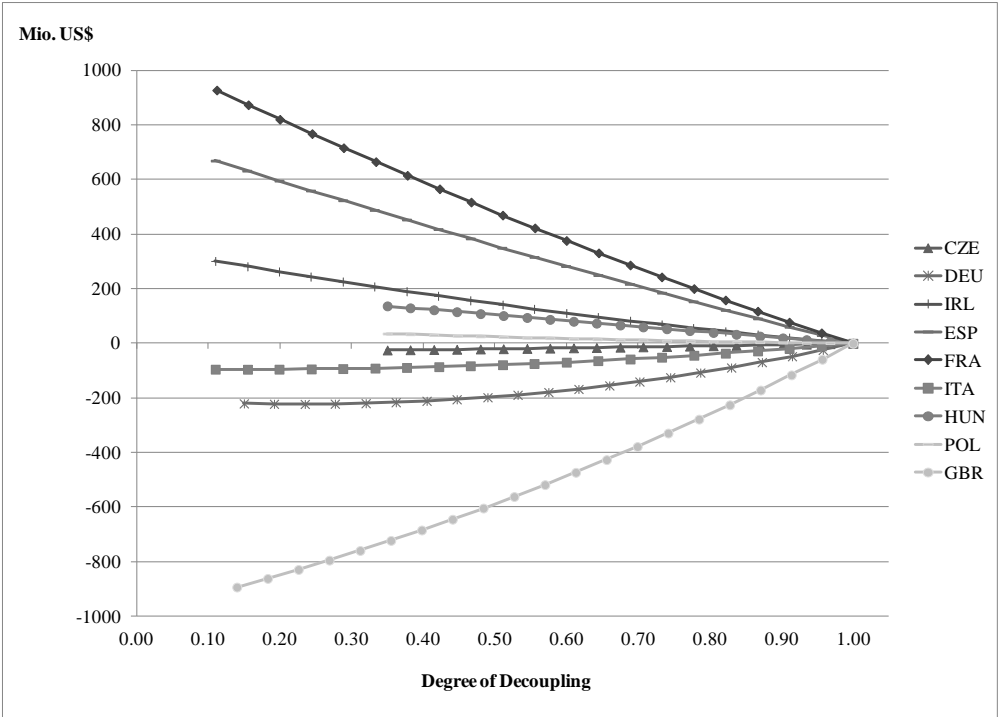

Source: Authors' elaboration.

The positive effects on production can be explained with the lowest share of OTP in relation to the value of output that counts for only 2%. This increases the competitiveness of

the plant breeding sectors and consequently leads to a shift of production factors from ruminant livestock and oilseed production to plant breeding:

Welfare in the GTAP model is determined using the equivalent variation. Figure 15 presents the changes in the equivalent variation induced by the elimination of OTP with deviating underlying degrees of decoupling. Similarly to the graphs shown beforehand, the changes in equivalent variation diminish with an increase in the degree of decoupling implying that the more decoupled the OTP is, the less affected is welfare. As shown in Figure 15, an effectively fully decoupled OTP has no influence on welfare. Besides, Figure 15 depicts that for some countries (e.g., France, Spain, and Ireland) OTP that are only partially decoupled create positive welfare changes, while the impact is negative for other countries (e.g., UK, Germany, and Italy). The explanation of why the equivalent variation is negative for some countries while positive for others requires a more specific experiment setting, which is beyond the scope of this paper. The different implications on welfare are possibly caused by other market distortions together with intra EU trade as well as inter-regional trade. The variation of OTP among regions also leads to unequal effects. In case of partially decoupled support a removal causes effects on output and prices, consequently the factor allocation is affected that may enhance the production in sectors that are highly supported in some EU countries and not or only minimal in others. This could lead to opposite welfare effects. Furthermore, the reaction of consumers and producers on price effects, caused by the removal of a partially decoupled subsidy, varies between EU member states.

Figure 15. Change in the equivalent variation in selected EU member states (Mio US$)
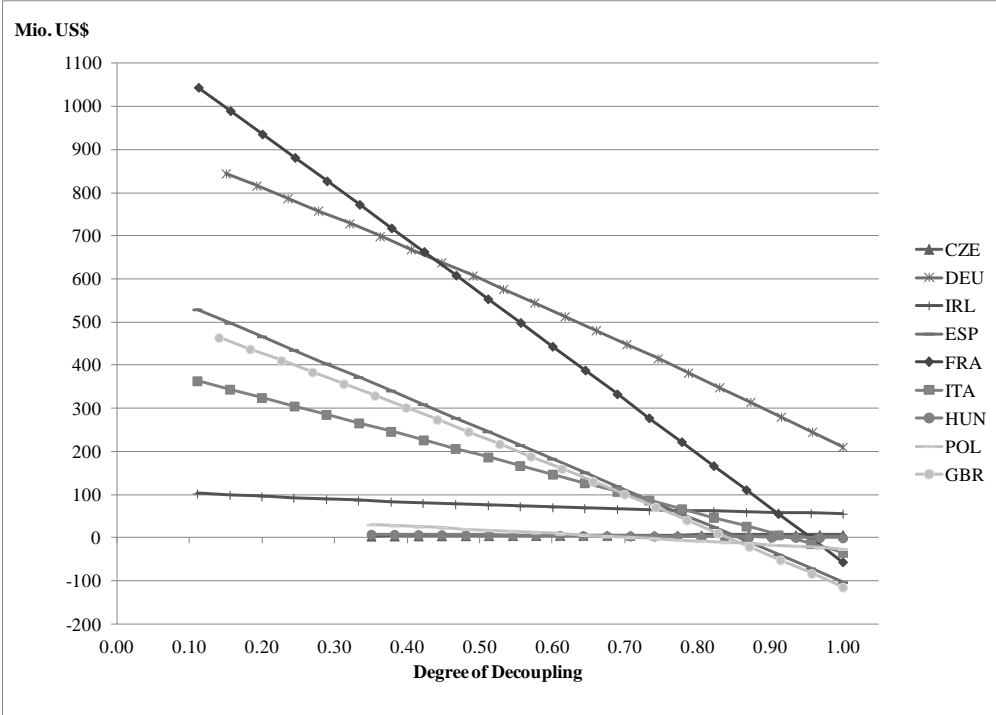

Source: Authors' elaboration.

Beyond the creation of production effects and the accompanied changes in the equivalent variation, it is interesting to point out the effects on trade. In particular, since OTP are designed as decoupled payments that create no production incentives and that are consequently only minimally trade distorting. To account for the distortive effects Figure 16

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highlights the changes in the trade balance in selected EU member states. Generally, one would assume that at least the removal of partially decoupled payments leads to a decrease in the trade balance. Here, it becomes apparent that partial decoupled payments create an increase in trade balance, again with a diminishing extent as the degree of decoupling rises. Striking is that the change in trade balance does not reduce to zero in all member states. In Germany, the change in the trade balance due to an effectively fully decoupled OTP is still positive while it turns to be negative for some other countries as France or UK when it reaches a high degree of decoupling.

Figure 16. Change in the trade balance of selected EU member states (Mio US$)

Source: Authors' elaboration.

The analysis of the German import and export value flows uncovers that the removal of OTP leads in all scenarios to a decrease in net exports in primary agricultural commodities. This does not apply to ruminant livestock and meat production as well as dairy products. However, this reduction in net exports is offset by the increases in net export in the manufacturing and service sectors. In France, the total net exports are negative in the initial situation due to the relative dominance of manufacturing. For the agricultural sectors such as wheat, other grains, oilseeds and livestock we see a different picture. France is net importer mainly for vegetables and fruits as well as other crops. The removal of OTP allocated homogenously according the factor usage or reflecting partial decoupling with only little degree of decoupling results in an increase in agricultural imports and decreases in exports except for wheat and cattle, together with an increase of manufacturing exports and less imports. In contrast, the elimination of an effectively fully decoupled OTP causes only minimally rises in the value of imports and exports leading to a more or less constant value for net exports of agricultural sectors. The negative change in the trade balance in the highly decoupled scenarios can be explained by the changes in the manufacturing sectors which are themselves modest in relation to the size of that sector. Consequently, even payments

modeled as decoupled in the GTAP framework are free of implications for trade, but the effects in the model can be regarded as modest.

So far, only the results of the implementation of OTP with varying degrees of decoupling are analyzed. Thus, we now turn the focus on the comparison with the default in the GTAP model that deviates from the other options through modeling OTP with a homogenous rate not only across primary agricultural commodities but as well across factors. The results are shown in Table 13 and contrasted against partially decoupled support distributed according the factor usage with a homogenous rate across primary agricultural commodities in GTAP.

Table 13. Comparison of the default distribution mode of the SFP in the standard GTAP with partial decoupling according the factor usage for selected countries

	SPAIN		FRANCE		IRELAND		NETHERLANDS	
	default	according factor usage	default	according factor usage	default	according factor usage	default	according factor usage
Degree of decoupling	0,11	0,11	0,11	0,11	0,11	0,11	0,11	0,11
Percentage change in output								
wheat	-7,32	-7,61	-6,21	-6,57	-28,07	-31,68	11,29	12,29
other grains	-3,32	-3,47	-3,18	-3,35	-13,97	-15,77	2,12	2,41
vegetables and fruits	-5,54	-5,76	-9,69	-10,26	-23,26	-26,24	1,09	1,49
oilseeds	-7,65	-8,00	-10,58	-11,18	-35,49	-38,93	-3,67	-3,65
sugar crops	-1,50	-1,57	-1,20	-1,28	-1,67	-1,91	0,37	0,44
other crops	-3,88	-4,07	-3,83	-4,07	-11,14	-12,80	2,59	3,06
cattle	-1,88	-2,12	-1,47	-1,52	-14,43	-16,42	-0,88	-0,69
other meet	-2,03	-0,05	-3,63	-3,85	-14,11	-16,02	2,34	2,73
raw milk	-0,05	12,20	-1,28	-1,36	-17,14	-19,28	-0,49	-0,36
Change in trade balance	532,93	529,89	1046,39	1044,68	96,08	103,14	99,61	104,17
Change in welfare	631,16	669,15	867,37	927,61	255,60	301,50	601,69	629,59

Source: Own calculations.

The simulation results clearly depict that the homogenous distribution across factors and agricultural commodities reduces the effect on production compared to the allocation according the factor usage. The changes in trade balance are negligible for Spain and France, while we see a reduction of around 7% in Ireland and the Netherlands. Contrary, the decline in the equivalent variation is more remarkable with 6% in Spain up to 18% in Ireland due to the allocation with a homogenous subsidy rate to the factors.

Summarizing the results, our sensitivity analysis reveals strong differences in simulation results, which are particularly notable in the responses of the food and agricultural sectors. Accordingly, results of trade liberalization including domestic support are highly sensitive to the approach which is chosen to implement OTP in simulation models.

7   Summary and future directions

This paper shows how to implement or alter domestic support in the GTAP database using the EU as an example. We use the PSE tables provided by the OECD and reallocated the PSE payments to align them with the sectoral aggregation employed in GTAP framework. In the paper, we explain stepwise how the standard GTAP model and the *Altertax* model are extended, the data are modified, and the shocks for the GTAP database are calculated and implemented within an iterative procedure. With this approach, we provide a tool allowing GTAP users to change the distribution of domestic support in the standard GTAP database to apply their assumptions regarding domestic support and particularly decoupled domestic support. Furthermore, GTAP users are able to update domestic support in the GTAP database for other countries included in the GTAP database given that PSE data is available. Hence, this approach can easily be adjusted to incorporate PSE data of other countries into the GTAP model and database.

The EU's SFP is regarded as more or less non-trade distorting. The literature review points out that decoupled payments still have an influence on production via various coupling channels, e.g., risk and wealth, credit constraint, land and labor allocation as well as farmers expectations about future policies. Most of the authors not only state that these effects are rather modest, but that the effect of decoupled payments on land allocation and related production effects are most important. Econometrically determined effects of decoupled payments are mainly estimated for individual coupling channels.

As revealed in the literature, there is not just "one degree of decoupling" that should be used in CGE models. This implies that every user needs to find out the most appropriate one depending on the selected aggregation of the GTAP database and the posed research question.

From our point of view, the default implementation in GTAP (homogenous distribution across factors and sectors) is too pessimistic, while effectively fully decoupled implementation in GTAP (allocation only to the factor land with a homogenous rate across sectors) is too optimistic. Several studies confirm that the SFP capitalizes in land rents (e.g., Latruffe and Le Mouel (2009), van Meijl et al. (2006)) and other studies state moderate effects of other coupling channels (e.g., Goodwin and Mishra (2009), Bhaskar and Beghin (2008)). Since we apply the same distribution to all EU member states without accounting for regional deviations of the SFP, without considering different types of agricultural producers (self-supporter up to agricultural co-operatives) and the importance of the agricultural sector in the EU countries, it is not possible to determine one specific degree of decoupling. However, we would suggest GTAP users to specify a range of the degree of decoupling that is more oriented in the direction of decoupled support, e.g. shifting 80 to 90% of the SFP allocated to labor and capital onto the factor land. This way the GTAP database and model reflect the decoupled character of the SFP without neglecting other coupling channels.

To improve the implementation of SFP in simulation models, one needs to employ coupling factors that are more accurate. The adjustment of the underlying assumptions for the distribution of the SFP using such coupling factors would reflect the coupling through other channels in a more realistic way. While allocating the SFP with a homogenous rate to the factor land, possible production effects due to other coupling channels are not reflected by the model. Therefore, these effects have to be estimated and can then be integrated into the model

by adjusting the degree of decoupling in the model. The higher the estimated degree of decoupling, the higher should be the share allocated to land in the GTAP model.

Based on the discussion in the literature, we conduct a sensitivity analysis on the mode of allocation of SFP payments in simulation models utilizing the OECD PSE data and the GTAP framework. Thus, we apply a set of simulations to update domestic support and, in particular, the SFP in the GTAP database by varying the underlying assumptions about the distribution of OTP/SFP. This sensitivity analysis reveals strong differences in simulations results, which are particularly pronounced in the production responses of the food and agricultural sectors. The results clearly indicate that the distribution of OTP over the factors is a crucial driver for the model's results. Accordingly, results of trade liberalization, including the removal of domestic support, are highly sensitive to the mode by which the SFP is implemented in simulation models. The current standard approach to calibrate the GTAP database is based on a distribution of OTP/SFP with a homogenous rate according to factor shares, which represents a low degree of decoupling. Our analysis reveals that effectively fully decoupling can be achieved, when the SFP is completely allocated to the factor land and distributed over agricultural production sectors with a homogenous subsidy rate.

Our approach enables GTAP users to adjust the GTAP database to be able to account for country specific domestic support issues and run more adequate agricultural policy simulations or WTO trade liberalizations scenarios. In case of WTO simulations, a reconciling of OECD and PSE data is required to capture the WTO classification of domestic support according to amber, blue, and green boxes. This is done for the EU25 in Jensen et al. (2009). For future analyses, it would be desirable to have better empirical results of the "real" degree of decoupling and an explicit modeling of market price support in the GTAP model.

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8   Appendix

8.1   Tables and Figures

Table A1.   Regional aggregation of the GTAP database

Countries and Regions		Abbreviation
1	Austria	aus
2	Belgium and Luxembourg	BLUX
3	Denmark	dnk
4	Finland	fin
5	France	fra
6	Germany	deu
7	Ireland	irl
8	United Kingdom	gbr
9	Greece	grc
10	Italy	ita
11	Netherlands	nld
12	Portugal	prt
13	Spain	esp
14	Sweden	swe
15	Czech Republic	cze
16	Hungary	hun
17	Malta and Cyprus	CM
18	Poland	pol
19	Slovakia	svk
20	Slovenia	svn
21	Estonia	est
22	Latvia	lva
23	Lithuania	ltu
24	Bulgaria	bgr
25	Romania	rou
26	Rest of the World: United States, Canada, Japan, Australia, New Zealand, Switzerland, Norway, Rest of EFTA, Albania, Croatia, China, India, Brazil, Argentina, Bolivia, Chile, Colombia, Ecuador, Paraguay, Peru, Uruguay, Venezuela, Panama, Rest of South America, Rest of Oceania, Rest of Caribbean, Mauritius, Zimbabwe, Botswana, South Africa, Hong Kong, Korea, Rest of East Asia, Indonesia, Malaysia, Philippines, Singapore, Thailand, Viet Nam, Pakistan, Sri Lanka, Mexico, Costa Rica, Guatemala, Nicaragua, Rest of Central America, Belarus, Rest of Eastern Europe, Kyrgyzstan, Armenia, Georgia, Turkey, Rest of Western Asia, Egypt, Morocco, Tunisia, Rest of North Africa, Rest of South African CU, Cambodia, Lao People's Democratic Republic, Myanmar, Rest of Southeast Asia, Bangladesh, Rest of South Asia, Nigeria, Senegal, Rest of Western Africa, Rest of Central Africa, Rest of South Central Africa, Ethiopia, Madagascar, Malawi, Mozambique, Tanzania, Uganda, Zambia, Other Eastern Africa, Taiwan, Rest of North America, Russian Federation, Rest of Europe, Kazakhstan, Rest of FSU, Azerbaijan, Iran Islamic Republic, Ukraine, Mongolia, Nepal, Honduras, El Salvador, Bahrein, Israel, Kuwait, Oman, Qatar, Saudi Arabia, United Arab. Emirates, Benin, Burkina Faso, Cameroon, Cote d'Ivoire, Ghana, Togo, Kenia, Rwanda, Namibia	ROW

Source: Own table.

Table A2.   Sectoral aggregation in GTAP

Sectors		Abbreviation
1	Paddy rice	pdr
2	Wheat	wht
3	Cereal grains nec	gro
4	Vegetables, fruits, nuts	v_f
5	Oilseeds	osd
6	Sugar cane, sugar beet	c_b
7	Plant-based fibres	pfb
8	Crops nec	ocr
9	Cattle, sheep, goats, horses	ctl
10	Animal products nec	oap
11	Raw milk	rmk
12	Wool, silk worm cocoons	wol
13	Meat: cattle, sheep, goats, hoarses	cmt
14	Meat products nec	oap
15	Vegetable oils and fats	vol
16	Dairy products	mil
17	Processed rice	pct
18	Sugar	sgr
19	Other food	ofd
20	Beverages and tobacco products	b_t
21	Manufacturing Coal, oil, gas, petroleum, coal products, Forestry, fishing, minerals, Textiles, wearing apparel, leather products, wood products, paper products, publishing, chemical, rubber, plastic prods, mineral products nec, ferrous metals, metals nec, metal products, motor vehicles and parts, transport equipment, electronic equipment, machinery and equipment, manufactures nec	MNFC
22	Services Water, construction, trade, transport nec, sea transport, air transport, communication, financial services nec, insurance, business services nec, recreation and other services, PubAdmin/Defence/Health/Educat, dwellings	SERVICES

Source: Own table.

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Table A3: EU27: PSE Payments, by type of support, 2007 (EURO Mio.)

SINGLE COMMODITY TRANSFERS (SCT)

			Paddy rice	Wheat	Cereal grains	Vegetables, fruits and nuts	Oilseeds	Sugar beet and sugar cane	Plant based fibres	Other crops	Beef & Sheep	Other meat products	Raw milk	Wool	Sum
Value of production, EUROSTAT aggregated to GTAP concordance (327.126)			715	22.352	24.204	62.783	12.129	3.475	621	61.713	34.053	56.574	48.398	109	
Output	Output payments	A2	9	-2	6	382	2	0	0	307	0	7	215	1	927
Input	Variable inputs	B1	0	0	0	0	0	0	0	-2	-1	-1	-1	0	-6
	On-farm services	B3	0	0	0	0	0	0	0	0	17	21	0	0	38
Land based	current A/An/R/I, prod req	C	168	125	1	212	118	30	248	302	0	0	0	0	1203
	non-current A/An/R/I, prod req	D	0	0	0	0	0	0	0	0	0	0	0	0	0
Capital based	Fixed capital formation	B2	0	0	0	0	0	0	0	242	0	1	0	0	243
	current A/An/R/I, prod req	C	0	0	0	0	0	0	0	0	2376	119	78	0	2574
	non-current A/An/R/I, prod req	D	0	0	0	0	0	0	0	0	0	0	0	0	0
Total SCT			178	123	6	594	120	30	248	848	2.393	147	293	1	4.978

ALL (ACT), GROUP (GCT) AND OTHER TRANSFERS (OTP)

			ALL	GROUP												OTHER
				GCT1 All crops	GCT2 All arable crops	GCT3 Grains	GCT4 Oilseeds	GCT5 Other crops	GCT6 All fruits and vegetables	GCT7 All livestock	GCT8 Ruminants	GCT9 Non-ruminants	GCT10 Protein crops	GCT11 Cereals, oilseeds and protein crops	GCT12 Milk and beef	Sum
Input	Variable inputs	B1	3.898	102	0	0	0	0	0	271	136	0	0	0	0	509
	On-farm services	B3	1.076	28	0	0	0	0	0	667	0	0	0	0	0	695
Land	current area, production required	C	6.615	1.125	35	0	0	478	19	0	0	0	43	2.096	0	3.795
	non-current area, production req'd	D	218	0	0	0	0	0	0	0	0	0	0	0	0	0
Capital	Fixed capital formation	B2	5.505	146	0	0	0	6	0	258	0	0	0	0	5	415
	current animal, production required	C	0	0	0	0	0	0	0	176	148	0	0	0	0	324
	non-current animal, production req'd	D	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Labor	current revenue/income, prod req'd	C	481	1	0	0	0	0	0	0	0	0	0	0	0	1
	non-current revenue/income, prod req'd	D	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Total ACT / GCT		E	17.792	1.402	35	0	0	484	19	1.373	284	0	43	2.096	5	5.740
All Factors non-current A/An/R/I, prod not req		E														31.970

Source: OECD PSE tables and own calculations.

Table A4.   List of files

Type	Name of file	Description
Excel file	EU_pse.xlsx	OECD PSE data, allocated according to GTAP aggregation
Gempack command file	alterdo.cmf, alterdo1.cmf, …, alterdo8.cmf	Command file to start the ds_slug.tab
	ds.cmf	Command file to start the file ds_eu.tab
	ds_shk.cmf	Command file to start the file ds_shk.tab
	ds_regmap.cmf	Command file to start the file regions_mapping.tab
	init.cmf	Command file to start the numeraire shock
	tsfpllc.cmf	Command file to shock SFP to zero
Gempack solution file	altbase.sl4, altbase1.sl4, …, altbase8.sl4	Solution file after updating the GTAP data base with the calculated domestic support shocks
	tsfpllc.sl4	Solution file after removal of SFP
Header array file	basedata.har	Original GTAP base data
	ds_sets.har	Additional sets required for the implementation of domestic support
	ds_gtap.har	Data file containing the GTAP PSE data
	pse_eu_agg.har	Data file containing the OECD PSE data aggregated to the selected GTAP aggregation
	pse_eu27.har	Data file containing the OECD PSE data for the 27 EU member states
	ds_shk.har, ds_shk1.har, …, dsshk9.har	Shock file comprising shares to shock the GTAP data base
	altbase8T.har	View files for the tax rates after DS update
	altbase8V.har	View files for coefficients after DS update
	tsfpllcT.har	View files for the tax rates after SFP removal
	tsfpllcV.har	View files for coefficients after SFP removal
	sets.har	Original GTAP set file
Stored input file	ds_slug.sti	Stored input file to change the closure in altertax programm
	ds_gtap.sti	Stored input file to change the closurefor ds_gtap.tab
Tablo file	ds.tab	Program to calculate the PSE domestic support shares
	ds_slug.tab	Altertax program to shock the GTAP data base
	ds_gtap.tab	Standard GTAP tab file with extension for domestic support
	ds_gtpvew.tab	GTAP view tab.file with modifications for domestic support
	ds_shk.tab	Shock file to calculate the values used to shock the GTAP data base
	ds_regmap.tab	Program to aggregate the PSE data according to the selected GTAP aggregation
Updated Gempack data file	altbase.upd, altbase1.upd, .., altbase8.upd	Updated data base after running the altertax program
	tsfpllc.har	Updated data base after SFP removal
Windows batch file	update_ds.bat	Batch file to update domestic support in the standard GTAP data base
	p_sfp_0.bat	Batch file to update domestic support in the standard GTAP data base and shock SFP in the updated GTAP data base zo zero

Source: Own table.

Table A5.   List of additional sets for domestic support

Name of set (paper/tab.file)	Description	Header
AGRI / AGRI_COMM	All primary agricultural commodities	AGRI
ALLPAYT	All payment types (output, input, land, labor and capital)	PAYT
BASEGROUP	ACT and GCT product groups plus OTP	GB
DS_REG	Domestic support countries	DS_R
ENDW / ENDW_COMM	Endowment commodities	H6
ENERGI / ENERGI_COMM	Manufacturing goods	ENER
GCT1	All agricultural commodities belonging to group 1 (all crops)	GCT1
GCT12	All agricultural commodities belonging to group 12 (all crops)	GC12
GROUP	ACT and GCT product groups	GR
INPUT	Input	INP
INT / INT_COMM	Intermediate inputs	INT
MFAC / MFAC_COMM	Labor and capital endowments	MFAC
NAGRI / NAGRI_COMM	Non-agricultural commodities	
NNAT / NNAT_COMM	Non-natural resources (land, labor and capital)	NNAT
NNATDIS / NNTATDIS_COMM	Non-natural resources, labor disagg. into skilled and unskilled	NDIS
NOPT	Non-output payments	NOPT
OUTPUT	Output	OUT
PROD / PROD_COMM	Produced commodities	H5
REGS	Disaggregated domestic support countries	H1
TRAD / TRAD_COMM	Traded commodities	H2

Source: Own table.

Table A6.   List of variables and coefficients

Name	Description
$ACTP_{ir}$	All commodity transfer payments (OECD) by payment type i and region r
$ACTPOWER_{ir}$	ACT power of support by payment type i and region r
$ACTTRAN_{ijr}$	All commodity transfer payments by payment type i, commodity j and region r
$DECOUPSHR_{ir}$	Degree of decoupling for endowment i and region r
$del\_otp\_shr_r$	Change in share of OTP support in region r
$del\_potax\_sct_{jr}$	Change in the power of tax for commodity j in region r
$del\_shr\_endw_{jrg}$	Change in share of subsidies allocated to land, labor and capital for commodity j in region r for group g
$del\_shr\_int_{jrg}$	Change in share of subsidies allocated to input for commodity j in region r for group g
$del\_shrout\_sct_{jr}$	Change in the share of output subsidy for commodity j in region r
$del\_votax\_sct_{jr}$	Change in the total tax for commodity j in region r
$EVFA_{ijr}$	Producer expenditure on factor i by sector j in region r at agents prices
$GCT1PAY_{ijr}$	GTAP activity-specific GCT1 payments by payment type i, commodity j and region r
$GCT1P_{ir}$	GCT1 payments (OECD) by payment type i, commodity j and region r
$GCT1POWER_{ir}$	GCT1 power of support by payment type i and region r
HOM_PVS_{irg}	Share of domestic support allocated to payment type i in region r for group g
$MMREG_{jrg}$	Regional mapping matrix to allocate products to groups for commodity j in region r for group g
OTP_PVS_{ir}	OTP share of the production value for endowment i in region r
OTP_SHR_r	Share of domestic support allocated to SFP in GTAP by region r
$OTPH_{kr}$	Other transfer payments to producers by endowment k in region r
$OTRAN_{ir}$	Other transfer to producers by factor usage for endowment i in region r
pfd_{ijr}	Price index for domestic purchases of i by j in region r
pfe_{ijr}	Firms' price for commodity i in commodity j of region r
pfm_{ijr}	Price index for imports of i by j in region r
pfm_{ijr}	Price index for imports of i by commodity j in region r
pim_{ir}	Market price of composite import i used by commodity j in region r
$pmes_{ijr}$	Market price of sluggish endowment i used by commodity j in region r
$pmest_{ijr}$	Market price of sluggish endowment i incl. factor tax used by j in r
$pmesx_{ijrg}$	Market price of sluggish endowment incl. homogenous support i used by j in r of g
pm_{ir}	Market price of commodity i in region r
pmx_{ijrg}	Market price for domestic i in commodity j of region r including ACT and GCT subsidies

Name	Description
$PO\_TAX\_SCT_{ir}$	Initial power of tax (SCT) levels for commodity i in region r
PO_TAX_{ir}	Power of tax in GTAP for commodity i in region r
$POSCT_{jr}$	Power of tax shock in GTAP for commodity j in region r
$PRODN_{jr}$	Value of agricultural production (EUROSTAT)by commodity j and region r
$PRODV\_SHR_{jrg}$	Relation of production values to account for deviating production values in GCT2 and GCT11 for commodity j in region r for group g
qfd_{ijr}	Industry demands for domestic goods
qfe_{ijr}	Demand for endowment i for use in commodity j in region r
qfm_{ijr}	Industry demands for aggregate imports
qo_{jr}	Output of commodity j in region r
$SCPM_{ijr}$	Single commodity payment by payment type i, commodity j and region r
$SCTPAYPOS_{jr}$	SCT payment power related to the production value by commodity j and region r
SCT_PVS_{ijr}	Share of SCT by payment type i, commodity j and region r
$SHIFTFCT_i$	Predetermined coefficient to vary from the distribution according factor usage for endowment i
SHK_ENDW_{irg}	Shock to payments allocates to land, labor and capital in GTAP in region r for group g
SHK_INT_{rg}	Shock to payments allocated to inputs in GTAP in region r for group g
SHK_OUT_{ir}	Shock to payments allocates to output i in GTAP in region r
$SHOTP_r$	Shock to SFP in GTAP by region r
SHR_ENDW_{irg}	Share of domestic support allocated to land, labor and capital in GTAPin region r for group g
SHR_INT_{rg}	Share of domestic support allocated to input in GTAP in region r for group g
$SHR\_OUT\_SCT_{ir}$	Share of domestic support allocated to output i in GTAP in region r
tfd_{ijr}	Tax on domestic i used by commodity j in region r
$tfdmsct_{jr}$	Tax (SCT) for commodity j in region r
$tfdmsub_{rg}$	Tax (ACT,GCT) in region r for group g
$tfdsct_{ijr}$	Tax (SCT) on domestic i used by commodity j in region r
tf_{ijr}	Tax on primary factor i used by commodity j in region r
$tfdsub_{irg}$	Tax (ACT,GCT) on commodity i used by commodity j in region r
tfm_{ijr}	Tax on imported i purchased by commodity j in region r
$tfsct_{ijr}$	Tax (SCT) on primary factor i used by commodity j in region r
$tfsfp_r$	Tax(SFP)in region r
$tfsub_{irg}$	Tax (ACT, GCT) on primary factor i in region r for group g
tft_{ijr}	Tax on primary factor i used by commodity j in region r
$TOTPAYM_{ijrg}$	Total group specific payments of all categories by payment type i, commodity j, region r and group g
TVFMijr	Factor usage for endowment i in regin r
TVFMSHRir	Factor usage share for endowment i in region r

Name	Description
VDFA$_{ijr}$	Purchases of domestic i for use in j in region r at agent's prices
VDFM$_{ijr}$	Purchases of domestic i for use in j in region r at market prices
VDFMX$_{ijrg}$	Purchases of domestic i incl. Homogenous support for use in j in region r for group g
VFM$_{ijr}$	Producer expenditure on factor i by sector j in region r at market prices
VFMT$_{ijr}$	VFM$_{ijr}$ plus factor employment revenue (*FTRV$_{ijr}$*)
VFMX$_{ijr}$	VFMT$_{ijr}$ plus homogenous support
VIFA$_{ijr}$	Purchases of imports i for use in j in region r at agent's prices
VIFM$_{ijr}$	Purchases of imports i for use in j in region r at market prices
VIFMX$_{ijrg}$	Purchases of imports i incl. homogenous support for use in j in region r for group g
VOA$_{ir}$	Value of commodity i output in region r
VOM$_{jr}$	Value of output j at market prices in region r
VOTAX_SCT$_{ir}$	Initial value of domestic support for commodity i in region r

Source: Own table.

Figure A1.   Closure used for domestic support implementation (*Altertax*)

Exogenous

> pop
> psave
> profitslack incomeslack endwslack
> cgdslack govslack tradslack saveslack
> ao af afe ava
> to
>   *!to(endw_comm,reg)*
>   *!to("cgds",reg)*
> txs tms tx tm txi
> tm atf ats atd atall
> qo(ENDW_COMM,REG)

! tf

> tfsfp
> tfsct
> tfsub

! tfd

! tfm

> tfdmsct
> tfdsct(ENGERI_COMM,PROD_COMM,REG)
> tfdsct(INT_COMM,NAGRI_COMM,REG)
> tfdsct(INT_COMM,AGRI_COMM,ROW)
> tfmsct(ENGERI_COMM,PROD_COMM,REG)
> tfmsct(INT_COMM,NAGRI_COMM,REG)
> tfmsct(INT_COMM,PROD_COMM,ROW)
> fdmsub
> tfdsub(ENGERI_COMM, REG,GROUP)
> tfmsub(ENGERI_COMM, REG,GROUP)
> tfdsub(INT_COMM,ROW,GROUP)
> tfmsub(INT_COMM,ROW,GROUP)
> qst(NMRG_COMM,REG)
> potax_sct
> ;

Rest Endogenous;

Source: Authors' elaboration.

Figure A2.   Adjusted closure used in the extended GTAP model

Exogenous

        pop
        psaveslack pfactwld
        profitslack incomeslack endwslack
        cgdslack tradslack
        ams atm atf ats atd
        aosec aoreg avasec avareg
        afcom afsec afreg afecom afesec afereg
        aoall afall afeall
        au dppriv dpgov dpsave
        to
        tp tm tms tx txs
        qo(ENDW_COMM,REG)

    !   tf
        tft
        tfsfp
        tfsub
        tfsct
    !   tfd
        tfdsub
        tfdsct
    !   tfm
        tfmsub
        tfmsct
        ;

Rest Endogenous

Source: Authors' elaboration.

8.2 Explanations of the effects of distributing the SFP with a homogenous rate to land

In GTAP, landowner ship and the farmer using the land to produce output are distinguished from each other, even though in fact they can be the same person. The landowner rents his land to the farmer receiving the market price PM (basic price) which includes the SFP subsidy plus the producer price PFE the farmer is paying the landowner. The farmer is paying the producer price PFE that reflects domestic and world market prices of output so that marginal cost (MC) of production is equal to marginal review (MR) (world/domestic output prices). When 100% of the SFP is allocated as a homogenous subsidy rate to land in the GTAP database, then the landowner captures the entire subsidy. If the homogenous land subsidy rates where to be removed then the landowner would also take the full loss of revenue. The landowner in the standard GTAP model has no alternative use of the land than renting it out to the present farmers. Since the homogenous subsidy rate is removed across all land uses, there is no incentive for farmer to change their production patterns, and thus, they keep paying the same producer price PFE to the landowner. The farmer does not change his or her output level/pattern because domestic / world mark prices for his produce have not changed and he is still producing output, for which MC is equal to MR. The landowner takes the full adjustment/loss of changes in the SFP.

When the SFP is allocated as a homogenous subsidy rate across land, labor and capital then farmer's production levels/patterns will change when the SFP is reduced. The market price of capital PM for example is a result of the economies demand for capital, where agricultural demand only plays a minor role. The SFP subsidizes among other endowments also the agricultural capital and thereby increases the amount of capital investment in agricultural production because the subsidy reduces the farmer's price of capital below the economy-wide price PM. The increased agricultural demand for capital increases the market price (PM) of capital marginally in the economy. When the agricultural subsidy is removed, the price of capital PM declines marginally as capital move out of agriculture into other industries. At the same time the farmers capital producer price PFE increase to equal the market price PM. This increases the MC of production, which raise output price, reducing the amount produced by the farmer until MC in again equal to MR, whereas the amount of capital employed in agriculture is reduced. In this case, the farmer takes nearly the full adjustment/loss of changes in capital subsidies linked to the SFP. The same is given when the SFP subsidies are allocated to labor employed in the primary agricultural sector.

This effect can also be shown with the help of the following equations of the extended GTAP model and selected results presented in Table A7 and A8 to demonstrate that the change in the market price for land has no effect on output.

Equation spfactprice1
 # This equation links domestic and firm demand prices. It holds for Sluggish
 endowment goods and captures the effect of taxation of firms' usage of
 primary factors. (HT#17) #
(**all**,i,ENDWS_COMM)(**all**,j,PROD_COMM)(**all**,r,REG)
   pfe(i,j,r) = tfsct(i,j,r) + pmesx(i,j,r,"gct12");
Equation spfactprice2
 # This equation links domestic and firm demand prices. It holds for Sluggish

endowment goods and captures the effect of taxation of firms' usage of primary factors. (HT#17) #

(**all**,i,ENDWS_COMM)(**all**,j,PROD_COMM)(**all**,r,REG)(**all**,g,GROUP)
pmesx(i,j,r,g) = sum{g0,BASEGROUP:$pos(g0)=$pos(g) ,pmesx(i,j,r,g0)
        + tfsub(i,r,g)};

Equation spfactprice3a
 # This equation links domestic and firm demand prices. It holds for Sluggish endowment goods and captures the effect of taxation of firms' usage of primary factors. (HT#17) #

(**all**,i,ENDWS_COMM)(**all**,j,AGRI_COMM)(**all**,r,REG)
pmesx(i,j,r,"otp") = **tfsfp(i,r)**+pmest(i,j,r);

Equation spfactprice3b
 # This equation links domestic and firm demand prices. It holds for Sluggish endowment goods and captures the effect of taxation of firms' usage of primary factors. (HT#17) #

(**all**,i,ENDWS_COMM)(**all**,j,NONA_COMM)(**all**,r,REG)
pmesx(i,j,r,"otp") = pmest(i,j,r);

Equation spfactprice4
 # This equation links domestic and firm demand prices. It holds for Sluggish endowment goods and captures the effect of taxation of firms' usage of primary factors. (HT#17) #

(**all**,i,ENDWS_COMM)(**all**,j,PROD_COMM)(**all**,r,REG)
pmest(i,j,r) = tft(i,j,r) + pmes(i,j,r);

In order to prove the above statement we eliminate the SFP distributed with a homogenous rate across agricultural sectors to the factor land - tfsfp(i,r) in the GTAP model. The results show a decrease in the market price for land (pmes) and only negligible changes in the agent's price for land (pfe) (see Table A7). Beyond, the changes in the agent's price for the other factors are equal to the change for the factor land. This confirms the explanation given in the previous two paragraphs. According to equation ENDWDEMAND, the change in the demand for land (qfe) is determined by the agent's price and consequently yields only marginal changes. Since the subsidy is allocated homogenously across sectors, the relative change in the market price for land (pmes) is the same for all primary agricultural sectors. The changes in all other sectors can be disregarded because no land is distributed to those sectors (compare Table A7, column "VFM"). Referring to GTAP equation "ENDW_SUPPLY" below that distributes the sluggish endowments across sectors, it becomes apparent that this causes no changes in the factor demand for land and thus no changes in output due to the modeling of pm equal to pmes * REVSHR (see Table A7, A8).

Equation endwdemand
 # Demands for endowment commodities (HT 34) #
(**all**,i,ENDW_COMM)(**all**,j,PROD_COMM)(**all**,r,REG)
   qfe(i,j,r)
      = - afe(i,j,r) + qva(j,r)
      - ESUBVA(j) * [pfe(i,j,r) - afe(i,j,r) - pva(j,r)];

Equation mktclendws
 # Eq'n assures mkt clearing for imperfectly mobile endowments in each r (HT 5) #
(**all**,i,ENDWS_COMM)(**all**,j,PROD_COMM)(**all**,r,REG)
   qoes(i,j,r) = qfe(i,j,r);

Coefficient (**ge** 0)(**all**,i,ENDW_COMM)(**all**,j,PROD_COMM)(**all**,r,REG)
   VFM(i,j,r) *# Producer expenditure on i by j in r valued at mkt prices #*;
Update (**all**,i,ENDWM_COMM)(**all**,j,PROD_COMM)(**all**,r,REG)
   VFM(i,j,r) = pm(i,r) * qfe(i,j,r);
Update (**all**,i,ENDWS_COMM)(**all**,j,PROD_COMM)(**all**,r,REG)
   VFM(i,j,r) = pmes(i,j,r) * qfe(i,j,r);

Coefficient (**all**,i,ENDW_COMM)(**all**,j,PROD_COMM)(**all**,r,REG)
   REVSHR(i,j,r);
Formula (**all**,i,ENDW_COMM)(**all**,j,PROD_COMM)(**all**,r,REG)
   REVSHR(i,j,r) = VFM(i,j,r) / **sum**(k,PROD_COMM, VFM(i,k,r));

Taking the sum over commodities "j" REVSHR equals 1 (see Table A7).

Equation ENDW_PRICE
 # eq'n generates the composite price for sluggish endowments (HT 50) #
(**all**,i,ENDWS_COMM)(**all**,r,REG)
   pm(i,r) = **sum**(k,PROD_COMM, REVSHR(i,k,r) * pmes(i,k,r));

Equation ENDW_SUPPLY
 # eq'n distributes the sluggish endowments across sectors (HT 51) #
(**all**,i,ENDWS_COMM)(**all**,j,PROD_COMM)(**all**,r,REG)
   qoes(i,j,r) = qo(i,r) - endwslack(i,r) + ETRAE(i) * [pm(i,r) - pmes(i,j,r)];

Table A7.   **The prices for land in the GTAP database**

j	REVSHR	VFM("land",j, "deu")	Percentage change in:				pm("land", "deu") = REVSHR ("land",j,"deu") * pmes ("land",j,"deu")
			pfe("land",j, "deu")	tfsfp("land", "deu")	pmes("land",j, "deu")	pm("land", "deu")	
pdr	0,00	0,62	0,10		-56,17		-0,01
wht	0,08	476,12	0,10		-56,17		-4,63
gro	0,07	426,75	0,10		-56,17		-4,15
v_f	0,12	679,90	0,10		-56,17		-6,61
osd	0,04	239,52	0,10		-56,17		-2,33
c_b	0,02	91,38	0,10		-56,17		-0,89
pfb	0,00	13,50	0,10	128,37	-56,17	-56,17	-0,13
ocr	0,27	1.543,90	0,10		-56,17		-15,02
ctl	0,03	177,61	0,10		-56,17		-1,73
oap	0,10	565,71	0,10		-56,17		-5,50
rmk	0,27	1.558,42	0,10		-56,17		-15,16
wol	0,00	1,40	0,10		-56,17		-0,01
Sum	**1,00**	**5.774,84**					**-56,17**

Source: Own calculations.

Table A8.   **Equation ENDW_SUPPLY**

j	qfe("land",j, "deu")	qoes("land", j,"deu"	qo("land", "deu")	endwslack("land","de u")	ETRAE("lan d")	pm("land", "deu")	pmes("land",j, "deu")
pdr	-0,000005	-0,000005					-56,17
wht	-0,000004	-0,000004					-56,17
gro	-0,000003	-0,000003					-56,17
v_f	-0,000005	-0,000005					-56,17
osd	-0,000004	-0,000004					-56,17
c_b	-0,000004	-0,000004	0,00	0,00	-1,00	-56,17	-56,17
pfb	-0,000003	-0,000003					-56,17
ocr	-0,000004	-0,000004					-56,17
ctl	-0,000003	-0,000003					-56,17
oap	-0,000004	-0,000004					-56,17
rmk	-0,000004	-0,000004					-56,17
wol	-0,000007	-0,000007					-56,17

Source: Own calculations.