Universität Hohenheim
Institute of Agricultural Sciences in the Tropics (Hans-Ruthenberg-Institute)
International Agricultural Trade and Food Security
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# Domestic Support Payments and Trade Distortions: The Neglected Issue in Global General Equilibrium Modeling

## Cumulative Dissertation

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presented by

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# Summary

The domestic support payments provided to agricultural producers are frequently the subject of heated debate because they distort industry and trade structures causing efficiency losses and welfare redistribution. In recent years, high-income countries have initiated several reforms of their agricultural policies to decrease such distortions. These reforms are partly enforced by the requirements to reduce distorting domestic support, as agreed upon by the World Trade Organization (WTO). A prominent example of such a heavily criticized policy is the agricultural support of the Common Agricultural Policy (CAP) of the European Union (EU). In 2005, the EU introduced the Single Farm Payment (SFP), which is supposedly decoupled from production, to decrease the production stimulating effects of its CAP, and thus to reduce the distortions caused by the domestic support payments. However, these policy instruments are also controversial because the extent to which decoupled payments, such as the SFP, distort trade is still unclear. Domestic support provided to agricultural producers comprises a multitude of different and country-specific agricultural policy instruments, which makes it difficult to analyze the corresponding effects on domestic and third countries' industry structure, trade, and welfare. The most common approach for evaluating the impacts from alternative policy options is based on Computable General Equilibrium (CGE) models. Nevertheless, the attention to detail regarding the complex structure and country specific properties of domestic support, and in particular the SFP, in such models has been largely neglected.

Against this backdrop, this cumulative thesis analyzes the effects of domestic support payments on industry output, international trade and welfare, with a particular focus on the impact of varying assumptions of the SFP's degree of decoupling in CGE modeling. In addition, this thesis introduces a new index to measure the degree to which agricultural domestic support distorts international trade.

The first article develops an extended version of the standard Global Trade Analysis Project (GTAP) modeling framework. This extended framework enables a much more detailed representation of domestic support payments based on the OECD Producer Support Estimate (PSE) database and considering the requirements regarding production that trigger the eligibility for specific subsidies. Applying a complex updating procedure, using the EU CAP as an example, a set of 21 databases accounting for various assumptions about the SFP's degree of coupling to output levels is created. These databases are then used to investigate the extent to which various assumptions of the SFP’s degree of decoupling and the corresponding modeling cause differences in results when a 100% removal of the SFP is simulated. The analysis shows that the allocation of the SFP can have strong impacts on factor allocation and thus industry output, market prices, trade structure and welfare in EU member states. Furthermore, it reveals, that the current way in which the SFP is modeled in the standard GTAP model and database represents a partial decoupling and still stimulates production to a large extent.

The second article adapts the extended GTAP modeling framework developed in the first article to examine the extent to which the SFP, depending on its degree of decoupling and modeling, contributes to the effect of removing EU domestic support payments on international trade and welfare. The results show significant variations due to alterations in the assumptions underlying the SFP’s degree of decoupling. Therefore, this paper clearly highlights the relevance of considering the degree of decoupling in international trade analysis. Nevertheless, the application of such a framework enables neither the evaluation of the trade distorting effect of domestic support over time nor a cross-country comparison.

These aspects are picked up by the third article, which evaluates the trade-distorting effects of domestic support payments using the EU CAP as an example. The third article develops a theoretically sound index based on the Mercantilist Trade Restrictiveness Index (MTRI) that measures the overall trade effects of domestic support in a general equilibrium framework. The new index named “MTRI of domestic support payments” (MTRI-DS) enables the measurement of the trade restrictiveness of domestic support payments over time and across countries. The results obtained by employing the extended GTAP framework to determine the uniform tariff equivalent of EU domestic support payments clearly indicate a decrease in trade distortion caused by the implementation of decoupled support in the EU. The MTRI-DS provides an appealing measure for evaluating the effects of agricultural policy reforms by summarizing the changes in the composition of domestic support payments, and thus, it might be of particular use in the support of trade negotiations.

The centerpiece of this thesis, resulting from the three included articles, is a comprehensive modeling framework to analyze the effects of domestic support payments that is generally applicable. Important features are the very detailed representation of domestic support payments, the consideration of various assumptions about decoupled payments, and the integration of the MTRI-DS to evaluate and compare trade distortions. The empirical analyses, conducted using the EU CAP as an example, clearly show significant effects caused by alterations of the assumptions regarding the SFP's degree of decoupling. The results confirm the necessity of this type of detailed setting to depict the impact of multifaceted agricultural policies covering a variety of different policy instruments on the efficiency of domestic industries, and international trade and welfare.

The introduced approach will facilitate future research. While high-income countries, such as those in the EU, have continuously reduced the production incentives of their agricultural policies, domestic support, with its trade-distorting side effects is on the rise in many emerging countries, such as Brazil, India, China, and South Africa; these countries have just started to expand their domestic support programs and are far from exceeding their WTO commitments. Based on the wide-spread use of the PSE concept to measure domestic support, the approach presented in this thesis is very general and hence can easily be extended to other countries. Therefore, the outcome of this thesis might offer an interesting and effective tool for analyzing various research questions concerning countries' reforms or new implementations of agricultural policy instruments.

# Zusammenfassung

Subventionen im Agrarsektor werden aufgrund ihrer handelsverzerrenden Wirkung, von entstehenden Effizienzverlusten, sowie ihrer wohlfahrtsumverteilenden Wirkung stark kritisiert. Mit dem Ziel diese Verzerrungen zu reduzieren und somit die Bedingungen der Welthandelsorganisation (WTO) zu erfüllen, reformierten Industrieländer ihre Agrarpolitik in den vergangenen Jahren zum Teil mehrfach. Die gemeinsame Agrarpolitik (GAP) der Europäischen Union (EU) ist eine der oft kritisierten Subventionspolitiken. Im Jahr 2005 führte die EU mit der so genannten Betriebsprämie entkoppelte Direktzahlungen ein, die Landwirten unabhängig von der Produktion gewährt werden, und reduziert somit die handelsverzerrende Wirkung der eingesetzten Subventionen. Aber auch diese neuen Politikinstrumente sind umstritten, da das Ausmaß, in dem entkoppelte Direktzahlungen wie die Betriebsprämie dennoch die Produktion beeinflussen, nicht erwiesen ist. Die inländische Stützung umfasst eine Vielzahl verschiedener und insbesondere länderspezifischer Agrarpolitikinstrumente, die die Analyse ihrer Auswirkungen auf Industriestruktur, Handel, und Wohlfahrt sowohl auf der nationalen als auch auf der globalen Ebene erschweren.

Allgemeine Gleichgewichtsmodelle zählen zu den häufig zur Politikfolgenabschätzung verwendeten Analysemethoden. Diese Modelle schenken jedoch der komplexen Struktur und den länderspezifischen Eigenschaften dieser Politikinstrumente bislang wenig Beachtung.

Vor diesem Hintergrund beleuchtet die vorliegende kumulative Dissertation die Auswirkungen der Politikinstrumente der inländischen Stützung auf die landwirtschaftliche Produktion, den internationalen Agrarhandel sowie die Wohlfahrt. Der Einfluss unterschiedlicher Annahmen über den Grad der Entkopplung der Betriebsprämie und ihrer Modellierung in Allgemeinen Gleichgewichtsmodellen findet hierbei besondere Beachtung. Darüber hinaus stellt die vorliegende Arbeit einen Index vor, der den Grad, zu dem die inländische Stützung zur Handelsverzerrung beiträgt, misst.

Der erste Artikel entwickelt eine erweiterte Version des Global Trade Analysis Project (GTAP) Modells und der zugrunde liegenden Datenbasis. Dieser erweiterte Modellierungsrahmen ermöglicht eine im Vergleich zu bisher angewendeten Modellen viel detailliertere Repräsentation der Subventionszahlungen an Landwirte basierend auf der OECD

Producer Support Estimate (PSE) Datenbank. Zusätzlich berücksichtigt dieser Ansatz die unterschiedlichen Anforderungen, mit denen Direktzahlungen an die Produktion von landwirtschaftlichen Produkten gebunden bzw. von der Produktion entkoppelt sind, die die Grundlage der Förderfähigkeit bilden. Am Beispiel der EU GAP werden unter Anwendung eines komplexen Aktualisierungsverfahrens 21 Datenbasen generiert, die die verschiedenen Annahmen über den Entkopplungsgrad der Betriebsprämie von Produktionsentscheidungen widerspiegeln. Diese Datenbasen dienen als Ausgangspunkt, um die Effekte der Abschaffung der Betriebsprämie zu simulieren. Dieser Analyseaufbau untersucht, in welchem Ausmaß sich unterschiedliche Annahmen über den Entkopplungsgrad der Betriebsprämie und deren Modellierung auf die Simulationsergebnisse auswirken. Die Analyse bestätigt einen großen Einfluss der Verteilung der Betriebsprämie auf die Faktorallokation und damit auf Produktion, Marktpreise, Handelsstruktur und Wohlfahrt in den EU Mitgliedsstaaten. Des Weiteren zeigt die Analyse, dass die derzeitige Abbildung der Betriebsprämie im ursprünglichen GTAP Modell und der Datenbasis einer partiellen Entkopplung entspricht und somit deutliche Produktionsanreize schafft.

Der zweite Artikel verwendet diesen erweiterten GTAP Modellierungsrahmen und passt diesen an die folgende Fragestellung an. Wie stark beeinflussen verschiedene Annahmen über den Entkopplungsgrad der Betriebsprämie und deren Modellierung die Effekte der Abschaffung der EU Agrarsubventionen auf den internationalen Handel und die Wohlfahrt? Die Ergebnisse zeigen erhebliche Unterschiede auf, die auf die Modifizierung des Entkopplungsgrades zurückzuführen sind. Die Relevanz der Berücksichtigung des Entkopplungsgrades in der Politikfolgenabschätzung wird durch diese Ergebnisse deutlich hervorgehoben.

Dessen ungeachtet ermöglicht die Anwendung eines auf diese Weise erweiterten Modellierungsrahmens weder eine Evaluierung der Entwicklung der durch die inländische Stützung verursachten Handelsverzerrung im Zeitablauf noch einen Ländervergleich.

Diese Aspekte greift der dritte Artikel auf. In diesem Artikel wird, ebenfalls am Beispiel der EU GAP, die handelsverzerrende Wirkung der Agrarsubventionen untersucht. Hierfür wird ein theoretisch fundierter Index, der auf dem Merkantilistischen Trade Restrictiveness Index (MTRI) basiert, weiterentwickelt, um den Gesamteffekt der inländischen Stützung auf den Handel in einem Allgemeinen Gleichgewichtsmodell zu messen. Dieser Index, genannt MTRI der inländischen Stützung (MTRI-DS), ermöglicht die Bewertung der Handelshemmnisse aufgrund von Subventionszahlungen im Zeitablauf und im Vergleich zu anderen Ländern. Das um den MTRI-DS erweiterte GTAP Modell wird verwendet, um das Zolläquivalent der inländischen Stützung zu bestimmen. Dieses Zolläquivalent bestätigt, dass die Einführung der entkoppelten Direktzahlungen in der EU die handelsverzerrende Wirkung der inländischen Stützung reduziert. Der MTRI-DS erweist sich somit als eine geeignete Maßzahl zur Politikfolgenabschätzung, da dieser Index Änderungen in der Zusammensetzung von Politikinstrumenten abbildet. Auf diese Weise empfiehlt sich der MTRI-DS als ein nützliches Instrument zur Unterstützung von Verhandlungen über den internationalen Handel.

Die Modellerweiterungen der drei eingebundenen Artikel bilden das Herzstück dieser Arbeit. Dieser umfassende Modellierungsrahmen zur Analyse der inländischen Stützung ist generell anwendbar und somit auf andere Länder übertragbar. Wichtige Bestandteile sind die detaillierte Abbildung der inländischen Stützung, die Berücksichtigung verschiedener Annahmen über den Entkopplungsgrad von Subventionszahlungen und deren Modellierung, sowie die Entwicklung und Einbindung des MTRI-DS zur Messung und Evaluierung der Handelsverzerrung. Die empirische Analyse wird exemplarisch für die EU GAP durchgeführt. Die Ergebnisse zeigen, bedingt durch Änderungen der Annahmen über den Entkopplungsgrad, signifikante Effekte. Demzufolge bestätigen die Ergebnisse die Notwendigkeit einer so detaillierten Methode, um die Auswirkungen vielfältiger Agrarpolitiken, bestehend aus einer Vielzahl unterschiedlicher Politikinstrumente, wie beispielsweise die EU GAP, auf Produktionssektoren, den internationalen Agrarhandel und die Wohlfahrt, abbilden zu können.

Der vorgestellte Ansatz bietet darüber hinaus Anknüpfungspunkte für weitere Forschung. Während einkommensstarke Länder, wie die Mitgliedsstaaten der EU, fortlaufend die Produktionsanreize ihrer Subventionsinstrumente reduzieren, steigt der Einsatz von Agrarsubventionen in vielen Schwellenländern, wie beispielsweise Brasilien, Indien, China und Südafrika. Diese Länder haben gerade erst damit begonnen, den Einsatz von Agrarsubventionen auszuweiten, und haben ihre Möglichkeiten im Rahmen der WTO Vereinbarungen noch nicht ausgeschöpft. Da das in dieser Arbeit verwendete PSE Konzept weitverbreitet zur Analyse der inländischen Stützung eingesetzt wird, lässt sich der in dieser Arbeit vorgestellte generelle Ansatz problemlos auf andere Länder übertragen und anwenden.

Das Ergebnis dieser Dissertation bietet daher eine interessante und nützliche Methode zur Analyse verschiedener Fragestellungen mit Bezug auf länderspezifische Reformen von Agrarpolitiken oder Neuimplementierungen von Politikinstrumenten.

# 1 Introduction

## 1.1 Motivation and objective

Domestic support provided to agricultural producers stimulates agricultural production, distorts countries' industry and trade structure, causes the redistribution of welfare and thus creates efficiency losses. These efficiency losses arise, e.g., from subsidy-induced factor reallocation and changes in the production structure favoring products that otherwise would not have been competitive or from preventing non-competitive farmers from exiting the business. Increased agricultural output lowers domestic market prices, increases exports and depresses world market prices. In addition, the introduction of export subsidies, import tariffs and non-tariff barriers to raise domestic prices, add to this distortion. However, domestic support affects third countries differently. Net exporters of agricultural and food products suffer from lower world market prices, whereas net importers gain.

This discussion about the trade-distorting effects caused by domestic support provided to agricultural producers gained momentum with the start of the Uruguay Round negotiations of the World Trade Organization (WTO). Since the Uruguay Round, domestic support reduction criteria have been negotiated among WTO member states in the same line as market access and export subsidies to move towards multilateral trade liberalization. Industrialized economies such as the European Union (EU) initiated several reforms of their agricultural policies to meet domestic support reduction commitments enforced by the WTO. The total amount of agricultural support utilized in high-income countries has not significantly decreased. However, an evaluation of the changes in countries' domestic support instruments reveals that the composition of domestic support in high-income countries has changed from highly distortive policy instruments, such as market price support, towards policy instruments that create fewer incentives to produce. Therefore, the trade-distortive effect of domestic support in high-income countries has presumably decreased. Nevertheless, the effect of policy instruments that are supposedly decoupled from farm-level output decisions and thus should not create production incentives is still controversial and debated. The extent to which decoupled payments stimulate production caused by other coupling channels such as imperfect credit markets, risk behavior, and farmers' decisions about farm exit or off-farm labor remains unclear.

By contrast, emerging economies, such as Brazil, India, China, and South Africa, that exhibit a considerably higher agricultural export share than industrialized economies have just started to expand their domestic support programs and are still far from exceeding their WTO commitments. Furthermore, these countries benefit from the so-called “special treatment” of developing countries, which provides them with a certain scope on the level and type of agricultural support subject to WTO criteria. Currently, these countries predominantly use highly distortive policy instruments, such as market price support. This development emphasizes that domestic support provided to agricultural producers will continue to be a topic in negotiations.

But how significant are the effects caused by domestic support payments on factor allocation, industry and trade structure, and welfare on the national and global level? How trade-distortive, and thus important for multilateral trade liberalization are domestic support payments? How successful are the policy reforms introduced to reduce such distortions and to what extent do they decrease trade distortions on the national and global level?

Trade policy instruments, and in particular their distortive properties, are a common topic in the Computable General Equilibrium (CGE) modeling community, and thus the methodology is rather mature in this area. The literature provides thorough analyses of the effects of multilateral trade liberalization policies, including the impacts of market access, export subsidies and domestic support. Market access policy analysis and related methods to calculate the required detailed tariff cuts are well established.

Domestic support is based on a multitude of different and country-specific agricultural policy instruments, which complicates the assessment of the corresponding trade and welfare impacts. Agricultural producers receive domestic support either as market price support; as budgetary transfers given on the basis of output, input and production factor usage; or as decoupled support in the form of direct income transfers to farm households conditional on land entitlements. In addition, these subsidies are granted to agricultural producers subject to specific production requirements, which regulate the eligibility for support. In contrast to market access analyses, the attention to detail regarding the complex structure and country-specific properties of domestic support, and in particular decoupled payments, has received little attention and has been largely neglected in CGE models.

These neglected details are the focus of this thesis. According to these deficiencies, the methodological objectives are first, the development of a general CGE modeling framework that is extended to cover a detailed representation of domestic support payments. Second, the introduction of an updating procedure that alters the underlying database and enables the analysis of the effects of different assumptions regarding the production incentives induced particularly by decoupled payments. Third, the derivation of a theoretically sound index and its integration into a CGE model that facilitates the measurement of trade distortions across policy instruments, across regions, and over time.

The standard Global Trade Analysis Project (GTAP) model and database, which are widely applied in international trade analysis, are used as the point of departure. This thesis further develops the standard GTAP model into a framework that can be applied not only to analyze the effects of detailed domestic support payments on countries' industry and trade structure and welfare but also to evaluate the level of trade distortion caused by such payments.

By applying this extended GTAP modeling framework, the empirical objective of this thesis is to analyze the effects and distortions caused by domestic support payments on the national and global levels. Particular emphasis lies on the effect of different assumptions regarding a subsidy payment's degree of decoupling and its modeling. The thesis aims to provide an elaborate analysis of domestic support and, in particular, decoupled support that can be used to validate the results obtained in international trade analysis in the absence of true estimators of the degree of decoupling. Therefore, this thesis examines the following empirical research questions:

1. To what extent are factor allocation, industry output, trade, and welfare affected by various assumptions about a payment's degree of decoupling and its modeling on a national level?
2. What are the effects of removing countries' domestic support payments on third countries, particularly developing countries? Do different assumptions about a subsidy payment's degree of decoupling and its modeling affect other countries trade structure and welfare?
3. How trade-restrictive is agricultural domestic support for international trade? Has the introduction of decoupled support decreased the magnitude of this effect?

## 1.2 Organization of the thesis: Structure and classification

This cumulative thesis includes three chapters that contribute to the objectives emphasized in the previous section. Table 1 provides an overview regarding the title of the chapters, contributing authors, and journals that the chapters are published in or submitted to.

In regard to the thesis' objectives, the chapters can be classified according to their methodological and empirical objectives. Figure 1, provides further information regarding chapter objectives and foci, assumptions, data sets utilized and simulation experiments and thus helps to distinguish each chapter's contribution. In addition, this graphical overview of the thesis illustrates how the chapters are connected with each other.

**Table 1: Overview of contributed articles**

| Chapter | Authors | Title | Journal |
|---|---|---|---|
| 2 | K. Urban, H. G. Jensen, M. Brockmeier | Extending the GTAP database and model to cover domestic support issues using the EU as example | GTAP Technical Paper Series No. 35 |
| 3 | K. Urban, H. G. Jensen, M. Brockmeier | How decoupled is the Single Farm Payment and does it matter for international trade? | Food Policy, Vol. 59, p. 126-138 |
| 4 | K. Urban, M. Brockmeier, H. G. Jensen | Measuring the Trade Restrictiveness of domestic support using the EU Common Agricultural Policy as an example | American Journal of Agricultural Economics (submitted November 2014) |

*Source: Author's elaboration*

Chapter 2 introduces a comprehensive extension of the standard GTAP framework and therefore has been published in the GTAP Technical Paper Series. This chapter provides an overview covering the theoretical principles of decoupling and discusses the importance of other coupling channels on the degree of decoupling. Next, the chapter compares how other CGE and partial equilibrium (PE) models consider decoupled payments emphasizing significant differences in the assumptions regarding the degree of decoupling and the modeling of decoupled payments. This comparison highlights the importance of analyzing the effects on policy simulation results caused by those differences, which to the authors' knowledge is not yet available.

This chapter can be subdivided into methodological and empirical contributions. The methodological contribution presents the extended version of the standard GTAP model and database, which captures a much more detailed representation of domestic support payments considering not only different types of policies but also eligibility criteria such as different production output level requirements. In addition, it describes the general, complex updating procedure that enables the systematically modification of assumptions regarding the degree of decoupling for domestic support payments underlying the GTAP database and model. This extended GTAP modeling framework and the updating mechanism serve as a starting point for the analyses conducted in chapters 3 and 4.

Using the EU Common Agricultural Policy (CAP) as an example, the empirical contribution of chapter 2 is to investigate the extent to which different assumptions regarding the SFP's degree of decoupling and its modeling cause differences in policy simulation results. The EU serves as an exceptional example because it is well-known for its multifaceted and complex agricultural policy, and this policy has been subjected to a considerable number of reforms. In 1992, the EU initiated the first conspicuous reform to herald the start of decoupling agricultural support from production output levels. Several major reforms followed in the subsequent years. With the implementation of the Single Farm Payment (SFP) in 2005, the EU introduced a policy instrument that is supposedly fully decoupled from farm-level output decisions.

Because the particular emphasis in this chapter lies on the discussion regarding the decoupling of direct payments from production requirements and its relevance to the underlying assumptions and modeling in CGE analyses, the EU is a prime example to test the sensitivity of models regarding such assumptions about different subsidy types. In addition, the EU's extensive reform history facilitates a thorough examination of whether the improved modeling of domestic support has the ability to depict such changes; this examination is investigated in chapter 4.

Applying the complex updating procedure, a set of 21 databases considering various assumptions about the SFP's degree of coupling to output levels is created. This set of databases is then used to analyze the effects of a complete removal of the SFP on factor allocation and thus on industry output, market prices, trade structure and welfare in the EU at member state level, accounting for primary agricultural commodities at the most disaggregated level.

The effects on industry and trade structure, and welfare, from domestic support payments on a global level are well established, as mentioned in the motivation. However, to the author's knowledge it has not yet been assessed how much different payment types and eligibility criteria contribute to these effects. The second chapter addresses this open question by analyzing and evaluating the extent to which differences in assumptions about the degree of decoupling of a support instrument and the corresponding modeling affect any changes in countries' industry and trade structure and welfare redistribution. Applying the extended GTAP modeling framework introduced in chapter 2 and again using the EU CAP as an example, chapter 3 adds to the picture of the effects of EU domestic support.

Nonetheless, even the most detailed modeling of domestic support payments to evaluate effects on industry and trade structure and welfare redistribution cannot assess how trade-distorting these subsidies are. For this purpose, chapter 4 aims to complete the modeling framework and empirical analysis of the two previous chapters by measuring the trade restrictiveness of domestic support. This chapter provides a literature review of several articles developing theory-based aggregation procedures to overcome aggregation problems arising from the different types and variations of policies across sectors and regions. The two most influential approaches are the Trade Restrictiveness Index (TRI) and the Mercantilist Trade Restrictiveness Index (MTRI). In addition, the review finds a substantial number of empirical applications of the TRI and MTRI for tariff analysis applying PE and CGE models, whereas literature on the development of an index that measures the restrictiveness, and hence the distortion, of domestic support and its applications remains scarce. Chapter 4 tackles this issue by introducing the concept of the "MTRI of domestic support payments" and its integration into the extended GTAP modeling framework developed in chapter 2. This index measures the overall effects of different policy instruments in a single number and thus enables the evaluation of trade policies across policy instruments, sectors, regions, and in particular, over time. The application of the updating procedure introduced in chapter 2 is applied to create of a set of databases accounting for EU domestic support data for the years 2004 and 2007 as well as for different degrees of decoupling. In contrast to chapters 2 and 3, this chapter analyzes not only the effects of removing domestic support payments but also the elimination of tariffs and export subsidies.

The final chapter concludes with a discussion and synthesis of the three main chapters, and highlights scope for future research.

| | Chapter 2 | Chapter 3 | Chapter 4 |
|---|---|---|---|
| **Objective** | Effect of different assumptions regarding the SFP's degree of decoupling and the corresponding modeling | | Trade restrictiveness of domestic support payments |
| **Literature** | Decoupling | Domestic support | Measuring of trade distortions, trade-restricitivenss |
| **Method** | Development | Adjustment and Application | |
| | Extended GTAP modeling framework to capture a detailed representation of domestic support payments and complex update procedure to alter the assumptions | | |
| | | | Developement |
| | | | Reconciliation of PSE and WTO data |
| | | | Integration of the MTRI of domestic distortions in the extended GTAP modeling framework |
| **Experiment design (utilized data and simulation)** | GTAP database V. 8.1 2007 | GTAP database V. 8.2 2007 | GTAP database V. 8.1 2007 |
| | 26 regions: EU 27 at member state level, rest of the world | 14 regions: EU 27 agg., IC, DC, LDC, rest of the world | 2 regions: EU 25 agg., rest of the world |
| | 22 agricultural and food commodities, manufacturing and services | | |
| | PSE data 2007 | | PSE data 2004 and 2007 WTO notification tables of the EU, marketing years 2004/2005 and 2007/2008 |
| | Set of 21 databases accounting for different assumptions of the SFP's degree of decoupling and its modeling | | Set of 4 databases: PSE 2007:partially decoupling with 80% and 90% reallocation of labor and capital to land, fully decoupling; PSE 2004: fully decoupling |
| | Elimination of the Single Farm Payment | Elimination of domestic support payments | Elimination of domestic support payments, tariffs or export subsidies; endogenizing MTRI and holding net-imports constant |

**Figure 1. Classification of included chapters**

*Source: Author's elaboration.*

# 2 Extending the GTAP database and model to cover domestic support issues using the EU as example

Kirsten Urban, Hans G. Jensen and Martina Brockmeier

Published in: GTAP Technical Paper Series, No. 35, 2014

The technical paper and additional information including the modeling code is available at: https://www.gtap.agecon.purdue.edu/resources/res_display.asp?RecordID=4569

# Extending the GTAP Database and Model to Cover Domestic Support Issues using the EU as example

By

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GTAP Technical Paper No. 35

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# Extending the GTAP Database and Model to Cover Domestic Support Issues using the EU as example[1]

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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 decrease 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.

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## List of Abbreviations

| | |
|---|---|
| ACT | All Commodity Transfer |
| AMS | Aggregate Measurement of Support |
| AoA | Agreement on Agriculture |
| CAP | Common Agricultural Policy |
| CGE | Computable General Equilibrium |
| 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 |
| PE | Partial Equilibrium |
| 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 the 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 is 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 homogeneous 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 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"(OECD, 2010, p. 17).

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. 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

[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 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 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, 2009). 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

[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, US counter-cyclical payments (CCP) create risk-related production incentives. Based on this approach Antón and Le Mouël (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 US 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 (2009) 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, that even without taking capitalization into account, an underestimation of coupling effects expected due to the impact of the programs on farmer's 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 investments 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 determine the rate of investment. Lobley et al. (2010) emphasize that market signals may become a more powerful driver of farmers' behavior than EU 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 result 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 in the factor price (rent) of land (Latruffe and Le Mouël, 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 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 Scenar 2020, as described in Nowicki et al. (2009), employed the CGE model LEITAP[5] together with partial equilibrium models such 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 have 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

[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 is made in the field of Partial Equilibrium (PE) analyses. PE models are often applied at more disaggregated levels and therefore are better aligned through a much 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 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 simulation 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

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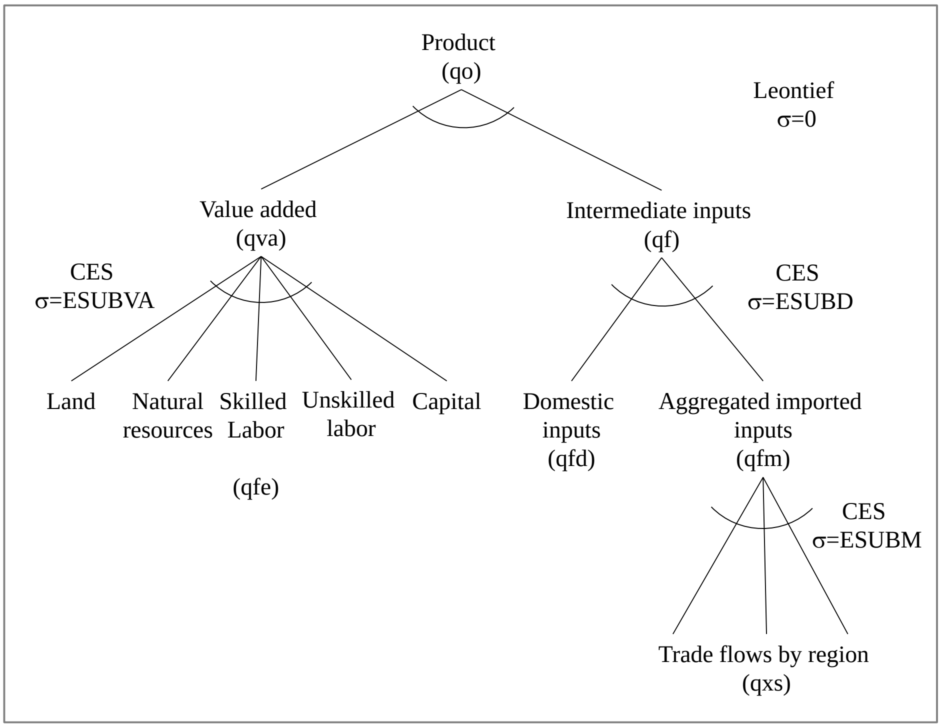
[7] Please refer to https://www.gtap.agecon.purdue.edu/products/gtap_book.asp

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 homogeneous rate across primary agricultural commodities (all land using sectors) only to the factor land, capitalizes in land rent, and hence leads to an increase in the market price for land while the agent's price is not affected.[9] Consequently, a subsidy allocated with a homogeneous 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 GTPA model. GTAP-AGR would be 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 therefore adjust the model to differentiate between income earned from farm or non-farm

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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).

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. 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 agent's and market prices for output, intermediate inputs, land, capital and labor. Each of

[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).

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 homogeneous 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.

***Excurse SFP:***

*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. It was phased out in 2013.*

[*] 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)

[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 homogeneous 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 homogeneous 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]

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

| | |
|---|---|
| $pfe_{ijr}$ | *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 homogeneous (OTP, ACT, GCT) and non-homogeneous (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

[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.

plus the policy instrument for the SCT payments. Since the SCT is product specific, the policy instrument is directly related to commodities.

(3.2)

$$pfe_{ijr} = tfsct_{ijr} + pmesx_{ijrg} \qquad \begin{array}{r} \forall i \in ENDW \\ \forall j \in PROD \\ \forall r \in REG \\ g = GCT12 \end{array}$$

| | |
|---|---|
| $pmesx_{ijrg}$ | *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 homogeneously 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)

$$\begin{aligned} pmesx_{ijrg} = {} & MMREG_{jrg} * PRODV\_SHR_{jrg} * tfsub_{irg} \\ & + pmesx_{ijrb} \end{aligned} \qquad \begin{array}{r} \forall i \in ENDW \\ \forall j \in PROD \\ \forall r \in REG \\ \forall g \in GROUP \\ \forall b \in BASEGROUP \end{array}$$

| | |
|---|---|
| $tfsub_{irg}$ | *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 homogeneous 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 homogeneous rate across primary agricultural commodities.

(3.4a)

$$pmesx_{ijrb} = tfsfp_{r} + pmest_{ijr} \qquad \begin{array}{r} \forall i \in ENDW \\ \forall j \in AGRI \\ \forall r \in REG \\ b = OTP \end{array}$$

| | |
|---|---|
| $tfsfp_{r}$ | *Tax (OTP/SFP) in region r* |

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

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

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

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

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

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

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.

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

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

| | |
|---|---|
| $pmest_{ijr}$ | *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 homogeneous and non-homogeneous support, while $pmesx_{ijrg}$ is the market price of sluggish endowment *i* used by industry *j* in region *r* that includes the homogeneous 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)).

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

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

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

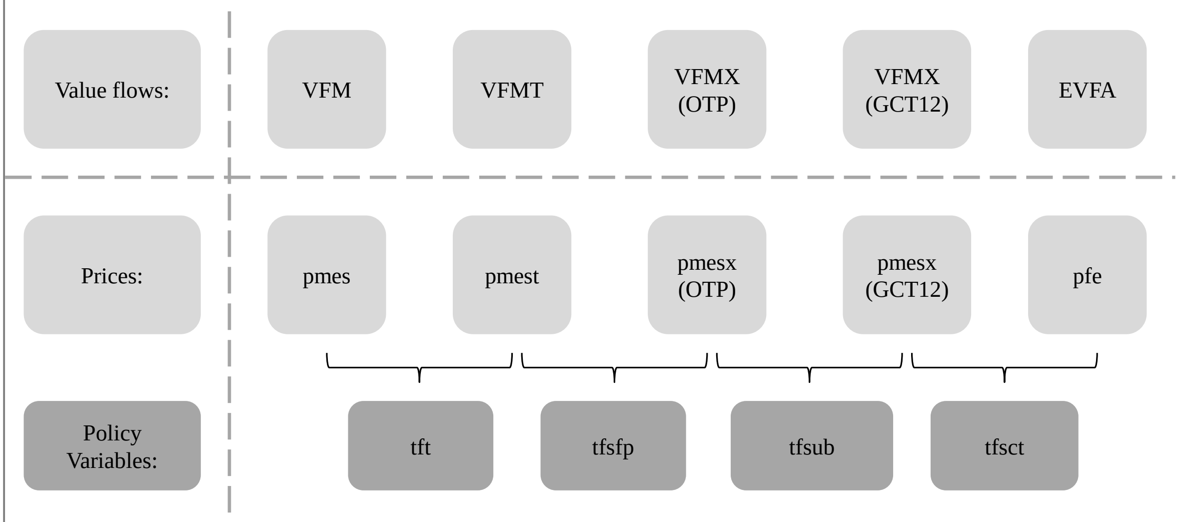
$\forall i \in ENDW$
$\forall j \in PROD$
$\forall r \in REG$
$\forall b \in BASEGROUP$

| | |
|---|---|
| $qfe_{ijr}$ | *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**




| | |
|---|---|
| $EVFA_{ijr}$ | *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)
$$pfd_{ijr} = tfd_{ijr} + pm_{jr} \qquad \forall i \in TRAD \quad \forall j \in PROD \quad \forall r \in REG$$

| | |
|---|---|
| $pfd_{ijr}$ | *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* |

$$pfm_{ijr} = tfm_{ijr} + pim_{ir} \qquad (3.10)$$

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

| | |
|---|---|
| $pfm_{ijr}$ | *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.

$$pfd_{ijr} = tfdsct_{ijr} + pmx_{ijrg} \qquad (3.11)$$

$$\forall i \in TRAD$$
$$\forall j \in PROD$$
$$\forall r \in REG$$
$$g = GCT12$$

$$pmx_{ijrg} = PRODV\_SHR_{jrg} * MMREG_{jrg} * tfdsub_{irg} + pmx_{ijrb} \qquad (3.12)$$

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

| | |
|---|---|
| $pmx_{ijrg}$ | *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* |
| $tfdsct_{ijr}$ | *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 homogeneous 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).

$$\text{(3.13)} \quad tfdsct_{ijr} = tfmsct_{ijr} = tfdmsct_{jr} \qquad \forall i \in INT \quad \forall j \in PROD \quad \forall r \in REG$$

$$\text{(3.14)} \quad tfdsub_{irg} = tfmsub_{irg} = tfdmsub_{rg} \qquad \forall i \in INT \quad \forall r \in REG \quad \forall g \in GROUP$$

| | |
|---|---|
| $tfdmsct_{jr}$ | *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).

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

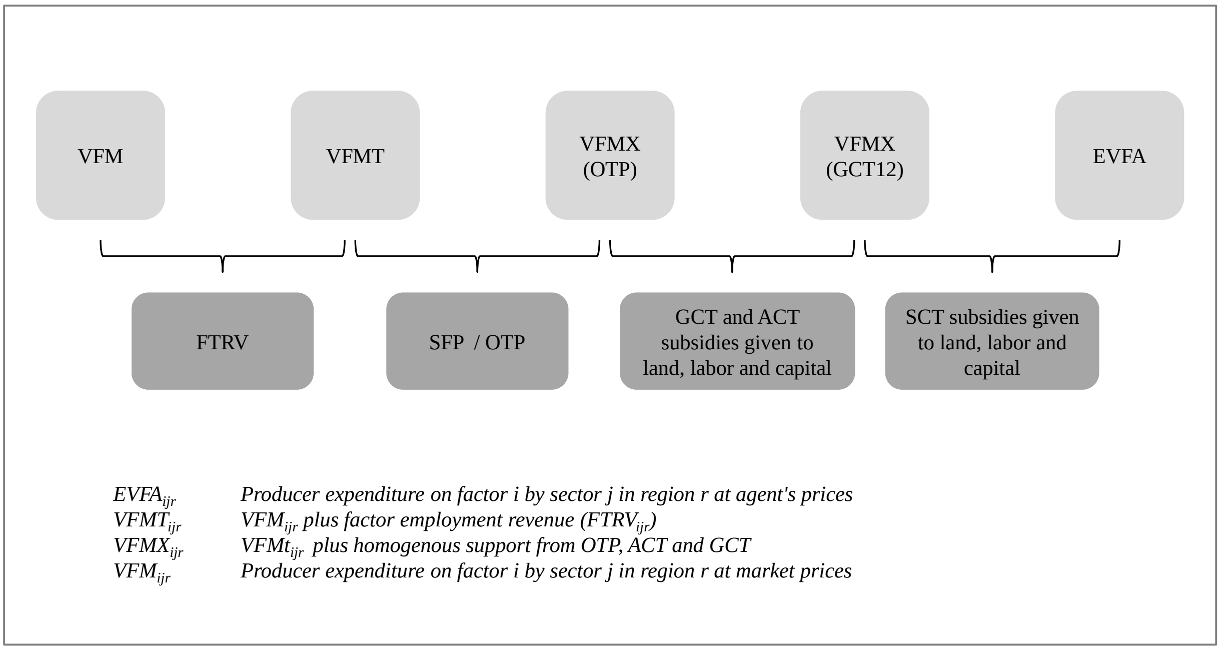
| | |
|---|---|
| $ps_{jr}$ | *Agents price of commodity j in region r* |
| $pm_{jr}$ | *Market price of commodity j in region r* |
| $to_{jr}$ | *Output tax for commodity j in region r* |

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. Homogeneous and non-homogeneous support in GTAP allocated to land, capital, and labor**




*Source: Authors' elaboration.*

For the implementation of e.g., the homogeneous 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)
$$SH\_OTP_r = \frac{\sum_{j \in AGRI} \sum_{i \in NNATDIS} VFMT_{ijr} - VFMX_{ijrb}}{\sum_{j \in AGRI} VOM_{jr}} \qquad \forall r \in REG \quad \forall b \in OTP$$

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

| | |
|---|---|
| $OTP\_SHR_r$ | *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.

$$\text{(3.17)} \qquad SHR\_GCT1_{ir} = \frac{\sum_{j \in AGRI} VFMX_{ijrb} - VFMX_{ijrg}}{\sum_{j \in AGRI} VOM_{jr}} \qquad \begin{array}{r} \forall i \in NNATDIS \\ \forall b \in ACT \\ \forall r \in REG \\ \forall g \in GCT1 \end{array}$$

| | |
|---|---|
| *SHR_GCT1ir* | *Share of GCT1 domestic support allocated to land, labor, and capital subsidies in GTAP in region r* |

$$\text{(3.18)} \qquad \begin{aligned} & 100 * \Big[ \sum_{j \in GCT1} VOM_{jr} * del\_shrendw_{jrg} \\ & + SHR\_GCT1_{ir} * \sum_{j \in GCT1} VOM_{jr} * \left( pm_{jr} + qo_{jr} \right) \Big] \\ & = \sum_{j \in GCT1} VFMX_{ijrg-1} * \left[ pmesx_{ijrg-1} + qfe_{ijr} \right] \\ & - VFMX_{ijrg} * \left[ pmesx_{ijrg} + qfe_{ijr} \right] \end{aligned} \qquad \begin{array}{r} \forall r \in REG \\ \forall i \in NNATDIS \end{array}$$

The share of domestic support allocated to ACT and the 12 GCT on input subsidies (*SHR_INTACTr, SHR_INTGCT1r, ..., SHR_INTGCT12r)* 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.

$$\text{(3.19)} \qquad \begin{aligned} SHR\_INTGCT1_r = \Big[ & \sum_{j \in AGRI} \sum_{k \in INT} VDFMX_{kjrb} - VDFMX_{kjrg} \\ & + \sum_{j \in AGRI} \sum_{k \in INT} VIFMX_{kjrb} - VIFMX_{kjrg} \Big] / \sum_{j \in AGRI} VOM_{jr} \end{aligned} \qquad \begin{array}{r} \forall r \in REG \\ \forall b \in ACT \\ \forall g \in GCT1 \end{array}$$

| | |
|---|---|
| *SHR_INTGCT1r* | *Share of GCT1 domestic support allocated to input subsidies in GTAP in region r* |

$$\text{(3.20)} \qquad \begin{aligned} & 100 * \Big[ \sum_{j \in GCT1} VOM_{jr} * del\_shr\text{int}_{jrg} \\ & + SHR\_INTGCT1_{ir} * \sum_{j \in GCT1} VOM_{jr} * \left( pm_{jr} + qo_{jr} \right) \Big] \\ & = \sum_{k \in INT} \sum_{j \in GCT1} VDFMX_{kjrg-1} * \left( pmx_{kjrg-1} + qfd_{kjr} \right) - VDFMX_{kjrg} * \left( pmx_{kjrg} + qfd_{kjr} \right) \\ & + \sum_{k \in INT} \sum_{j \in GCT1} VIFMX_{kjrg-1} * \left( pimx_{kjrg-1} + qfm_{kjr} \right) - VIFMX_{kjrg} * \left( pimx_{kjrg} + qfm_{kjr} \right) \end{aligned} \qquad \forall r \in REG$$

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.

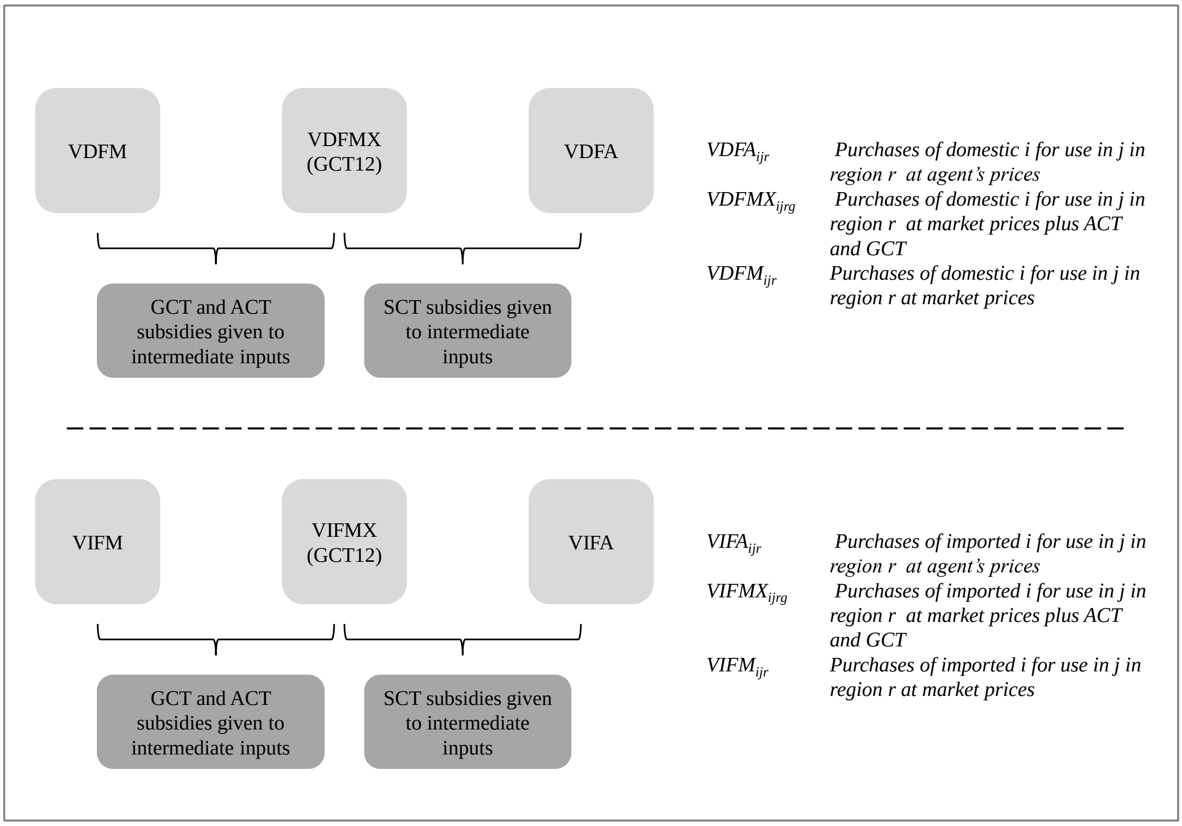
[16] For the categories OTP, ACT, and GCT, we calculated the shares in relative to the value of output. Here, the category SCT comprises subsidies that needs to be allocated to output. Thus, the method used beforehand would create a bias, so that we slightly adjusted it.

(3.21)

$$VOTAX\_SCT_{ir} = VOA_{ir} - VOM_{ir} + \left(\sum_{j \in ENDW\_COMM} VFA_{ijr} - VFMX_{ijrg}\right) + \left(\sum_{j \in INT\_COMM} VDFMX_{ijrg} - VDFA_{ijr}\right) + \left(\sum_{j \in INT\_COMM} VIFMX_{ijrg} - VIFA_{ijr}\right) \quad \forall i \in TRAD \; \forall r \in REG \; \forall g \in GCT12$$

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

**Figure 4. Homogeneous and non-homogeneous support in GTAP allocated to intermediate goods**




*Source: Authors' elaboration.*

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

(3.22)

$$PO\_TAX\_SCT_{ir} = 1 + \left[ \left(VOA_{ir} - VOM_{ir}\right) + \left(\sum_{j \in ENDW\_COMM} VFMX_{ijrg} - VFA_{ijr}\right) + \left(\sum_{j \in INT\_COMM} VDFMX_{ijrg} - VDFA_{ijr}\right) + \left(\sum_{j \in INT\_COMM} VIFMX_{ijrg} - VIFA_{ijr}\right) \right] / VOM_{ir} \quad \forall i \in TRAD \; \forall r \in REG \; \forall g \in GCT12$$

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

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

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

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).

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

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).

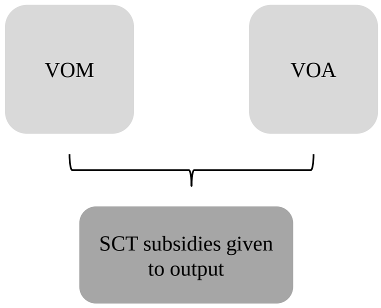
$$
\begin{aligned}
SHR\_OUT_{ir}=\ &\left[VOA_{ir}-VOM_{ir}\right]\\
&/\ \left[VOA_{ir}-VOM_{ir}\right.\\
&+\ \sum_{j}VFMX(GCT12)_{jir}-VFA_{jir}\\
&+\ \sum_{k}VDFMX(GCT12)_{kir}-VDFA_{jir}\\
&+\ \left.\sum_{k}VIFMX(GCT12)_{kir}-VIFA_{jir}\right]
\end{aligned}
\qquad (3.25)\qquad \forall i\in AGRI,\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

| | |
|---|---|
| *SHR_OUT*$_{ir}$ | *Share of domestic support allocated to output subsidies in GTAP for commodity i in region r* |

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

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 homogeneous 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 homogeneous 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).

$$(3.27) \qquad pmesx_{ijrg} = tfsub_{ijrg} + pmesx_{ijrb} \qquad \forall i \in ENDW,\ \forall j \in PROD,\ \forall r \in REG,\ \forall g \in GROUP,\ \forall b \in BASEGROUP$$

| | |
|---|---|
| $tfsub_{ijrg}$ | *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.

[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.

$$pmx_{ijrg} = tfdsub_{ijrg} + pmx_{ijrb} \quad (3.28)$$

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

| | |
|---|---|
| $pmx_{ijrg}$ | *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

[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.

---

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

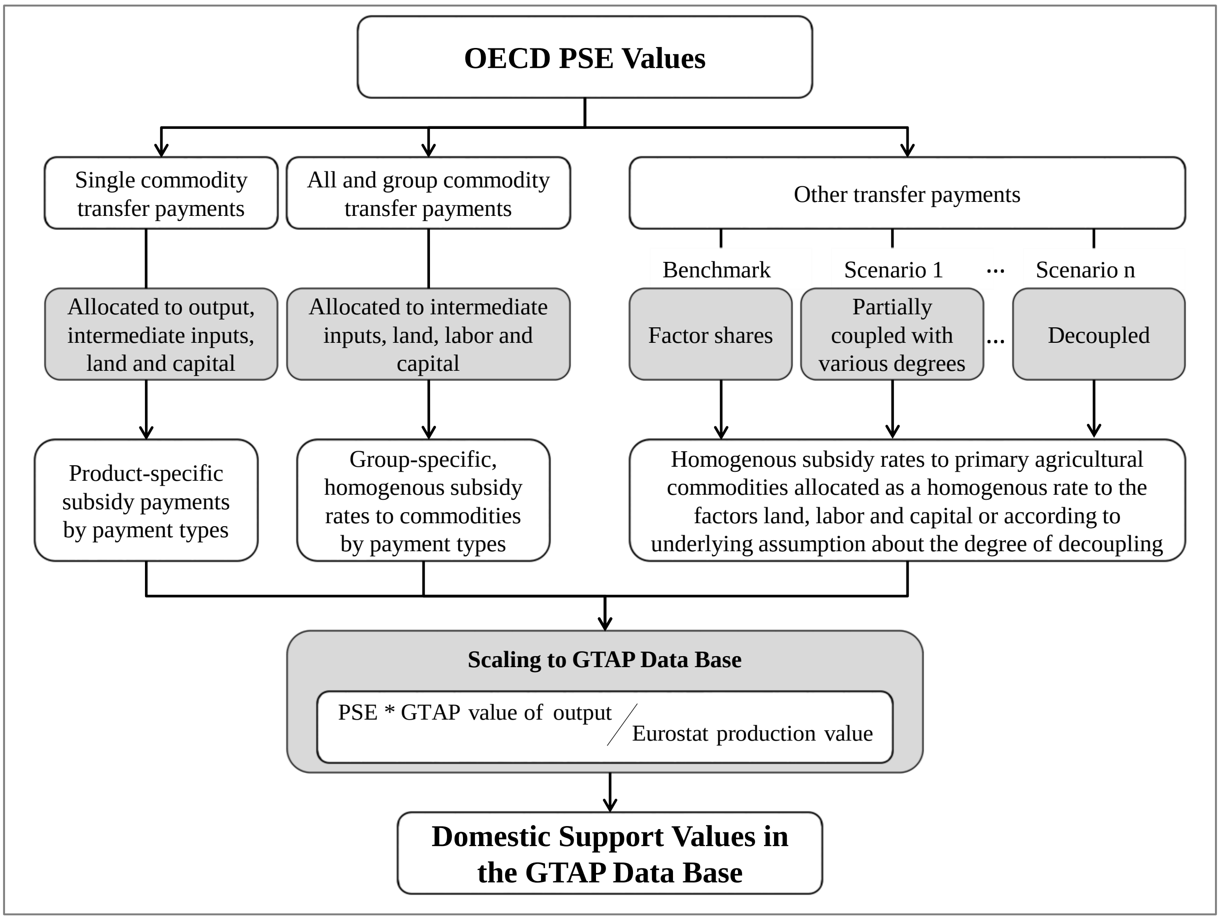
[21] The financial year 2008 covers the period from July 2007 until June 2008.

[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

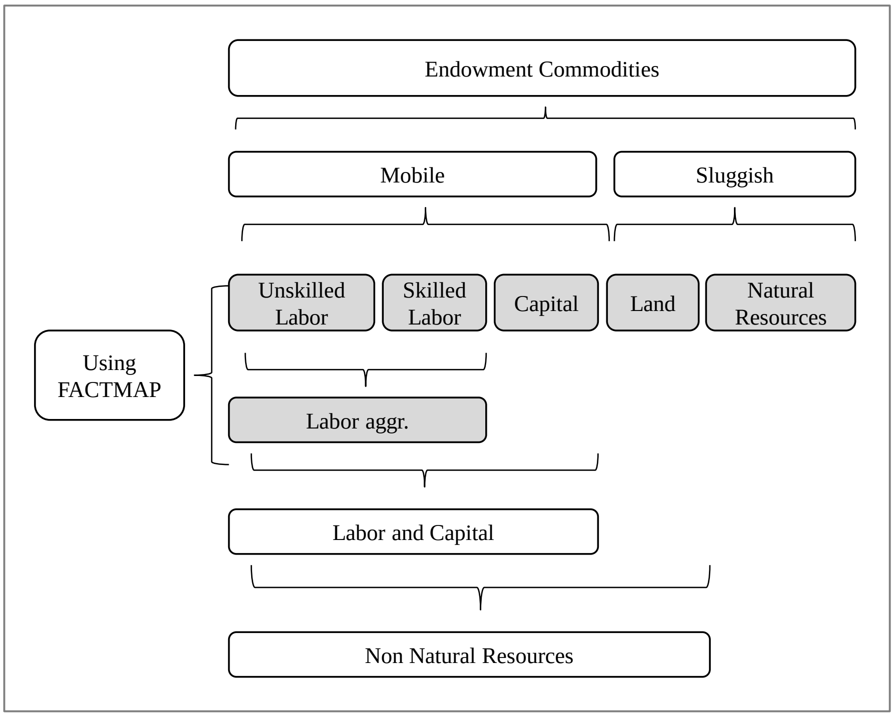
[24] The factor shares are utilized in the simulations are exogenous. In an ideal situation, the factor shares would be updated based on other information. However, this information is not available to us.

[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 homogeneous 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.

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 $OTPH_r$ (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.*

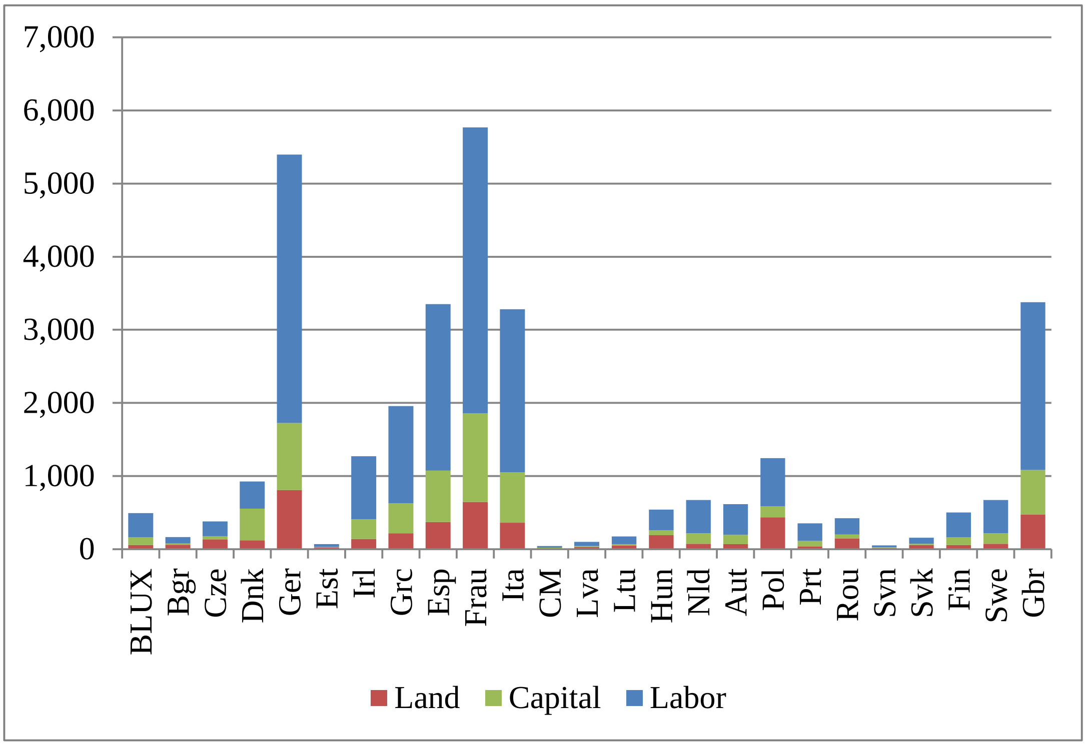
(4.1) $$TVFMSHR_{ir} = \frac{\sum_j TVFM_{ijr}}{\sum_i \sum_j TVFM_{ijr}} \qquad \forall i \in NNAT \quad \forall r \in REG$$

| | |
|---|---|
| *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) $$OTRAN_{ir} = TVFMSHR_{ir} \times OTPH_r \qquad \forall i \in NNAT \quad \forall r \in REG$$

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

**Figure 8. EU OTP payments by factor share in 2007 (EURO Mio.)**




*Source: Authors' elaboration based on OECD PSE data.*

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) $$DECOUPSHR_{ir} = TVFMSHR_{ir} \times SHIFTFCT_i \qquad \forall i \in FCAP \quad \forall r \in REG$$

| | |
|---|---|
| $DECOUPSHR_{ir}$ | *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) $$DECOUPSHR_{ir} = 1 - \sum_{k=FCAP} DECOUPSHR_{kr} \qquad \forall i \in LAND \quad \forall r \in REG$$

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

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) $$ACTPOWER_{ir} = \frac{ACPM_{ir}}{\sum_{j \in AGRI} PRODN_{jr}} \qquad \forall i \in NOPT \quad \forall r \in REG$$

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

| | |
|---|---|
| $ACTPOWER_{ir}$ | *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 homogeneous 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: Authors' elaboration.*

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 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 commodities | 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 | ACT | GCT1 | GCT2 | GCT3 | | | | | | | | | |
| wht | ACT | GCT1 | GCT2 | GCT3 | | | | | | | | GCT11 | |
| gro | ACT | GCT1 | GCT2 | GCT3 | | | | | | | | GCT11 | |
| v_f | ACT | GCT1 | | | | GCT5 | GCT6 | | | | | | |
| osd | ACT | GCT1 | GCT2 | | GCT4 | | | | | | | GCT11 | |
| c_b | ACT | GCT1 | GCT2 | | | | | | | | | | |
| pfb | ACT | GCT1 | GCT2 | | | | | | | | | | |
| ocr | ACT | GCT1 | | | | GCT5 | | | | | GCT10 | GCT11 | |
| ctl | ACT | | | | | | | GCT7 | GCT8 | | | | GCT12 |
| oap | ACT | | | | | | | GCT7 | | | | | |
| rmk | ACT | | | | | | | GCT7 | GCT8 | GCT9 | | | GCT12 |
| wol | ACT | | | | | | | GCT7 | GCT8 | | | | |

*Source: Authors' elaboration.*

Consequently, the payments of a specific group need to be distributed homogeneously 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.

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

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

| | |
|---|---|
| $GCT1POWER_{ir}$ | *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* |

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

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

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.

**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: Authors' elaboration.*

**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: Authors' elaboration.*

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.)**

| GCT1 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: Authors' elaboration.*

[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-homogeneous 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)
$$SCTPAYPOS_{jr} = 1 + \frac{\sum_{i=ALLPAYT} SCPM_{ijr}}{PRODN_{jr}} \qquad \forall j \in AGRI \quad \forall r \in REG$$

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

| | |
|---|---|
| *$SCTPAYPOS_{jr}$* | *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 homogeneous payments over all payment categories ($TOTPAYM_{ijrg}$) is then calculated by summing up the 12 GCT payments and ACT payments.

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

| | |
|---|---|
| *$HOM\_PVS_{irg}$* | *Homogeneous 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) $$OTP\_PVS_{ir} = \frac{OTRAN_{ir}}{\sum_{j=AGRI} PRODN_{jr}} \qquad \begin{matrix} \forall i \in NNAT \\ \forall r \in REG \end{matrix}$$

| | |
|---|---|
| *$OTP\_PVS_{ir}$* | *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 homogeneous 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 homogeneous and non-homogeneous 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 homogeneous 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 with i = 1, …, N (see Figure 9) with an increase in the degree of decoupling from benchmark to fully decoupled.

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

2) PARTIAL-DECOUPLED: OTP allocated with a homogeneous 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.

…

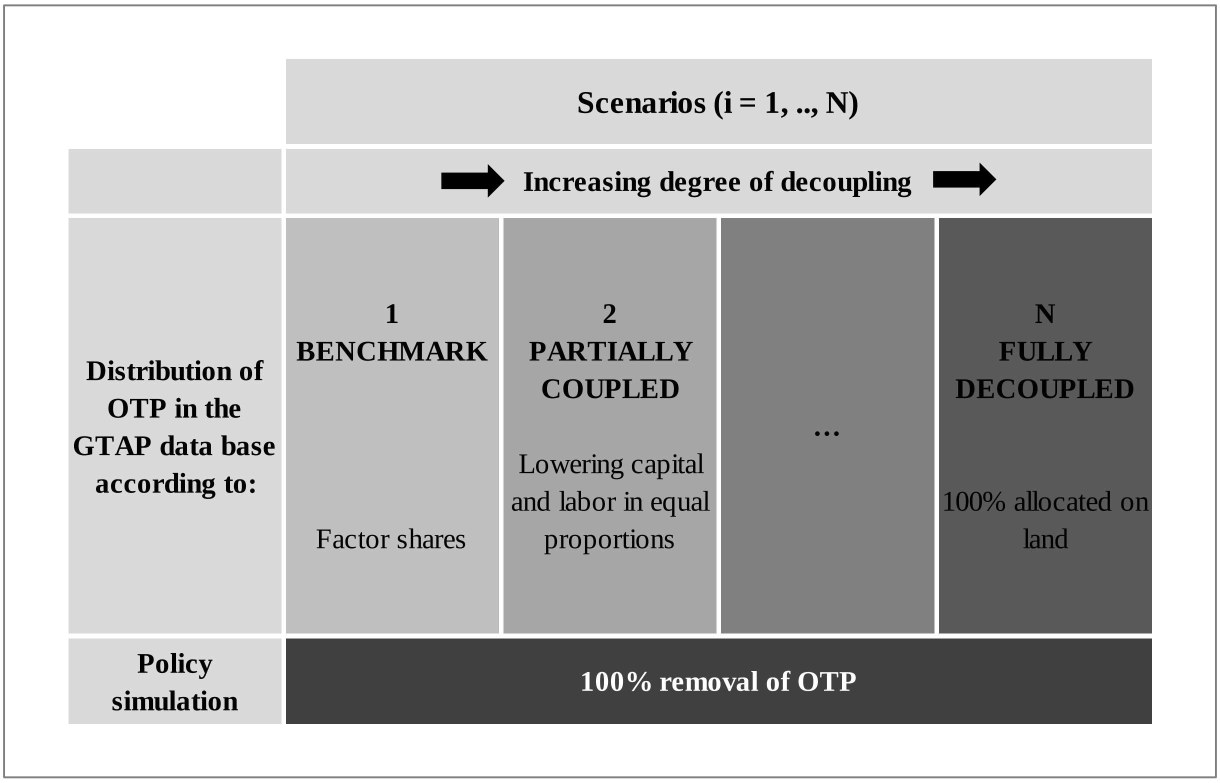
N) EFFECTIVELY FULLY DECOUPLED: OTP allocated with a homogeneous rate across primary agricultural commodities to the factor land.

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.

[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**




*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.

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

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

| | |
|---|---|
| $OTP\_SHR_r$ | *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) $$SHR\_ENDW_{irg} = \frac{\sum_{j \in AGRI} VFMX_{ijrb} - VFMX_{ijrg}}{\sum_{j \in AGRI} VOM_{jr}} \qquad \forall i \in NNATDIS \quad \forall r \in REG \quad \forall g \in GROUP \quad \forall b \in BASEGROUP$$

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

| | |
|---|---|
| $SHR\_ENDW_{irg}$ | *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) $$SHR\_INT_{rg} = \Big[\sum_{j\in AGRI}\sum_{k\in INT} VDFMX_{kjrb} - VDFMX_{kjrg} + \sum_{j\in AGRI}\sum_{k\in INT} VIFMX_{kjrb} - VIFMX_{kjrg}\Big] / \sum_{j\in AGRI} VOM_{jr} \quad \forall r \in REG \;\; \forall g \in GROUP \;\; \forall b \in BASEGROUP$$

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

| | |
|---|---|
| *$SHR\_INT_{rg}$* | *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) $$PO\_TAX_{ir} = 1 + \Big[VOA_{ir} - VOM_{ir} + \sum_j VFMX(GCT12)_{jir} - VFA_{jir} + \sum_k VDFMX(GCT12)_{kir} - VDFA_{kir} + \sum_k VIFMX(GCT12)_{kir} - VIFA_{kir}\Big] / VOM_{ir} \quad \forall i \in AGRI \;\; \forall r \in REG \;\; \forall j \in ENDW \;\; \forall k \in INT$$

| | |
|---|---|
| *$PO\_TAX_{ir}$* | *Power of tax in GTAP for commodity i in region r* |

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

| | |
|---|---|
| *$POSCT_{jr}$* | *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)

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

*$SHR\_OUT_{ir}$* — *Share of domestic support allocated to output subsidies in GTAP for commodity i in region r*

(4.20)

$$
SHK\_OUT_{ir} = SCT\_PVS_{ijr} - SHR\_OUT_{jr}
\qquad
\begin{aligned}
&\forall i \in OUTPUT \\
&\forall r \in REG \\
&\forall j \in AGRI
\end{aligned}
$$

*$SHK\_OUT_{ir}$* — *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 is 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 homogeneous 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 homogeneous 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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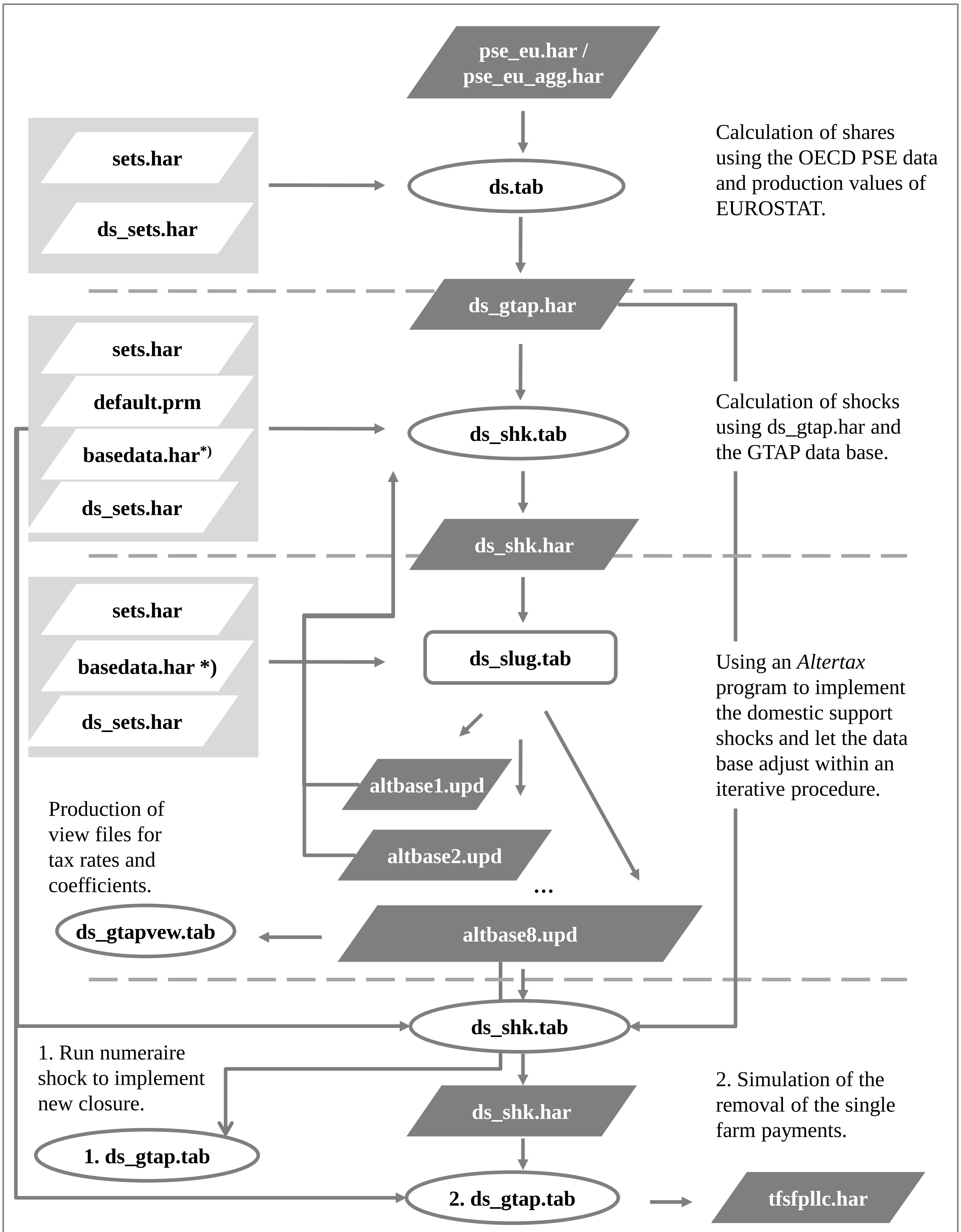
[31] Refer to table A4 in the appendix for the description of files. Please note that all required files will be provided via www.gtap.org.

[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**




*) Only in the first simulation, afterwards basedata.har is replaced by altbase.upd,…, altbase8.upd

*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 homogeneous 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 ($tfs_r$, $to_r$, $tfdmsct_{r,\dots}$) 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 homogeneous percentage support rate across factors and sectors using Germany as an example.

**Table 6. Homogeneous 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: Authors' elaboration.*

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: Authors' elaboration.*

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

**Table 8. Factor specific homogeneous 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: Authors' elaboration.*

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 homogeneous rate across these commodities. In Germany GCT1 payments are only given to the factor land.

**Table 9. Group and factor specific homogeneous 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: Authors' elaboration.*

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

**Table 10. Group and factor specific homogeneous 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: Authors' elaboration.*

In the case of Germany the sectors for wheat, other grains and oilseeds receive a homogeneous 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 | 1,384 | 1,384 |
| **Input** | 0 | 0 | 0 | 0 | 0 |
| **Land** | 8,775 | 9,507 | 5,236 | 2,557 | 26,075 |
| **Capital** | 9,680 | 7,782 | 965 | 3,587 | 22,015 |
| **Unskilled Labor** | 24,789 | 635 | 2 | 0 | 25,426 |
| **Skilled Labor** | 1,688 | 44 | 0 | 0 | 1,732 |
| **Total** | 44,933 | 24,635 | 6,757 | 7,576 | 83,901 |

*Source: Authors' elaboration.*

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 GTAP production values | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | **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: Authors' elaboration.*

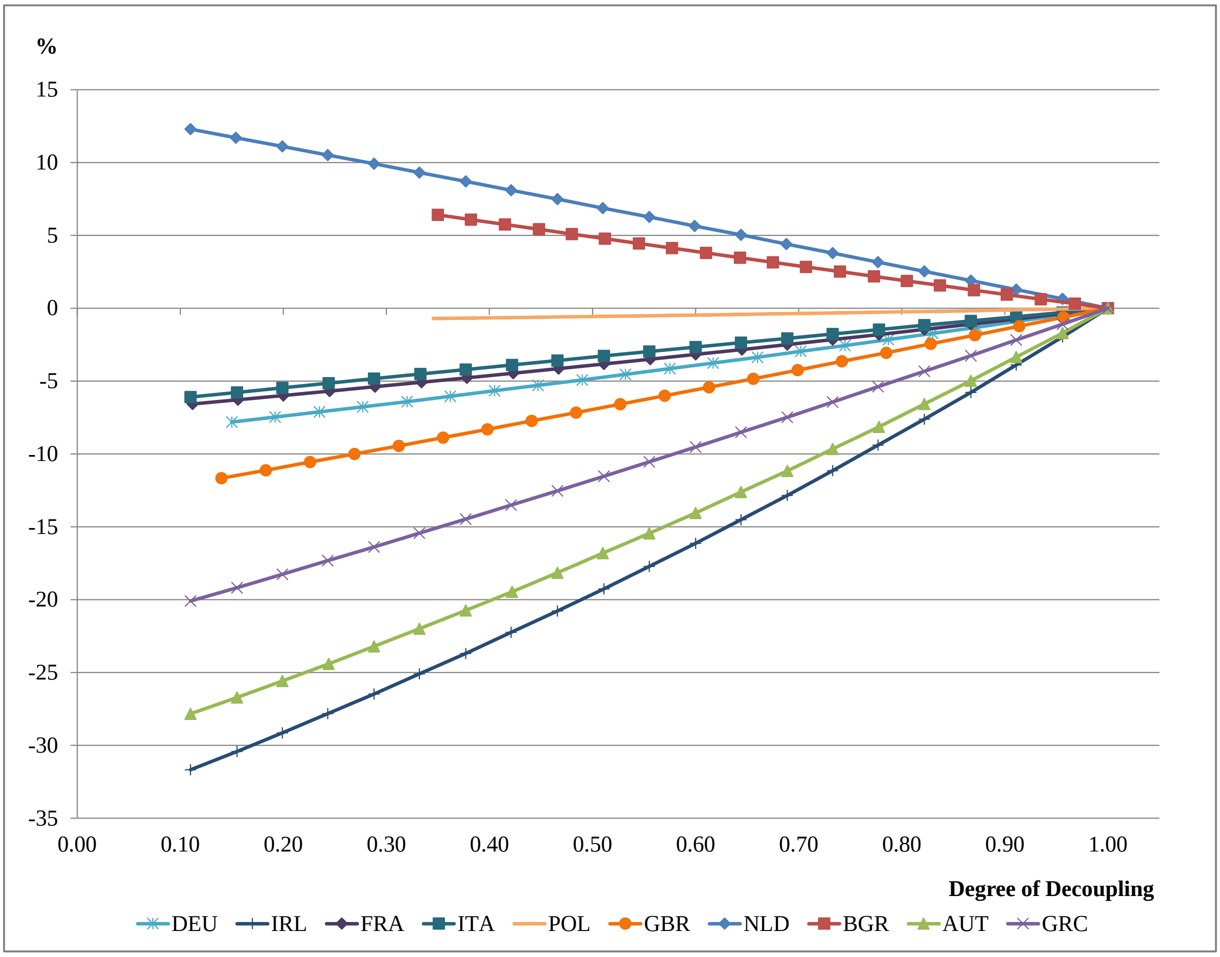
[34] To obtain a closer match of OECD and GTAP domestic support data more iterations of the update procedure would be required. In complex simulation models, we always face a trade-off fine-tuning versus solution time. Users of this implementation procedure can adjust the iterations and hence the accuracy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

## 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 homogeneous subsidy rate across primary agricultural commodities given to the factor land, which is used only by agricultural sectors.

**Figure 11. Production effects in the wheat sector for selected EU member states**

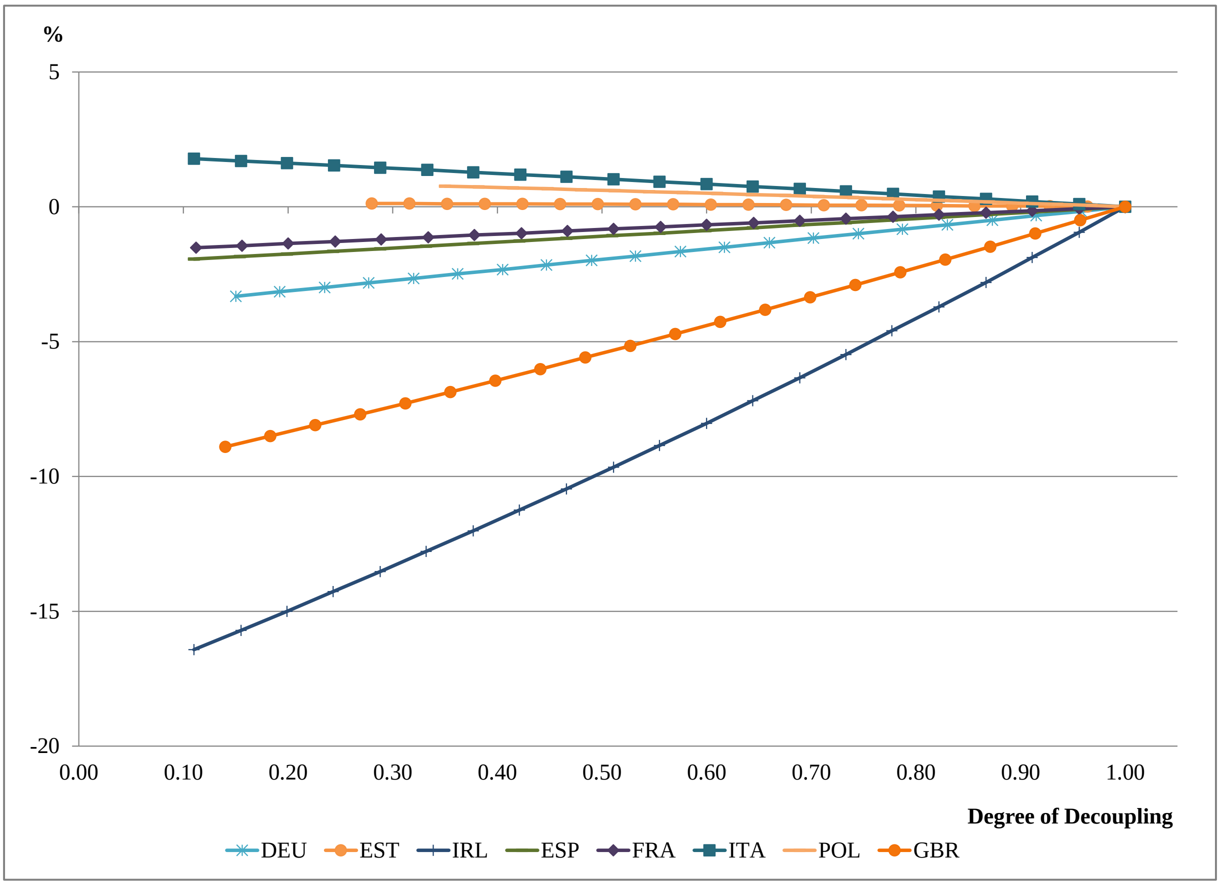



*Source: Authors' elaboration.*

The Figures 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%.

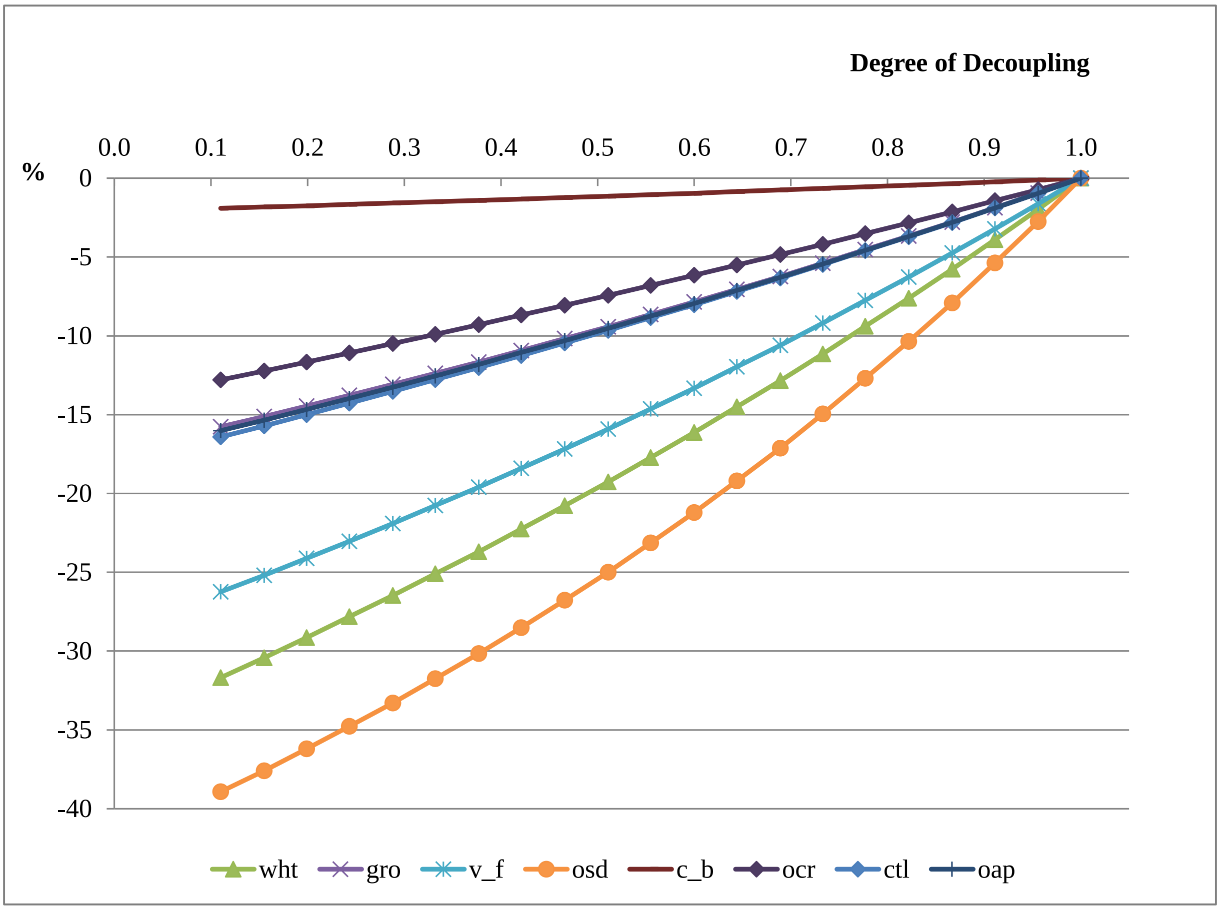
**Figure 12. Production effects in the cattle sector for selected EU member states**




*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.

**Figure 13. Production effects in selected sectors in Ireland**



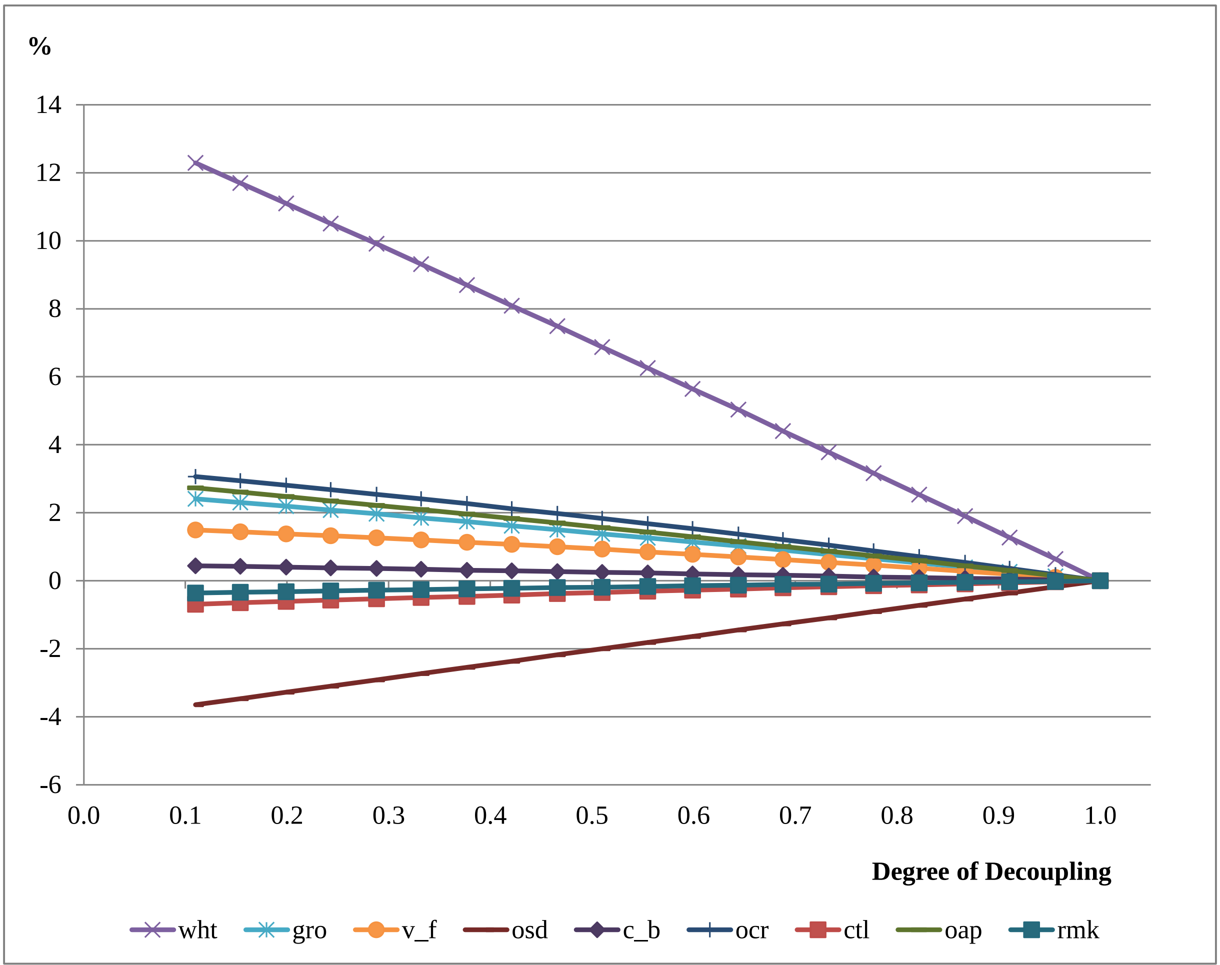

*Source: Authors' elaboration.*

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 comparable low to all other EU 15 member states. Beyond this, the OTP counts for almost 16% of the total value of primary agricultural output, while countries such 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 such as wheat, vegetables and fruits, and oilseeds into sectors such 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 denote 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 14. Production effects in selected sectors in the Netherlands**

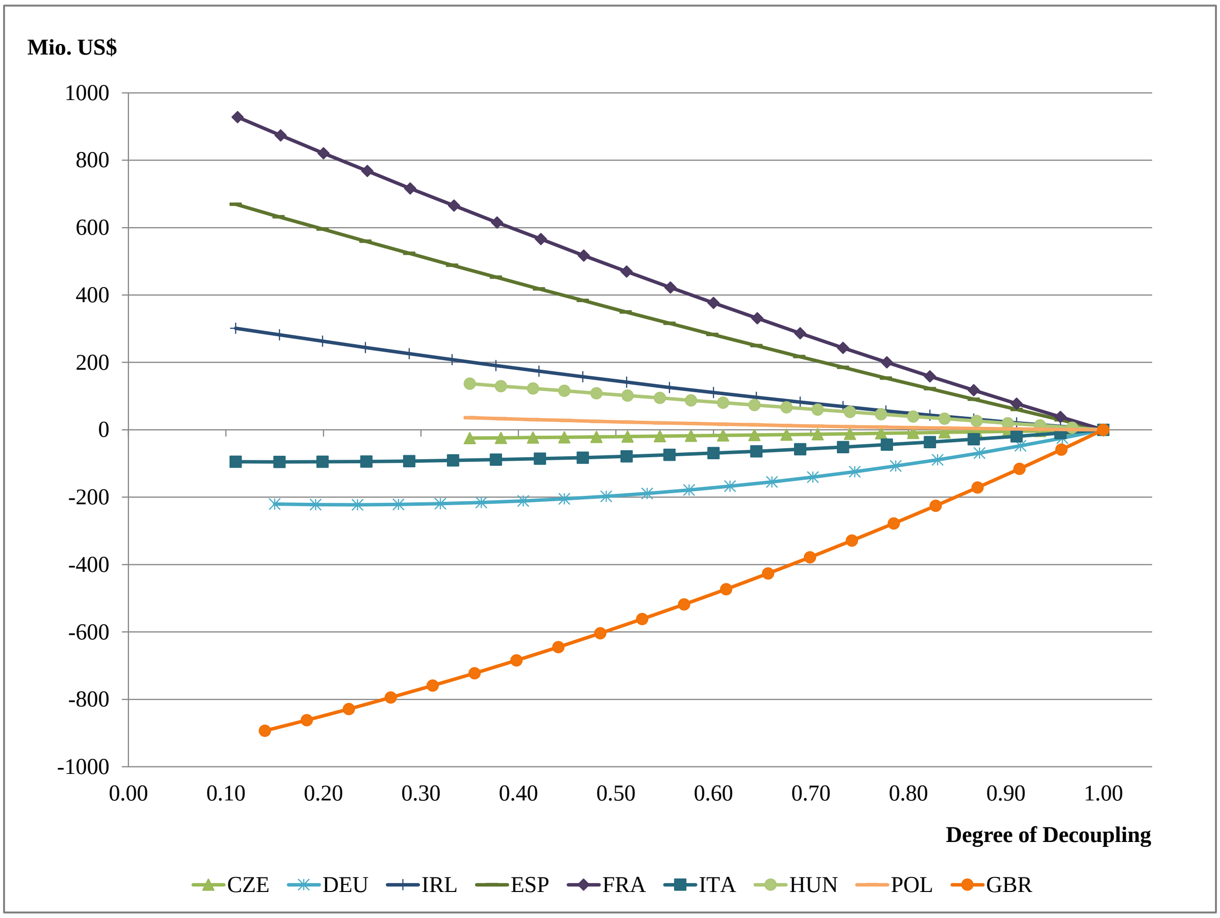



*Source: Authors' elaboration.*

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. 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.

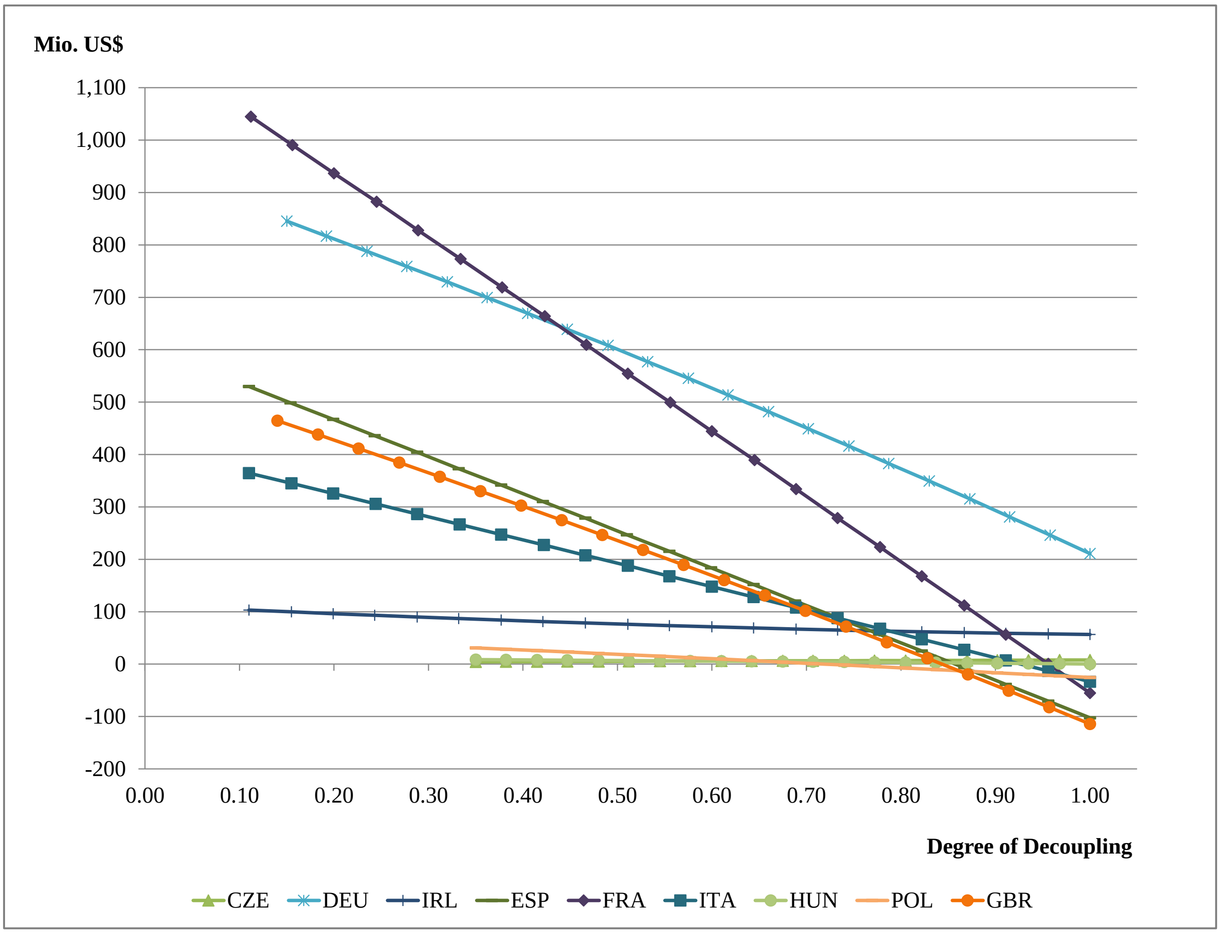
**Figure 15. Change in the equivalent variation in selected EU member states (Mio US$)**




*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 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 partially 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 homogeneously according the factor usage or reflecting partial decoupling with only little degree of decoupling results in an increase in agricultural imports and a decrease 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 not 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 homogeneous 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 homogeneous 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 to factor usage** | **default** | **according to factor usage** | **default** | **according to factor usage** | **default** | **according to factor usage** |
| Degree of decoupling | 0.11 | 0.11 | 0.11 | 0.11 | 0.11 | 0.11 | 0.11 | 0.11 |
| % 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 | 1,046.39 | 1,044.68 | 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: Authors' elaboration.*

The simulation results clearly depict that the homogeneous 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 homogeneous 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 is 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 selected 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 (homogeneous distribution across factors and sectors) is too pessimistic, while effectively fully decoupled implementation in GTAP (allocation only to the factor land with a homogeneous rate across sectors) is too optimistic. Several studies confirm that the SFP capitalizes in land rents (e.g., Latruffe and Le Mouël (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 (2009)). 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 homogeneous 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 is 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 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 homogeneous 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 homogeneous 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 analysis, 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, and Namibia | | ROW |

*Source: Authors' elaboration.*

## 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: Authors' elaboration.*

# 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 base | 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 | GCT2 | GCT3 | GCT4 | GCT5 | GCT6 | GCT7 | GCT8 | GCT9 | GCT10 | GCT11 | GCT12 | | |
| | | | | All crops | All arable crops | Grains | Oilseeds | Other crops | All fruits and vegetables | All livestock | Ruminants | Non-rumi-nants | Protein crops | Cereals, oilseeds and protein crops | 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 | |
| | | | | | | | | | | | | | | | | 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** | | | **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 file 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 including the GTAP PSE data |
| | pse_eu_agg.har | Data file including the OECD PSE data aggregated to the selected GTAP aggregation |
| | pse_eu27.har | Data file including the OECD PSE data for the 27 EU member states |
| | ds_shk.har, ds_shk1.har, …, dsshk9.har | Shock file including 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* program |
| | ds_gtap.sti | Stored input file to change the closure for 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 to zero |

*Source: Authors' elaboration.*

**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: Authors' elaboration.*

## 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 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. homogeneous support i used by j in r of g |

**Table A6. List of variables and coefficients (cntd.)**

| Name | Description |
|---|---|
| $pm_{ir}$ | 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 |
| $PO\_TAX\_SCT_{ir}$ | 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 to 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 GTAP in 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 |
| $tfdsct_{ijr}$ | Tax (SCT) on domestic i used by commodity j in region r |

**Table A6. List of variables and coefficients (cntd.)**

| Name | Description |
|---|---|
| $tfdsub_{irg}$ | 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 |
| $tf_{ijr}$ | Tax on primary factor i used 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 |
| $TVFM_{ijr}$ | Factor usage for endowment i in region r |
| $TVFMSHR_{ir}$ | Factor usage share for endowment i in region r |
| $VDFA_{ijr}$ | 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. Homogeneous 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 homogeneous 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. homogeneous 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: Authors' elaboration.*

**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,EU_REG)
            tfdsct(INT_COMM,NAGRI_COMM,EU_REG)
            tfdsct(TRAD_COMM,PROD_COMM,ROW)
            tfmsct(ENGERI_COMM,PROD_COMM,EU_REG)
            tfmsct(INT_COMM,NAGRI_COMM,EU_REG)
            tfmsct(TRAD_COMM,PROD_COMM,ROW)
            fdmsub
            tfdsub(ENGERI_COMM,EU_REG,GROUP)
            tfmsub(ENGERI_COMM,EU_REG,GROUP)
            tfdsub(TRAD_COMM,ROW,GROUP)
            tfmsub(TRAD_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 homogeneous 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 homogeneous subsidy rate to land in the GTAP database, then the landowner captures the entire subsidy. If the homogeneous 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 homogeneous 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 homogeneous 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 homogeneous 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 homogeneously 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: pfe("land",j, "deu") | tfsfp("land", "deu") | pmes("land",j, "deu") | pm("land","deu") | pm("land", "deu") = REVSHR ("land",j,"deu") * pmes ("land",j,"deu") |
|---|---|---|---|---|---|---|---|
| pdr | 0.00 | 0.62 | 0.10 | 128.37 | -56.17 | -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 | | -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: Authors' elaboration.*

### Table A8. Equation ENDW_SUPPLY

| j | qfe("land", j,"deu") | qoes("land",j,"deu" | qo("land", "deu") | endwslack ("land","deu") | ETRAE("land") | pm("land", "deu") | pmes("land",j, "deu") |
|---|---|---|---|---|---|---|---|
| pdr | -0.000005 | -0.000005 | 0.00 | 0.00 | -1.00 | -56.17 | -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 | | | | | -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: Authors' elaboration.*

# 3 How decoupled is the Single Farm Payment and does it matter for international trade?

Kirsten Urban, Hans G. Jensen and Martina Brockmeier

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# How decoupled is the Single Farm Payment and does it matter for international trade?

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ABSTRACT

The extent to which decoupled agricultural support – including the European Union Single Farm Payment (SFP) – creates production incentives remains unclear. We apply an extended version of the standard Global Trade Analysis Project model and generate a set of 21 databases that captures a comprehensive representation of domestic support. By considering and modeling a range of different assumptions regarding the SFP's degree of decoupling, we investigate the SFP's effect on the model's results. The results of our analysis reveal substantially different effects that depend on the degree of decoupling, and the findings can help validate trade analysis results, particularly for developing countries.


## Introduction

For decades, there have been ongoing discussions regarding the trade distortions caused by the domestic support provided to agricultural producers. It is well established that agricultural support in high-income countries critically affects agricultural producers in developing countries, particularly in the least developed countries (McCalla and Nash, 2007a). Subsidies to agricultural producers enhance agricultural production, and border measures, such as tariffs and non-tariff barriers, protect many subsidized agricultural sectors by ensuring higher market prices. In addition, instruments such as export subsidies facilitate the dumping of subsidy-induced overproduction onto the world market, thus lowering world market prices. In this manner, subsidized countries procure a competitive advantage compared with other exporting countries and hurt developing countries, particularly those that are net exporters of agricultural and food commodities, by limiting net exporters' share of exports to the world market. By contrast, the impact on those developing countries that are net importers of agricultural and food commodities is less clear. These countries have become increasingly dependent on low-priced imports of long-term subsidized products from highly protected countries. As a consequence, consumers in net food-importing countries are, at least in the short run, potential beneficiaries of domestic support. Furthermore, developing countries are favored through preferential trade agreements, and producers thus gain from the higher market prices in highly protected countries (Hertel and Keeney, 2006; Matthews, 2008; Panagariya, 2005).

The European Union (EU) is a prominent example of a heavily subsidized – and thus trade-distorting – agricultural sector. Despite multiple reforms to its Common Agricultural Policy (CAP) that aim to fulfill WTO requirements, the EU remains the subject of criticism because of the support it provides to agricultural producers. The EU's most important step toward less distortive trade was the introduction of the Single Farm Payment (SFP) in 2005, through which the EU provides direct income support to farmers with no production required, and which now accounts for over 50% of the EU's total domestic support payments. Thus, the SFP might be regarded as decoupled from production, but even the newly introduced SFP remains controversial. Decoupled payments may stimulate production through other coupling channels – including risk, uncertainty, imperfect credit markets, land and labor markets, and farmer's expectations about future payments (Bhaskar and Beghin, 2009) – and thus remain at least somewhat trade distortive (e.g., Chau and de Gorter, 2005; Goodwin and Mishra, 2006; Key and Roberts, 2009; Latruffe and Le Mouël, 2009; O'Toole and Hennessy, 2015). Furthermore, there is no consensus yet about the extent to which decoupled payments are capitalized in land values (Ciaian et al., 2014).

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In recent years, a considerable number of articles have analyzed the effects of multilateral trade liberalization that focus on market access, export subsidies, and domestic support and that evaluate these effects with a particular focus on developing countries (Anderson and Martin, 2006, 2005; Anderson and Valenzuela, 2007; Bouët et al., 2005; Bureau et al., 2006; Martin and Anderson, 2008; McCalla and Nash, 2007b). Notwithstanding general trade liberalization, some analyses continue to focus on the effects of domestic support versus export subsidies (Nuetah et al., 2011), domestic support versus tariffs (Tamini et al., 2012), and agricultural tariffs versus subsidies (Hoekman et al., 2004). (Dimaranan et al., 2004; Rae and Strutt, 2003), in particular, examine the effects of domestic support on developing countries. Although a number of analyses have identified the effects of the CAP on the EU agricultural market, fewer assessments are available that emphasize the effects of the CAP on developing countries (Boysen et al., 2015a; Matthews, 2008; Nowicki et al., 2009; Winters, 2005).

Some of this literature analyzes the effects of trade liberalization scenarios by accounting for domestic support payments and applying various methodological settings. However, to our knowledge, no available analysis considers the effects of different underlying assumptions regarding the degree of decoupling of decoupled payments. With respect to the extent to which the SFP continues to incentivize production, the effects of the degree of the SFP's decoupling must be considered when analyzing the effects of domestic support on international trade.

Computable general equilibrium (CGE) models are comprehensive tools for analyzing trade liberalization scenarios. However, the attention to detail regarding the complex structure and country-specific properties of domestic support has been lacking in the previous literature. Although most of the applied CGE models consider the SFP, the assumptions about the degree of decoupling differ. The majority of approaches treat the SFP as fully decoupled by distributing 100% of it to land (Boulanger and Philippidis, 2015; Frandsen et al., 2003; Nowicki et al., 2009), whereas single-country CGE models treat the SFP as lump sum transfers allocated to households (Boysen et al., 2015b; Ferrari et al., 2012). By contrast, the standard Global Trade Analysis Project (GTAP) model allocates the SFP according to factor usage. Gohin (2006) and Balkhausen et al. (2008) compile different assumptions regarding the SFP's degree of decoupling as applied in CGE and partial equilibrium models and conclude that the degree of decoupling is the most important factor when comparing different analyses.

The objective of this article is to provide an analysis that reveals the effect of the SFP accounting for different assumptions regarding its degree of decoupling, its modeling, and its effects on trade with developing countries. Thus, this analysis helps validate results based on the experiences of experts and the available econometric results of the degree of decoupling. We base our analysis on the GTAP model, which incorporates domestic support payments that originate from the OECD Producer Support Estimate (PSE) tables. Based on the approach of Urban et al. (2014), we extend the standard GTAP model to capture detailed domestic support payments, accounting for different types and categories of support, and we adjust the GTAP database accordingly. Applying this extended version, we generate a set of 21 databases that reflect various degrees of decoupling, which are then used to simulate a total elimination of domestic support payments, of which the SFP accounts for more than 50%, and to quantify the effects on international trade and welfare. In so doing, we conduct an elaborate analysis that enables us to consider the effects of different assumptions regarding the production incentives resulting from the SFP. We compute different meaningful and commonly used indexes in international trade analysis to represent the SFP's effect on the model's results with a particular focus on developing countries. The results of this analysis provide a solid benchmark to contrast with other simulation results based on ad hoc assumptions and to validate their impact.

This article is organized as follows. First, we introduce the extended GTAP modeling framework and account for a detailed representation of domestic support payments and the modeling options of the SFP. The next section describes the elaborate experiment design that enables us to consider various degrees of decoupling. A selection of the results obtained is presented in Section 'Results'. The article concludes with a discussion of the effects that removing EU domestic support payments would have on international trade and welfare, with a particular focus on both developing and the least developed countries and prioritizing the impact of the SFP's degree of decoupling.

## Extended GTAP modeling framework

The analysis in this article is based on the comparative-static, multi-regional general equilibrium GTAP model, which is well documented in Hertel (1997). The standard GTAP model represents all policy instruments as ad valorem tax equivalents that create wedges between the undistorted prices and the prices including the policy. Accordingly, the GTAP model mirrors agricultural policy instruments related to domestic support in the form of five price wedges that affect producers' transactions at agents' and market prices: output, intermediate inputs, land, capital, and labor. In this manner, the GTAP model considers only budgetary transfers but also indirectly captures market price support that is implicitly included in border measures. The primary production factors of land, labor, capital, and natural resources are fully employed within each economy. Labor and capital are mobile in the model and can relocate among sectors but not among regions. By contrast, land and natural resources are sluggish.

In this article, we apply an extended version of the standard GTAP model and updated versions of the underlying GTAP database Version 8.2 (Narayanan et al., 2012) that consider a much more detailed representation of domestic support payments, including payment categories and types. The PSE concept, which is defined on the basis of different production requirements, allocates domestic support payments to a specific product (single commodity transfers (SCT)), a special group of commodities (group commodity transfers (GCT)), all commodities (all commodity transfers (ACT)), or farm households without requiring any production (other transfers to producers (OTP)). In addition, the PSE distinguishes between payments based on output, input use, area, number of animals, receipts, income, and non-commodity criteria that are predicted on a current or fixed basis (OECD, 2010).

Adopting the approach of Urban et al. (2014), we integrate detailed domestic support payments into the GTAP database by applying an elaborate procedure. This updated procedure enables the integration of the PSE data by payment type, which is reflected in the GTAP model as five price wedges: output, input, land, labor, and capital. To integrate additional – and thus more precise – policy instruments into the GTAP model, we further subdivide each of the five price wedges according to the four PSE categories. In so doing, we achieve a detailed representation of domestic support payments in the underlying value flows and the corresponding price linkage equations.

The SFP is categorized as an OTP payment in the PSE concept, which by definition is a policy that requires no production. Thus, farmers receive those subsidies in the form of direct income transfers to households based on land entitlements. In the GTAP model, one representation of the SFP is the allocation to land at a homogenous rate across primary agricultural commodities (Urban et al., 2014). Policy instruments modeled in this manner do not create production effects in the GTAP model; thus, payments can be regarded as effectively fully decoupled and the SFP payment fully capitalizes into the land rents (Frandsen et al., 2003).[1] Accounting for other coupling channels requires a reconnection of the SFP to production. The SFP affects structural changes in agriculture, which implies that farms are prevented from farm exit (Chau and de Gorter, 2005), and particularly for low-profit farmers, exit is reduced. Imperfect labor markets and off-farm labor or farm-exit decisions affect the labor market; thus, these coupling channels can be represented in a general equilibrium modeling framework as subsidies provided according to each agricultural sector's labor usage. (Breen et al., 2005; Goodwin and Mishra, 2006; Sckokai and Moro, 2009; O'Toole and Hennessy, 2015) refer to the increase in farm income and the reduced volatility of farm income due to the SFP that allows for higher savings and investment and a better access to credit. The risk behavior and investment decisions of farmers are affected and stimulated; and thus the SFP creates risk-related effects on production incentives. Imperfect credit markets, risk behavior and farmers' expectations about future payments clearly influence the agricultural sector's capital endowment, and thus can be represented as subsidies provided according to each sectors' capital usage. Subsidies allocated according to each sector's land usage capitalize only partly into the price of land (Chau and de Gorter, 2005; Ciaian et al., 2014; Kilian et al., 2012; Latruffe and Le Mouël, 2009; Michalek et al., 2014; Van Meijl et al., 2006). Therefore, we introduce a second modeling option for the SFP. Utilizing the first modeling approach, we obtain the allocation of the SFP according to each sectors land usage. This information enables us to redistribute the SFP sector specific to land, labor, and capital, and thus introduces a general link to production without incentivizing the production of a specific commodity.[2] This approach is therefore partially decoupled.

Furthermore, our model reports widely used meaningful indexes, such as different aggregations of the trade balance, Herfindahl–Hirschman concentration indexes, and the equivalent variation. These indexes enable us to provide a concise but expressive overview of the effects on developing countries' trade of removing domestic support payments while explicitly considering different assumptions about the SFP's degree of decoupling.

## Experiment design

The effects on farmers' production decisions through other coupling channels (e.g., Bhaskar and Beghin, 2009; Goodwin and Mishra, 2006; Key and Roberts, 2009; Latruffe and Le Mouël, 2009; O'Toole and Hennessy, 2015; Petrick and Zier, 2012) and the capitalization of decoupled payments in land rents (Ciaian et al., 2014) have been the subjects of controversial discussions in the literature. However, empirical evidence for the EU remains scarce. Despite considerable research efforts in analyzing the effect of decoupled payments on farm level output decisions the results cannot be considered as conclusive (Moro and Sckokai, 2013). Ciaian et al. (2014) and Michalek et al. (2014) note that differences in land markets and land regulations in the EU might lead to important differences among EU member states. These authors generate an evaluation of empirical estimates of the capitalization rate of decoupled subsidies in land rent that results in a capitalization ratio that ranges from 20% to 80%. In addition, Michalek et al. (2014) emphasize that the SFP's capitalization in land rents largely varies between EU member states (from 3% to 94% of the value of the payment). The average capitalization of the SFP in land rents equals 6–7% for the EU-15.

Considering the significant differences in the extent to which the SFP is capitalized in land values – thus stimulating production through other coupling channels – we utilize the GTAP database Version 8.2 (base year 2007) and the approach of Urban et al. (2014) as the starting point for our analysis. Using OECD PSE data (OECD, 2014) to integrate the EU domestic support payments, we therefore create a set of different GTAP databases by gradually varying the underlying degrees of the SFP's decoupling encompassing two components of the SFP – a decoupled one and a re-coupled one. Because there is no consensus yet, we start from a 100% fully decoupled SFP that is allocated at a homogenous rate across primary agricultural commodities to the factor land (modeling option 1). Then, we stepwise increase the share of the re-coupled component of the SFP that enables the representation of various assumptions about the effect of other coupling channels (modeling option 2).

Table 1 shows the composition of the created set of databases. According to the eligibility criteria of the SFP, this subsidy is provided to agricultural producers based on historical land usage. Thus, the starting point in our analysis is the allocation of the SFP only to land with a homogenous distribution across primary agricultural sectors. This database, which is labeled fully decoupled (FD), represents a full capitalization of the SFP into land rent and hence reflects a fully decoupled SFP. Various degrees of decoupling are obtained by gradually reducing the amount of the SFP initially distributed to the factor land and moving this amount to the re-coupled component of the SFP, which is distributed by sector at a homogeneous rate according to factor usage.[3] In Table 1, the SFP in the second database (PD-5) slightly stimulates production through other coupling channels and therefore no longer fully capitalizes in the market price for land. To achieve PD-5, we begin with the SFP allocation according to land (FD) and shift 5% of the sector-specific SFP values that were achieved by initially allocating the SFP at a homogenous rate across agricultural commodities to land (first component) to the second component of the SFP that is distributed by sector at a homogenous rate according to capital, labor and land. This procedure continues by gradually reducing the SFP initially allocated to land until we obtain the last database, which is labeled partially decoupled (PD-100). Thus, the share of the SFP allocated to the second component increases stepwise in equal proportions until 100% of the SFP is distributed by sector according to the factor usage, which represents the highest effect of other coupling channels and thus a high degree of coupling.

This procedure leads to 21 alternative databases, which serve as starting points for simulating the elimination of domestic support payments. This analysis enables an evaluation of the effect of varying assumptions regarding the extent to which other coupling

[1] Cahill (1997) distinguishes between full decoupling, which reflects policies that do not influence farmers' production decisions, and effective full decoupling, which reflects policies that do not result in production changes that differ from those that would have occurred in the absence of the policy.

[2] Taking the first modeling option as the basis implies that land-intensive sectors receive a higher amount of the SFP than do labor- or capital-intensive sectors. Consequently, through initially allocating the SFP according to land usage, we ensure that labor- and capital-based sectors such as vegetables and fruits and the livestock sector do not achieve a biased amount of the SFP, which would lead to an overestimation of the effect of the SFP on those markets.

[3] Example: The SFP amounts to 44,828 million USD in the GTAP database. In allocating this amount at a homogeneous rate across the 12 primary agricultural commodities to land (FD), for example, the capital- and labor-abundant cattle sector receives only 3.5% of the SFP, which is equal to 1,599 million USD, whereas the more land-employing wheat sector receives 10% of the SFP, which is equal to 4,386 million USD. Redistributing this amount by sector at a homogeneous rate across factors (PD-100), the cattle sector receives an allocation of 12% to land (818 million USD), 39% to capital (608 million USD) and 49% to skilled and unskilled labor (768 million USD). The wheat sector shows the following distribution: 26% to land (1,128 million USD), 19% to capital (836 million USD) and 55% to skilled and unskilled labor (2,422 million USD). Particularly interesting is the other crops sector, as this sector uses the highest amount of land, although other crops are labor and capital abundant. Thus, this sector receives 24% of the SFP (10,655 million USD) based on land use. Distributing this amount according to the factor usage of the other crops sector allocates 18% to land (1,930 million USD), 21% to capital (2,285 million USD) and 61% to skilled and unskilled labor (6,439 million USD).

**Table 1**
Database setting. *Source*: Authors' elaboration.

| Domestic support implementation into the GTAP database | SFP[a] allocation | | Effect on production | | Simulation |
|---|---|---|---|---|---|
| | Land<br>Homogeneous allocation across agricultural sectors | Factor use<br>Sector-specific allocation | Fully decoupled (FD) | Partially decoupled (PD) | |
| FD | 100% of SFP | – | X | | |
| PD-5 | 95% of SFP | 5% of initial allocation to land | | X | |
| ⋮ | Gradually shifting SFP from land onto capital, labor and land[b] | | X | | 100% removal of domestic support payments |
| PD-95 | 5% of SFP | 95% of initial allocation to land | | X | |
| PD-100 | – | 100% of initial allocation to land | | X | |

[a] SFP = Single Farm Payment.
[b] This includes a homogenous distribution of SFP according to each sectors' factor usage. Please refer to Section 'Experiment design' for more information on the integration of domestic support into the GTAP model and database and the experiment design.

channels induce the SFP to generate production incentives. Utilizing this set of databases in our analysis sheds light on the effects of the underlying assumptions about the effect of the degree of decoupling on the model's results with a particular focus on countries' development status.

The utilized GTAP database additionally includes bilateral trade and protection matrices linking 57 sectors in 140 regions. To facilitate computation, we use an aggregate of 14 regions and 22 sectors. The regional aggregation accounts for the EU as one region and for aggregates of developed (IC) and developing (DC) WTO member countries, in addition to the least developed countries (LDC) (Tables A1 and A2 in the appendix). We singled out at least two EU trading partners from each of the aggregates. The primary agricultural sectors and the forward-linked food-producing sectors that enter the analysis are as disaggregated as possible, but all other industries are aggregated into a service and a manufacturing sector.

## Results

Removing EU domestic support payments causes well-known effects, such as reduced EU output and exports, whereas EU imports and world market prices increase.[4] The first section of the results presents the changes in countries' trade balances. Delving deeper into the results, the focus moves toward trade indicators to shed light on the changes in countries' trade patterns by applying the Herfindahl–Hirschman market and product concentration indexes. Finally, the equivalent variation provides further insights into how eliminating domestic support affects countries' welfare.

The results focus on primary agricultural and food commodities and are reported for developed, developing, and the least developed countries. However, in interpreting the results, the main emphasis is on the effects on developing and the least developed countries.

### *Effect on the trade balance for agricultural commodities*

Production changes and increasing world market prices raise the question of how the removal of domestic support payments affects foreign trade patterns. To answer this question, this section analyzes the changes in countries' import and export structures. Fig. 1 presents the initial and the 21 post-simulation values of the trade balances for the aggregation of all primary agricultural commodities, of which the results for scenarios FD, PD-100, PD-25, PD-50, and PD-75 are highlighted. Effects on the trade balance are represented as both values ($y$-axis) and percentage changes ($x$-axis) to offer more insight into these effects. A movement to the right hand side means that a country/region reinforces

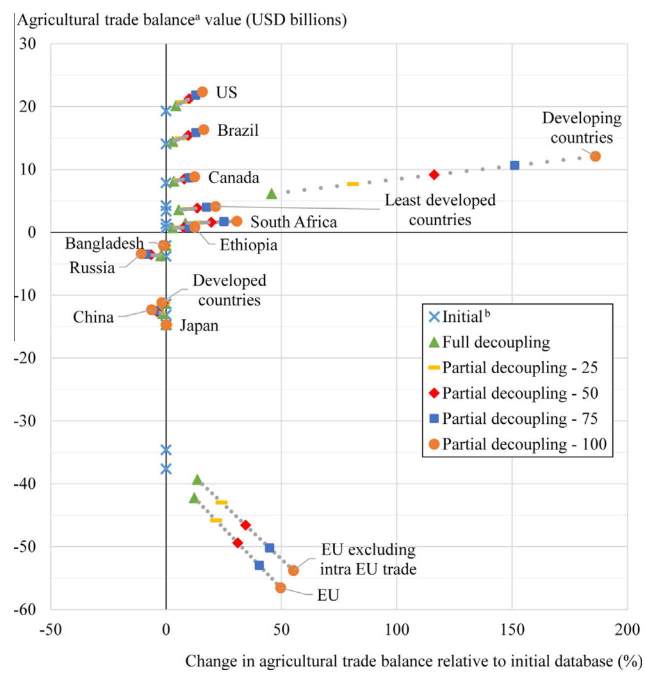


**Fig. 1.** Effects of eliminating domestic support under different assumptions of the SFP's degree of decoupling on the agricultural trade balance.[c,d] Note: [a] Agricultural trade balance = agricultural exports minus agricultural imports; negative value = net importing country; positive value = net exporting country. This graph plots the pre- and post-simulation values of the agricultural trade balance ($y$-axis) and the percentage changes compared to pre-simulation value ($x$-axis). Movement to the right hand side means that a country/region reinforces its status as net exporter (upper right quadrant) or net importer country (lower right quadrant). With a movement to the left the country reduces its status as net exporter/importer (upper/lower left quadrant). [b] Initial = Pre-simulation value of the trade balance for food commodities. [c] Please refer to Table 1 for more information on the set of databases and the scenario design. The numbers 25, 50, 75 and 100 in the legend indicate the share of the SFP that is shifted from the initial distribution according to land to the distribution according to a sector's factor usage to capital, labor and land. The coupling degree is increasing as the number increases. Selected scenarios are highlighted, all others are depicted as small dots. [d] Please refer to Table A1 in the appendix for more details on the regional aggregation. *Source*: Authors' elaboration.

[4] The changes in output and world market prices are provided in Tables B5–B8 in Appendix B.

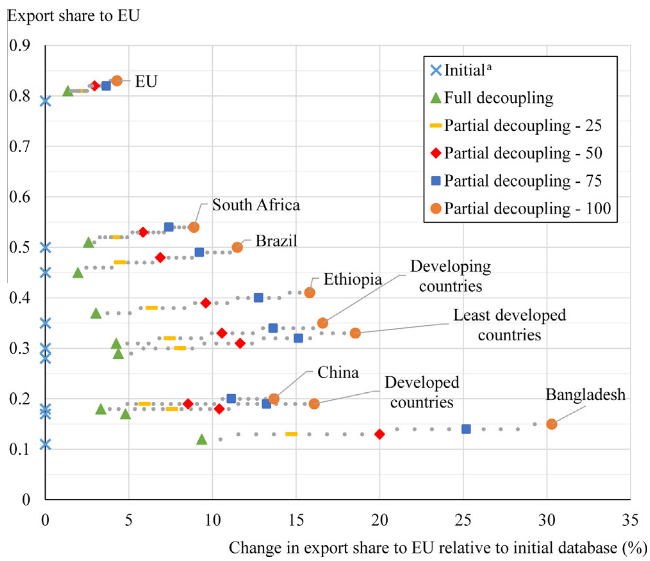


**Fig. 2.** Effects of eliminating domestic support under different assumptions of the SFP's degree of decoupling on countries' export share.[b,c] Note: [a] Initial = Pre-simulation index number. [b] Please refer to Table 1 for more information on the set of databases and the scenario design. The numbers 25, 50, 75 and 100 in the legend indicate the share of the SFP that is shifted from the initial distribution according to land to the distribution according to a sector's factor usage to capital, labor and land. The coupling degree is increasing as the number in the legend increases. Selected scenarios are highlighted, all others are depicted as small dots. [c] Please refer to Table A1 in the appendix for more details on the regional aggregation. *Source*: Authors' elaboration.

its status as net exporter of agricultural commodities (upper right quadrant) or net importer of agricultural commodities (lower right quadrant). With a movement to the left the country reduces its status as net exporter/importer of agricultural commodities (upper/lower left quadrant). Furthermore, Fig. 1 shows the effect on the EU's trade balance twofold considering total EU trade and EU extra trade excluding intra-EU trade.

Initially, the EU is a net importer of agricultural commodities (trade balance = −38 billion USD). Removing domestic support payments widens this import-export gap. In scenario FD, the trade balance increased to −42 billion USD (12%), whereas the trade balance increased by 50% to −57 billion USD in scenario PD-100. Thus, the graph shows that removing agricultural domestic support tends to strengthen the initial direction of trade in the EU. By contrast, in all other countries, whether net importing or net exporting, agricultural exports increase more than imports. Therefore, net-exporting countries clearly benefit from rising world market prices (Canada 3% in FD to 12% in PD-100, the US 4–16%, Brazil 3–16%, South Africa 8–31%, Ethiopia 3–12%, and the LDC 5–21%). The effect on net-importing countries other than the EU is only moderate (China −1% in FD to −6% in PD-100, Bangladesh 0% to −1% and Russia −11% to −2%.

In addition, Fig. 2 highlights the increase in the share of exports to the EU in all countries. Net-exporting countries such as South Africa, Brazil, and Ethiopia export more than 50%/45%/35% of their total exports to the EU, respectively. Depending on the degree of decoupling, these shares increase to 54%/50%/41%, respectively. Although net-importing countries initially show much lower shares of exports to the EU than net-exporting countries, they experience higher percentage changes at each degree of decoupling. The share for Bangladesh increases from 11% to 15%, and the share for Russia increases from 11% to 16%. Tables A3 and A4 in the appendix display further information regarding the changes in bilateral exports of aggregated agricultural commodities.

Fig. 1 presents the extent to which the underlying assumptions regarding the SFP's degree of decoupling affect these results. Removing the fully decoupled SFP creates only minimal and thus negligible effects. Therefore, scenario FD reflects the change caused mainly by non-SFP domestic support payments. Plotting the trade balance value with the percentage changes of the 21 scenarios depicts the range. Thus, comparing scenarios FD and PD-100 indicates that – depending – on the assumptions about the degree of decoupling – removing domestic support payments may cause an effect of up to quadruple that of the effect obtained in scenario FD.

*Trade balance of net-exporting developing countries*

By contrast, the range of the effect on the trade balance shown in Fig. 1 reveals high variation in the results for net food-exporting countries (DC 140%, South Africa 23%, LDC 16%, Brazil 13%, Ethiopia 9%, the US 12%, and Canada 9%). These results clearly indicate that changing the degree of decoupling affects developing countries the most. The ratio of the range (e.g., Brazil 13%) and the maximum effect of removing domestic support payments obtained in scenario PD-100 (e.g., Brazil 16%) shows that the SFP is responsible for up to 81% of the overall effect on the Brazilian trade balance for primary agricultural commodities. Thus, the SFP allocated by factor usage increases the effect of removing EU domestic support payments in Brazil more than fivefold. Correspondingly, the results demonstrate that developing and the least developed countries (more than quadruple the effect) are more affected than developed countries (triple the effect).

In the EU, other crops and vegetables and fruits are the most heavily subsidized agricultural products, followed by wheat, other grains, and livestock. Countries that specialize in exporting at least some of these products are thus considerably more affected by the EU removing domestic support payments than are other countries. Developing countries' exports are more concentrated in agricultural commodities than are the exports of high-income countries, which typically specialize in manufacturing and services. Brazil gains the most from the removal of vegetable, fruit, other crops, and livestock subsidies in the EU, whereas South Africa benefits from the removal of vegetable, fruit and, in particular, other crop subsidies. In addition to other crops, Ethiopia is negatively affected in its arable crops sectors because the factors of production are relocated to raise other crops. Nevertheless, why does the SFP affect countries differently? Subsidies distributed at a homogeneous rate across commodities allocated to land are capitalized in land prices and thus cause no production effects in the EU. By contrast, subsidies allocated by factor usage continue to stimulate production. In this case, the more capital- and labor-intensive a sector is, the more it is affected by removing the subsidy, and it thus would achieve a higher SFP amount than in the previous case when the subsidy was granted based on land. Although we allocated the SFP in the first step based on land and in the second step we redistributed the land-based value according to the sectors' factor usage to diminish such a bias, vegetables and fruits, other crops, and livestock remain the most responsive sectors in the EU[5] (compare Footnote 3). Eliminating the SFP leads to decreased production in these sectors. Production decreases to a lesser extent in other sectors that are less dependent on capital and labor – and that are thus more land-intensive – such as wheat, other grains, and oilseeds. Consequently, those sectors are less harmed by removing the SFP and hence do not generate effects as large as those from changes in vegetables, fruits, and other crops. Accordingly, developing countries in general and countries such as Brazil and South Africa, whose agricultural production and trade substantially rely on sectors such

[5] Additional information regarding domestic support payments is provided in Tables A5 and A6 in the Appendix.

as vegetables and fruits and other crops, are affected the most by removing the SFP and therefore show the highest variance caused by the underlying assumptions about the degree of decoupling.

*Trade balance of net-importing developing countries*

Regarding other net food-importing countries, the range of the effect on the trade balance varies between 0% (Japan), 1% (Bangladesh) and 9% (Russia) and thus indicates only minor effects (Fig. 1). Consumers in net food-importing countries are negatively affected through higher world market prices, whereas producers gain and exports increase. Fig. 1 reveals that the negative impact on consumers is offset by increases in agricultural commodity exports and hence leads to slight reductions in negative trade balance values. The more the degree of decoupling decreases, the larger the difference is between the extent of the effect on producers vs. consumers. Russia reports a comparably high number because it is in fact a net importer of agricultural commodities but a net exporter of wheat and is thus more affected than other net-importing countries.

*Effects on the trade balance of food commodities*

The aggregated trade balance of food commodities presents differences for total EU trade and EU trade that excludes intra-EU trade (Fig. 3). Initially, the EU is in both cases a net exporter of food commodities. Removing domestic support decreases net exports by 49% on average for the EU, excluding intra-EU trade; however, when considering intra-EU trade, the results show an average decrease in net exports of −104%. A percentage change greater than −100% implies that the net export value inverts. Thus, the SFP's degree of decoupling determines a change in the direction of EU trade. In scenario PD-100, the EU becomes a net importer, whereas in scenario FD, the EU remains a net exporter of food commodities. Here, the degree of decoupling determines price changes for the agricultural inputs used in the food sector. The less decoupled the SFP is, the higher the increase in agricultural commodity prices is and the less competitive is the EU food industry. Thus, EU food imports increase with a decreasing degree of decoupling. As a result, for the majority of countries, regardless of whether they are net importers or net exporters of food commodities, removing domestic support payments tends to strengthen the value of exports more than that of imports. Depending on the degree of decoupling, the SFP can increase the effect of removing domestic support payments by up to three times that obtained in scenario FD. However, in value terms, the implications for the food sector caused by the underlying degree of decoupling are less important than they are in the agricultural sector. In particular, the least developed countries reveal only minor effects.

The results in Figs. 1–3 clearly show that the degree of decoupling has a significant impact on the effect caused by removing domestic support payments – particularly for agricultural products.[6]

*Effect on market and product concentration*

This section addresses the effect of market and product concentration on trading partners and the commodities traded. The Herfindahl–Hirschmann market concentration index (HHMCI) and the Herfindahl–Hirschmann product concentration index (HHPCI) are well-known indexes for analyzing the effect of trade dispersion applied in trade analysis. The HHMCI determines the dispersion of trade value across an exporter's trading partners. By contrast, the HHPCI measures the dispersion of trade value across an exporter's products.

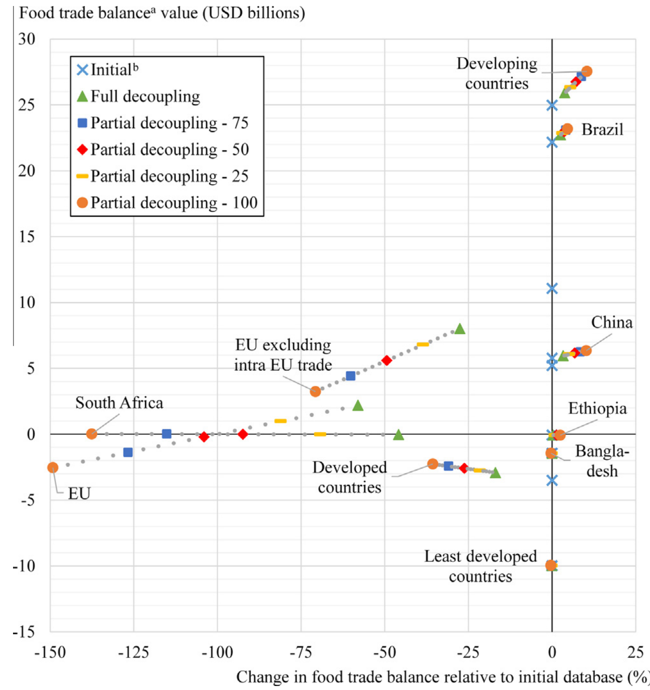


**Fig. 3.** Effects of eliminating domestic support under different assumptions of the SFP's degree of decoupling on the food trade balance.[c,d] Note: [a] Food trade balance = food exports minus food imports; negative value = net importing country; positive value = net exporting country. This graph plots the pre- and post-simulation values of the food trade balance (*y*-axis) and the percentage changes compared to pre-simulation value (*x*-axis). Movement to the right hand side means that a country/region reinforces its status as net exporter (upper right quadrant) or net importer (lower right quadrant). With a movement to the left the country reduces its status as net exporter/importer (upper/lower left quadrant). [b] Initial = Pre-simulation value of the trade balance for food commodities. [c] Please refer to Table 1 for more information on the set of databases and the scenario design. The numbers 25, 50, 75 and 100 in the legend indicate the share of the SFP that is shifted from the initial distribution according to land to the distribution according to a sector's factor usage to capital, labor and land. The coupling degree is increasing as the number increases. Selected scenarios are highlighted all others are depicted as small dots. [d] Please refer to Table A1 in the appendix for more details on the regional aggregation. *Source*: Authors' elaboration.

Fig. 4 shows the development of the HHMCI for agricultural commodities for selected countries. The *y*-axis represents the HHMCI, which ranges from 0 to 1. An index value close to 1 implies that a country has a high trade share concentrated in only a few markets, whereas an index value close to zero implies equally distributed trade. The *x*-axis shows the percentage changes in the index caused by removing domestic support payments. Fig. 4 highlights the results for five scenarios, whereas it depicts all other scenarios with a small dot.

At 0.67 (PD-100), the EU exhibits the highest HHMCI value of all countries and regions, which indicates that a high share of its agricultural trade value is concentrated in a few trading partners. EU agricultural trade is relatively concentrated in that intra-EU trade accounts for a significant share of EU exports (Fig. 2). The HHMCI increases by 9.3% when domestic support payments in database PD-100 are eliminated, which can at least partly be explained by an increase in intra-EU trade.

Fig. 1 confirms that intra-EU trade slightly diminishes the difference between EU imports and exports. Considering a fully decoupled SFP, the HHMCI of the EU increases by only 2.9%, to 0.63. Thus, abolishing domestic support payments tightens the concentration of EU agricultural trade to a few trading partners. Thereby, the higher the degree of decoupling is, the lower the increase in the HHMCI is.

[6] Trade balance results are provided in Appendix B.

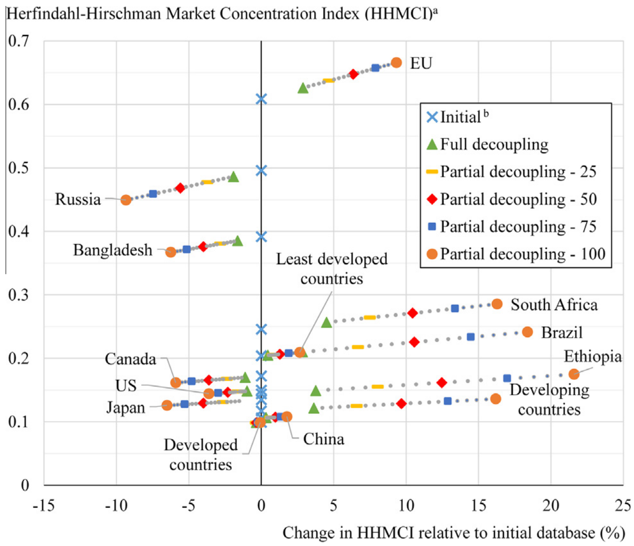


**Fig. 4.** Effects of eliminating domestic support under different assumptions of the SFP's degree of decoupling on the Herfindahl–Hirschman Market Concentration Index.[c,d] Note: [a] Herfindahl–Hirschman Market Concentration Index (HHMCI): 0 = trade is equally distributed; 1 = trade is concentrated in one market. This graph plots the pre- and post-simulation values of the HHMCI (*y*-axis) and the percentage changes compared to pre-simulation value (*x*-axis). Upwards movements to the right indicate an increase in market concentration. Downward movements to the left indicate a decrease in market concentration. [b] Initial = Pre-simulation index number. [c] Please refer to Table 1 for more information on the set of databases and the scenario design. The numbers 25, 50, 75 and 100 in the legend indicate the share of the SFP that is shifted from the initial distribution according to land to the distribution according to a sector's factor usage to capital, labor and land. The coupling degree is increasing as the number increases. Selected scenarios are highlighted, all others are depicted as small dots. [d] Please refer to Table A1 in the appendix for more details on the regional aggregation. *Source*: Authors' elaboration.

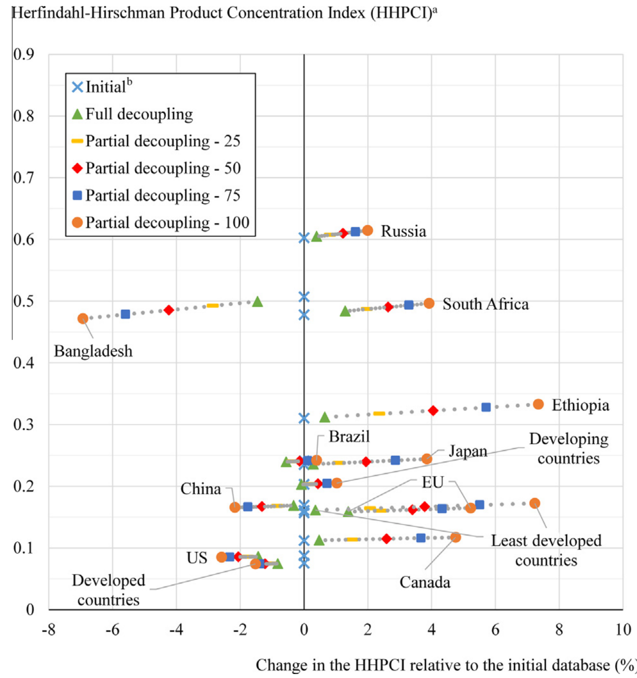


**Fig. 5.** Effects of eliminating domestic support under different assumptions of the SFP's degree of decoupling on the Herfindahl–Hirschman Product Concentration Index.[c,d] Note: [a] Herfindahl–Hirschman Product Concentration Index (HHPCI): 0 = trade is equally distributed across products – not vulnerable to trade shocks; 1 = trade is concentrated on one product – vulnerable to trade shocks. This graph plots the pre- and post-simulation values of the HHPCI (*y*-axis) and the percentage changes compared to pre-simulation value (*x*-axis). Upwards movements to the right indicate an increase of the vulnerability to trade shocks Downward movements to the left indicate a decrease of the vulnerability to trade shocks. [b] Initial = Pre-simulation index number. [c] Please refer to Table 1 for more information on the set of databases and the scenario design. The numbers 25, 50, 75 and 100 in the legend indicate the share of the SFP that is shifted from the initial distribution according to land to the distribution according to a sector's factor usage to capital, labor and land. The coupling degree is increasing as the number increases. Selected scenarios are highlighted, all others are depicted as small dots. [d] Please refer to Table A1 in the appendix for more details on the regional aggregation. *Source*: Authors' elaboration.

Most of the other countries, and the developed countries in particular, are less dependent on their trading partners compared with the EU, as indicated by an index value that is lower than 0.2. The exceptions are South Africa (0.25), Bangladesh (0.39), Brazil (0.2), Ethiopia (0.14) and the LDC (0.2).

The removal of domestic support payments results in a non-uniform picture. The HHMCI decreases for developed countries but increases for developing countries, which implies that developed countries' trade diversifies more, whereas developing countries' dependency on their trading partners increases. The exceptions are Bangladesh and Russia, which are net importers of agricultural commodities. Initially, both countries show a comparably high dependency on their trading partners; removing domestic support payments (scenario PD-100) leads to rather low changes (−6.2% and −9.3%, respectively) but reduces each country's dependency on its trading partners. The most affected countries are Brazil (18.4%), South Africa (16.3%), Ethiopia (21.6%), and the DC (16.2%). Accordingly, Fig. 4 shows that deviations in the SFP allocation clearly influence the index. Comparing scenarios PD-100 and FD, the means (5.1% and 1.0%, respectively) and standard deviations (10.8% and 2.3%, respectively) calculated across regions clearly decrease. Thus, the effect of removing domestic support is much more uniform across countries, assuming a fully decoupled SFP.

Particularly notable are the developing and least developed countries regarding agricultural commodities. Only these countries reveal an increased concentration of trading partners that is considerably affected by the degree of decoupling. Brazil and South Africa are already important EU trading partners. Consequently, the significant impact of the degree of decoupling on sectors such as vegetables, fruits, and other crops leads to increased exports to the EU, thus increasing these countries' dependency on EU trade.

Fig. 5 shows the HHPCI for agricultural commodities for selected countries. An HHPCI value close to 1 implies that a country has a high trade share concentrated in a few products. The HHPCI of 0.16 for the EU indicates that the EU is not particularly vulnerable to trade shocks because its trade is substantially dispersed across products. In this regard, most of the countries also show an index value below 0.2.

The exceptions include Brazil (0.24), South Africa (0.5), Bangladesh (0.47), and Ethiopia (0.34). These countries are much more vulnerable to trade shocks because their trade is considerably more concentrated in a small number of products. In the initial GTAP database, vegetables and fruits account for 71% of South Africa's agricultural export value. In Brazil, other crops and oilseeds comprise 75% of the country's agricultural export value, and other crops determine 55% of Ethiopia's agricultural export value. Eliminating domestic support payments in the EU – and particularly the SFP, depending on the degree of decoupling – causes the highest effects in the vegetables, fruits, and other crops sectors. South Africa and Ethiopia are notable for their increased exports in the vegetables and fruits sectors and other crops sector, respectively. Thus, trade diversification diminishes. Brazilian exports are concentrated in other crops and vegetables and fruits; therefore, product concentration increases only slightly and is thus less affected by variations in the degree of decoupling. By contrast,

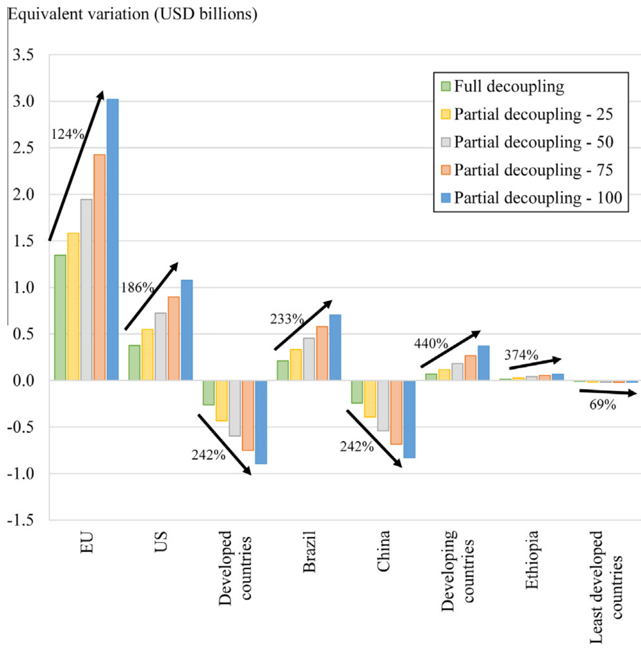


**Fig. 6.** Effects of eliminating domestic support under different assumptions of the SFP's degree of decoupling on welfare in selected countries.[a,b,c] Note: [a] The percentage number gives the percentage change between scenario full decoupling and partial decoupling – 100. [b] Please refer to Table 1 for more information on the set of databases and the scenario design. The numbers 25, 50, 75 and 100 in the legend indicate the share of the SFP that is shifted from the initial distribution according to land to the distribution according to a sector's factor usage to capital, labor and land. The coupling degree is increasing as the number increases. [c] Please refer to Table A1 in the appendix for more details on the regional aggregation. *Source*: Authors' elaboration.

the index decreases in Bangladesh. Bangladesh diversifies its trade by reducing plant-based fiber exports, which initially accounted for 72% of the country's agricultural export value, in favor of other crops.

Comparing the effects on both indexes reveals that the degree of decoupling of EU domestic support affects the HHMCI considerably more than it does the HHPCI. Nevertheless, the HHPCI also shows that increased decoupling leads to more balanced effects across regions. The degree of decoupling again determines the extent to which the effect on highly affected countries such as South Africa and Ethiopia varies and demonstrates that the contrast with less affected countries can be strong, depending on the degree of decoupling.

### *Effect on welfare*

Finally, Fig. 6 sheds light on the welfare effects of eliminating domestic support payments for selected countries. Scenario FD shows that the EU clearly gains from removing domestic support payments (1.3 billion USD). In addition, the welfare gain increases by 124% in scenario PD-100 to 3 billion USD. This result indicates that the EU welfare gain clearly diminishes with increased decoupling. Such a welfare gain occurs because the SFP's effect on the market is less distortive when there is a higher degree of decoupling. Thus, production incentives and the effects on agents' prices decline and lead to a crowding out of non-competitive producers and reduced distortion losses.

The mean based on the simulation results found with the 21 databases, reveals that the average EU welfare gain equals 2 billion USD. Overall, the EU exhibits the highest welfare effects. Other countries and regions are affected differently when the EU removes its domestic support payments. Net food-exporting countries such as the US, Brazil, South Africa and Ethiopia report welfare gains, whereas net food-importing countries such as China and least developed countries experience welfare losses. In addition, China, and least developed countries reveal a low share of agricultural exports to the EU relative to total exports and thus benefit less from the EU's increasing import demands. By contrast, these countries have a relatively higher share for all traded commodities and are therefore somewhat negatively affected by reduced EU import demand for all traded commodities. Fig. 6 highlights the considerable effect on the equivalent variation that stems from integrating the SFP into the GTAP model and database. In general, the effect of decreased decoupling on welfare is higher for all other countries than it is for the EU. The effect on welfare varies between 186% and 440% in scenario FD compared with PD-100.

The results for the least developed countries are an exception because modeling the SFP as partially decoupled (scenario PD-100) increases the welfare loss by only 69% for those countries. Delving deeper into the results reveals that the welfare loss is caused by the degree of decoupling. However, reallocating the SFP to labor and capital (PD-5–PD-100) leads to changes in the factor allocation and consequently affects production, such that the effect of other payment categories on welfare increases and offsets the effect of a fully decoupled SFP. We observe these effects in all countries, but not to this extent.

## Discussion and conclusion

The SFP is granted to agricultural producers based on land entitlements. Hence, it can be regarded as a lump-sum transfer to households, which is an approach that is often applied in single-country CGE models in particular. According to the literature, it is widely accepted that at least part of the SFP capitalizes in the price for land. However, lump-sum transfers to households do not account for such an effect. Therefore, to account for the capitalization in land rent, the SFP is allocated according to land at a homogeneous rate across primary agricultural commodities in the GTAP model. According to Frandsen et al. (2003) and Urban et al. (2014), the SFP then fully capitalizes in the market price for land. According to the GTAP approach, the value added is modeled as a transfer to the regional household, which allocates the income to households, savings and the government. Thus, modeling the SFP in this way reflects an income transfer to households. However, the extent to which the SFP capitalizes in the land rent is still uncertain, and the estimates differ between regions depending on land markets. The implications of other coupling channels are not conclusively addressed. Numerous studies specifically analyze the effect of a particular coupling channel. In addition, the effects of other coupling channels are country specific and depend on the structure of the factor market. Our approach still relies on ad-hoc assumptions. The GTAP model does not represent the different coupling channels explicitly, which would require several major extensions of the model, such as the introduction of heterogeneous firms to account for farm-exit decisions and risk aversion of producers to account for the risk-reducing effect of the SFP. In addition, a dynamic framework would be necessary to include the future expectations of farmers and the effect on wealth. By matching the coupling channels with the GTAP production factors, we are able to overcome this problem. This modeling procedure enables the re-coupling of the SFP at different degrees; thus, we adjust the model's assumptions to depict country-specific ranges of estimation results or the full range of degrees of decoupling and quantify the effect of over- or underestimations of the real degree of decoupling.

Our sensitivity analysis confirms the results revealed by a number of other studies that have analyzed agricultural domestic support, such as those by Dimaranan et al. (2004), Bouët et al. (2005), Matthews (2008), Winters (2005), and Hertel and Keeney (2006). In addition to the prior literature, we show a strong contrast between scenarios PD-100 and FD. The variance in the results measured across regions considerably increases as the degree of decoupling decreases. It becomes apparent that the SFP's degree of decoupling significantly influences the results for net exporters of agricultural and food commodities, in particular for developing and the least developed countries. The effects on the trade balance substantially increase from scenario FD to scenario PD-100 (e.g., Brazil: 3–16%; South Africa 8–31%; Ethiopia 3–12%), leading to results that range from four to five times higher when domestic support payments are removed under different assumptions regarding the SFP's degree of decoupling and its modeling. A similar dimension can be observed regarding changes in the HHMCI, whereas the impact of the degree of decoupling is lower for the HHPCI. In addition, the degree of decoupling has a clear impact on high-income countries. However, the magnitude of these effects compared with developing countries is slightly lower. By contrast, the impact of the degree of decoupling is the lowest in net food-importing countries. Higher world market prices negatively affect consumers, whereas agricultural producers benefit. The effect on producers offsets the effect on consumers, such that the ratio of exports to imports slightly increases. Of course, these contradictory effects reflect the impact of the degree of decoupling, but the observed overall effect is clearly mitigated. The welfare gains achieved in net food-exporting countries and the welfare losses in net food-importing countries increase by more than 200% with increased decoupling, with the highest effects in developing countries, which experience an increase of 440% from scenario FD to PD-100.

This result emphasizes the relevance of considering the underlying assumptions about the SFP's degree of decoupling when analyzing agricultural domestic support. These assumptions significantly affect the results and thus clearly matter for international trade analyses, particularly in developing countries. In the absence of comprehensive estimators of the degree of decoupling that cover other coupling channels, experienced experts and the results of the best available analysis determine the assumptions about the SFP's degree of decoupling in trade analyses. Consequently, these analyses might over- or underestimate the effects of domestic support payments. To overcome this problem, our analysis delivers insights into the effects of removing domestic support payments that account for the full bandwidth of underlying assumptions about the degree of decoupling. Therefore, our analysis helps validate the results by providing a range for the actual impact.

Our analysis presents a step toward validating the model's results, and it thus provides a scope for further research. In recent years, a number of high-income countries have altered the support they provide to agricultural producers, and emerging countries such as Brazil, India, China, and South Africa have begun to expand their support programs. Accordingly, analyzing multilateral trade liberalization requires more than EU domestic support payments to validate results. It would also be helpful to extend this analysis to cover at least all of the countries that provide their producers with a significant amount of domestic support, particularly with uncertain assumptions about the possible outcomes of policy instruments. The approach applied in this article is general and can thus be easily transferred to all other countries, given that PSE data are provided. Second, the focus in this article is on domestic support. The impact of country-specific border measures that prevent producers and consumers from receiving the total gains associated with removing EU domestic support payments possibly affected the results. Such policies might hinder the adjustment of domestic market prices according to changes in world market prices, and there might therefore be only a partial pass-through of the effects on other countries' domestic markets. Thus, this result might have led to understated effects of domestic support payments in our analysis.

## Acknowledgements

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## Appendix A

See Tables A1–A6.

**Table A1**
Regional aggregation. *Source*: Authors' elaboration.

| | Countries and regions | Abbreviation |
|---|---|---|
| 1 | EU<br>Austria, Belgium, Denmark, Finland, France, Germany, Ireland, United Kingdom, Greece, Italy, Luxembourg, Netherlands, Portugal, Spain, Sweden, Czech Republic, Cyprus, Hungary, Malta, Poland, Slovakia, Slovenia, Estonia, Latvia, Lithuania, Bulgaria, Romania | EU |
| 2 | Canada | can |
| 3 | US | usa |
| 4 | Japan | jpn |
| 5 | Rest of WTO developed countries<br>Australia, New Zealand, Switzerland, Norway, Rest of EFTA, Croatia, Hong Kong, Korea, Singapore, Kuwait, United Arab. Emirates | IC |
| 6 | Brazil | bra |
| 7 | South Africa | zaf |
| 8 | China | chn |
| 9 | Rest of WTO developing countries<br>Mongolia, Rest of East Asia, Brunei Darassalam, Indonesia, Malaysia, Philippines, Thailand, Viet Nam, India, Pakistan, Sri Lanka, Mexico, Argentina, Bolivia, Chile, Colombia, Ecuador, Paraguay, Peru, Uruguay, Venezuela, Costa Rica, Guatemala, Honduras, Nicaragua, Panama, El Salvador, Rest of Central America, Dominican Republic, Jamaica, Puerto Rico, Trinidad and Tobago, Caribbean, Albania, Ukraine, Rest of Eastern Europe, Kyrgyzstan, Armenia, Georgia, Bahrein, Israel, Jordhan, Oman, Qatar, Saudi Arabia, Turkey, Rest of Western Asia, Egypt, Morocco, Tunisia, Rest of North Africa, Cameroon, Cote d'Ivoire, Ghana, Nigeria, Kenia, Mauritius, Zimbabwe, Botswana, Namibia, Rest of South African CU | DC |

**Table A1** (*continued*)

| | Countries and regions | Abbreviation |
|---|---|---|
| 10 | Bangladesh | bgd |
| 11 | Ethiopia | eth |
| 12 | Rest of least developed countries<br>Cambodia, Lao People's Democratic Republic, Rest of Southeast Asia, Nepal, Rest of South Asia, Benin, Burkina Faso, Guinea, Senegal, Togo, Rest of Western Africa, Rest of Central Africa, Rest of South Central Africa, Madagascar, Malawi, Mozambique, Rwanda, Tanzania, Uganda, Zambia, Other Eastern Africa | LDC |
| 13 | Russia | rus |
| 14 | Rest of the World<br>Rest of Oceania, Taiwan, Rest of North America, Rest of South America, Belarus, Rest of Europe, Kazakhstan, Rest of FSU, Azerbaijan, Iran Islamic Republic, rest of the world | RoW |

**Table A2**
Sector aggregation. *Source*: Authors' elaboration.

| | Sectors | Abbreviation |
|---|---|---|
| | *Primary agricultural commodities* | |
| 1 | Paddy rice | pdr |
| 2 | Wheat | wht |
| 3 | Cereal grains | gro |
| 4 | Vegetables, fruits, nuts | v_f |
| 5 | Oilseeds | osd |
| 6 | Raw sugar (sugar cane, sugar beet) | c_b |
| 7 | Plant-based fibers | pfb |
| 8 | Crops nec | ocr |
| 9 | Ruminants (cattle, sheep, goats, horses) | ctl |
| 10 | Non-ruminants (other animal products nec) | oap |
| 11 | Raw milk | rmk |
| 12 | Wool, silk worm cocoons | wol |
| | *Food commodities* | |
| 13 | Ruminant meat products | cmt |
| 14 | Non-ruminant meat products | omt |
| 15 | Vegetable oils and fats | vol |
| 16 | Dairy products | mil |
| 17 | Processed rice | pcr |
| 18 | Refined sugar | sgr |
| 19 | Other food | ofd |
| 20 | Beverages and tobacco products | b_t |
| | *Other commodities* | |
| 21 | Manufacturing<br>Coal, oil, gas, petroleum, coal products, Forestry, fishing, minerals, Textiles, wearing apparel, leather products, wood products, paper products, publishing, chemical, rubber, plastic prods, mineral pro- ducts nec, ferrous metals, metals nec, metal products, motor vehicles and parts, transport equipment, electronic equipment, machinery and equipment, manufactures nec | MNFC |
| 22 | Services<br>Water, construction, trade, transport nec, sea transport, air trans-port, communication, financial services nec, insurance, business services nec, recreation and other services, PubAdmin/Defence/Health/Educat, dwellings | SERV |

**Table A3**
Effects of eliminating domestic support on bilateral exports for aggregated agricultural commodities for selected countries in % (fully decoupled SFP)[a,b] *Source*: Authors' elaboration.

| Reporter \ Partner | EU | can | US | IC | bra | zaf | chn | DC | bgd | eth | LDC |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **EU** | 0.3 | -5.1 | -9.1 | -5.0 | -4.6 | -5.5 | -4.3 | -7.7 | -14.5 | -8.2 | -7.5 |
| **can** | 9.0 | 0.9 | 1.5 | 1.9 | 0.2 | 0.5 | 0.5 | 1.2 | 0.3 | 2.5 | 3.7 |
| **US** | 8.6 | 0.8 | 1.1 | 1.9 | 0.9 | 0.6 | 0.6 | 1.3 | 0.3 | 3.8 | 2.5 |
| **IC** | 7.0 | 0.4 | 0.4 | 3.4 | 1.3 | 1.0 | 0.3 | 1.3 | 0.0 | 1.0 | 2.7 |
| **bra** | 4.5 | 0.9 | 1.1 | 1.3 | 1.3 | 1.9 | 0.4 | 1.5 | 0.2 | 2.0 | 1.4 |
| **zaf** | 6.8 | 0.5 | 0.7 | 2.2 | 1.8 | 1.3 | 1.2 | 1.5 | 0.4 | 1.3 | 1.4 |
| **chn** | 5.9 | 1.2 | 1.1 | 2.5 | 1.9 | 1.5 | 1.5 | 1.8 | 1.0 | 2.1 | 2.0 |
| **DC** | 7.3 | 0.7 | 0.9 | 2.1 | 0.9 | 1.1 | 0.4 | 1.2 | 0.4 | 1.8 | 2.0 |
| **bgd** | 13.5 | 2.0 | 2.2 | 3.3 | 1.2 | 3.7 | 1.1 | 2.8 | 1.1 | 1.5 | 2.9 |
| **eth** | 5.4 | 0.5 | 0.4 | 1.6 | 0.7 | 0.9 | 0.0 | 0.8 | 0.0 | 1.0 | 0.9 |
| **LDC** | 7.6 | 0.8 | 0.8 | 2.5 | 0.7 | 1.1 | 0.4 | 1.4 | 0.3 | 1.9 | 1.1 |

[a] Please refer to Table 1 for more information on the set of databases and the scenario design.
[b] IC = developed countries, DC = developing countries, LDC = least developed countries. Please refer to Table A1 in the appendix for more details on the regional aggregation.

**Table A4**
Effects of eliminating domestic support on bilateral exports for aggregated agricultural commodities for selected countries in % (partially decoupled SFP – 100)[a,b] *Source*: Authors' elaboration.

| Reporter \ Partner | EU | can | US | IC | bra | zaf | chn | DC | bgd | eth | LDC |
|---|---|---|---|---|---|---|---|---|---|---|---|
| EU | -1.4 | -19.4 | -22.9 | -17.3 | -15.8 | -22.7 | -14.7 | -26.8 | -38.3 | -32.9 | -30.2 |
| can | 45.5 | 2.2 | 3.2 | 6.3 | -0.8 | 0.5 | 1.5 | 3.6 | 0.1 | 9.3 | 13.5 |
| US | 34.4 | 2.5 | 2.9 | 6.4 | 2.0 | 1.5 | 1.9 | 4.1 | 0.4 | 15.6 | 9.1 |
| IC | 23.8 | 1.4 | 1.5 | 8.1 | 4.5 | 4.3 | 0.7 | 4.0 | -0.1 | 5.7 | 11.4 |
| bra | 26.8 | 3.7 | 4.3 | 5.2 | 2.9 | 9.0 | 1.2 | 4.8 | 0.1 | 10.1 | 5.2 |
| zaf | 25.1 | 1.4 | 2.3 | 7.2 | 6.1 | 4.5 | 3.3 | 4.8 | 0.8 | 6.0 | 5.3 |
| chn | 24.6 | 4.1 | 3.6 | 9.0 | 6.3 | 5.2 | 4.8 | 6.8 | 3.2 | 8.9 | 8.2 |
| DC | 29.9 | 2.5 | 2.7 | 7.2 | 2.8 | 3.7 | 0.9 | 4.0 | 1.0 | 9.0 | 8.0 |
| bgd | 45.2 | 8.4 | 8.8 | 11.9 | 4.2 | 19.4 | 3.3 | 7.5 | 3.6 | 5.9 | 14.1 |
| eth | 27.8 | 0.9 | 0.4 | 4.7 | 0.5 | 1.9 | -1.1 | 1.6 | -1.6 | 2.1 | 2.0 |
| LDC | 32.5 | 2.1 | 2.2 | 8.1 | 2.1 | 4.2 | 1.1 | 3.7 | 0.0 | 8.4 | 3.6 |

[a] Please refer to Table 1 for more information on the set of databases and the scenario design. The number (100) indicate the share of the SFP that is shifted from the initial distribution according to land to the distribution according to a sector's factor usage to capital, labor and land. The coupling degree is increasing as the number increases.

[b] IC = developed countries, DC = developing countries, LDC = least developed countries. Please refer to Table A1 in the appendix for more details on the regional aggregation.

**Table A5**
Allocation of domestic support payments in the GTAP database version 8.2 year 2007 – partially decoupled SFP-100.[a] *Source*: Authors' elaboration.

| Payment type | Product[b] | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | pdr | wht | gro | v_f | osd | c_b | pfb | ocr | ctl | oap | rmk | wol | Total |
| *Value of domestic support payments in million USD* | | | | | | | | | | | | | |
| Land | 562 | 3,627 | 3,708 | 4,283 | 1,985 | 287 | 1,520 | 5,673 | 520 | 2,065 | 2,021 | 5 | 26,255 |
| Capital | 106 | 1,352 | 1,442 | 3,434 | 885 | 185 | 189 | 4,698 | 4,584 | 2,402 | 2,583 | 5 | 21,866 |
| Unskilled labor | 197 | 2,320 | 2,516 | 5,029 | 1,481 | 297 | 383 | 6,198 | 748 | 2,939 | 3,071 | 7 | 25,185 |
| Skilled labor | 14 | 149 | 156 | 344 | 97 | 19 | 27 | 419 | 53 | 183 | 206 | 0 | 1,667 |
| Output | 16 | 0 | 8 | 493 | 4 | 0 | 0 | 507 | 0 | 9 | 286 | 1 | 1,325 |
| Input | 4 | 366 | 281 | 957 | 161 | 39 | 10 | 904 | 1,468 | 1,986 | 1,455 | 6 | 7,636 |
| Total | 899 | 7,814 | 8,110 | 14,541 | 4,612 | 828 | 2,130 | 18,399 | 7,372 | 9,583 | 9,623 | 24 | 83,934 |
| *Share of domestic support payments in %* | | | | | | | | | | | | | |
| Land | 0.7 | 4.3 | 4.4 | 5.1 | 2.4 | 0.3 | 1.8 | 6.8 | 0.6 | 2.5 | 2.4 | 0.0 | 31.3 |
| Capital | 0.1 | 1.6 | 1.7 | 4.1 | 1.1 | 0.2 | 0.2 | 5.6 | 5.5 | 2.9 | 3.1 | 0.0 | 26.1 |
| Unskilled labor | 0.2 | 2.8 | 3.0 | 6.0 | 1.8 | 0.4 | 0.5 | 7.4 | 0.9 | 3.5 | 3.7 | 0.0 | 30.0 |
| Skilled labor | 0.0 | 0.2 | 0.2 | 0.4 | 0.1 | 0.0 | 0.0 | 0.5 | 0.1 | 0.2 | 0.2 | 0.0 | 2.0 |
| Output | 0.0 | 0.0 | 0.0 | 0.6 | 0.0 | 0.0 | 0.0 | 0.6 | 0.0 | 0.0 | 0.3 | 0.0 | 1.6 |
| Input | 0.0 | 0.4 | 0.3 | 1.1 | 0.2 | 0.0 | 0.0 | 1.1 | 1.7 | 2.4 | 1.7 | 0.0 | 9.1 |
| Total | 1.1 | 9.3 | 9.7 | 17.3 | 5.5 | 1.0 | 2.5 | 21.9 | 8.8 | 11.4 | 11.5 | 0.0 | 100.0 |
| *Ratio of domestic support payments to value of production in %* | | | | | | | | | | | | | |
| Land | 0.1 | 0.8 | 0.8 | 0.9 | 0.4 | 0.1 | 0.3 | 1.2 | 0.1 | 0.5 | 0.4 | 0.0 | 5.7 |
| Capital | 0.0 | 0.3 | 0.3 | 0.7 | 0.2 | 0.0 | 0.0 | 1.0 | 1.0 | 0.5 | 0.6 | 0.0 | 4.8 |
| Unskílled labor | 0.0 | 0.5 | 0.5 | 1.1 | 0.3 | 0.1 | 0.1 | 1.4 | 0.2 | 0.6 | 0.7 | 0.0 | 5.5 |
| Skilled labor | 0.0 | 0.0 | 0.0 | 0.1 | 0.0 | 0.0 | 0.0 | 0.1 | 0.0 | 0.0 | 0.0 | 0.0 | 0.4 |
| Output | 0.0 | 0.0 | 0.0 | 0.1 | 0.0 | 0.0 | 0.0 | 0.1 | 0.0 | 0.0 | 0.1 | 0.0 | 0.3 |
| Input | 0.0 | 0.1 | 0.1 | 0.2 | 0.0 | 0.0 | 0.0 | 0.2 | 0.3 | 0.4 | 0.3 | 0.0 | 1.7 |
| Total | 0.2 | 1.7 | 1.8 | 3.2 | 1.0 | 0.2 | 0.5 | 4.0 | 1.6 | 2.1 | 2.1 | 0.0 | 18.3 |

[a] Please refer to Table 1 for more information on the set of databases and the scenario design. The number indicate the share of the SFP that is shifted from the initial distribution according to land to the distribution according to a sector's factor usage to capital, labor and land. The coupling degree is increasing as the number increases.

[b] Please refer to Table A2 in the appendix for more details on the sectoral aggregation.

**Table A6**
Allocation of domestic support payments in the GTAP database version 8.2 year 2007 – fully decoupled SFP.[a] *Source*: Authors' elaboration.

| Payment type | Product[b] | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | pdr | wht | gro | v_f | osd | c_b | pfb | ocr | ctl | oap | rmk | wol | Total |
| *Value of domestic support payments in million USD* | | | | | | | | | | | | | |
| Land | 842 | 6,886 | 7,220 | 11,290 | 4,050 | 699 | 2,069 | 14,387 | 1,893 | 6,225 | 6,339 | 15 | 61,916 |
| Capital | 33 | 514 | 547 | 1,636 | 360 | 81 | 48 | 2,401 | 3,974 | 1,270 | 1,437 | 2 | 12,302 |
| Unskilled labor | 3 | 44 | 48 | 140 | 31 | 7 | 4 | 165 | 30 | 76 | 86 | 0 | 634 |
| Skilled labor | 0 | 3 | 3 | 10 | 2 | 0 | 0 | 11 | 2 | 5 | 6 | 0 | 43 |
| Output | 16 | 0 | 8 | 494 | 4 | 0 | 0 | 508 | 0 | 9 | 286 | 1 | 1,326 |
| Input | 4 | 369 | 283 | 965 | 162 | 39 | 10 | 910 | 1,477 | 1,999 | 1,465 | 6 | 7,689 |
| Total | 898 | 7,815 | 8,109 | 14,534 | 4,610 | 827 | 2,132 | 18,381 | 7,377 | 9,583 | 9,619 | 24 | 83,909 |

**Table A6** (*continued*)

| Payment type | Product[b] | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | pdr | wht | gro | v_f | osd | c_b | pfb | ocr | ctl | oap | rmk | wol | Total |
| *Share of domestic support payments in %* | | | | | | | | | | | | | |
| Land | 1.0 | 8.2 | 8.6 | 13.5 | 4.8 | 0.8 | 2.5 | 17.1 | 2.3 | 7.4 | 7.6 | 0.0 | 73.8 |
| Capital | 0.0 | 0.6 | 0.7 | 1.9 | 0.4 | 0.1 | 0.1 | 2.9 | 4.7 | 1.5 | 1.7 | 0.0 | 14.7 |
| Unskilled labor | 0.0 | 0.1 | 0.1 | 0.2 | 0.0 | 0.0 | 0.0 | 0.2 | 0.0 | 0.1 | 0.1 | 0.0 | 0.8 |
| Skilled labor | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.1 |
| Output | 0.0 | 0.0 | 0.0 | 0.6 | 0.0 | 0.0 | 0.0 | 0.6 | 0.0 | 0.0 | 0.3 | 0.0 | 1.6 |
| Input | 0.0 | 0.4 | 0.3 | 1.1 | 0.2 | 0.0 | 0.0 | 1.1 | 1.8 | 2.4 | 1.7 | 0.0 | 9.2 |
| Total | 1.1 | 9.3 | 9.7 | 17.3 | 5.5 | 1.0 | 2.5 | 21.9 | 8.8 | 11.4 | 11.5 | 0.0 | 100.0 |
| *Ratio of domestic support payments to value of production in %* | | | | | | | | | | | | | |
| Land | 0.2 | 1.5 | 1.6 | 2.5 | 0.9 | 0.2 | 0.5 | 3.1 | 0.4 | 1.4 | 1.4 | 0.0 | 13.5 |
| Capital | 0.0 | 0.1 | 0.1 | 0.4 | 0.1 | 0.0 | 0.0 | 0.5 | 0.9 | 0.3 | 0.3 | 0.0 | 2.7 |
| Unskílled labor | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.1 |
| Skilled labor | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 |
| Output | 0.0 | 0.0 | 0.0 | 0.1 | 0.0 | 0.0 | 0.0 | 0.1 | 0.0 | 0.0 | 0.1 | 0.0 | 0.3 |
| Input | 0.0 | 0.1 | 0.1 | 0.2 | 0.0 | 0.0 | 0.0 | 0.2 | 0.3 | 0.4 | 0.3 | 0.0 | 1.7 |
| Total | 0.2 | 1.7 | 1.8 | 3.2 | 1.0 | 0.2 | 0.5 | 4.0 | 1.6 | 2.1 | 2.1 | 0.0 | 18.3 |

[a] Please refer to Table 1 for more information on the set of databases and the scenario design.
[b] Please refer to Table A2 in the appendix for more details on the sectoral aggregation.

## Appendix B. Supplementary material

Supplementary data associated with this article can be found, in the online version, at http://dx.doi.org/10.1016/j.foodpol.2016.01.003.

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# How decoupled is the Single Farm Payment and does it matter for international trade?

Kirsten Urban, Hans G. Jensen and Martina Brockmeier

## Appendix B. Supplementary material

**Table B1. Effects of eliminating domestic support under different assumptions of the SFP's degree of decoupling on the trade balance (TB)[a,b,c]**

| | Primary agricultural commodities | | | | | | Food commodities | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Partial de-coupling - 100 | | Full decoupling | | Statistics | | Partial de-coupling - 100 | | Full decoupling | | Statistics | |
| | USD mn | % | USD mn | % | m[d] (%) | rng[d] (%) | USD mn | % | USD mn | % | m[d] (%) | rng[d] (%) |
| EU: | | | | | | | | | | | | |
| Total trade | -56,535 | 49.7 | -42,222 | 12.3 | 31.1 | 37.4 | -2,538 | -149.2 | 2,187 | -58 | -103.8 | 91.2 |
| Excl. intra EU trade | -53,791 | 55.2 | -39,318 | 13.6 | 34.5 | 41.6 | 3,236 | -70,7 | 8,016 | -27.6 | -34.5 | -43.1 |
| Canada | 8,829 | 12.4 | 8,118 | 3.3 | 7.9 | 9.1 | -502 | -41.0 | -730 | -14.2 | -27.7 | 26.8 |
| US | 22,336 | 15.7 | 20,136 | 4.3 | 10.0 | 11.4 | -22,469 | -4.7 | -23,224 | -1.5 | -3.1 | 3.2 |
| Japan | -14,695 | 0.1 | -14,709 | 0.2 | 0.1 | -0.1 | -34,384 | -0.1 | -34,468 | 0.1 | 0.0 | 0.2 |
| Developed countries | -11,159 | -1.8 | -11,308 | -0.5 | -1.2 | 1.3 | -2,261 | -35.6 | -2,915 | -16.9 | -26.2 | 18.7 |
| Brazil | 16,331 | 16.3 | 14,460 | 2.9 | 9.6 | 13.4 | 23,186 | 4.6 | 22,726 | 2.5 | 3.6 | 2.1 |
| South Africa | 1,757 | 30.7 | 1,458 | 8.4 | 19.6 | 22.3 | 25 | -137.6 | -36 | -45.9 | -92.2 | 91.7 |
| China | -12,309 | -6.3 | -12,942 | -1.5 | -3.9 | 4.8 | 6,348 | 10.2 | 5,954 | 3.3 | 6.8 | 6.9 |
| Developing countries | 12,091 | 186.1 | 6,175 | 45.7 | 116.1 | 140.3 | 27,551 | 10.4 | 25,912 | 3.8 | 7.1 | 6.6 |
| Bangladesh | -2,084 | -1.1 | -2,103 | -0.2 | -0.7 | 0.9 | -1,443 | -0.3 | -1,448 | 0.0 | -0.2 | 0.3 |
| Ethiopia | 802 | 12.5 | 733 | 2.8 | 7.7 | 9.7 | -77 | 2.4 | -75 | 0.3 | 1.3 | 2.1 |
| Least developed countries | 4,109 | 21.5 | 3,570 | 5.5 | 13.5 | 16.0 | -9,958 | -0.4 | -9,986 | -0.1 | -0.2 | 0.3 |
| Russia | -3,413 | -10.8 | -3,734 | -2.4 | -6.5 | 8.4 | -12,544 | -2.2 | -12,731 | -0.8 | -1.5 | 1.4 |
| Rest of the world | -142 | -85.8 | -749 | -24.8 | 55.4 | 61.0 | -8,877 | -2.9 | -9,058 | -0.9 | -1.9 | 2.0 |
| m_reg[e] | | 17.1 | | 4.0 | 10.6 | 24.0 | | -24.7 | | -9.2 | -17.0 | 18.1 |
| std_reg[e] | | 57.3 | | 14.6 | 36.0 | 37.3 | | 52.5 | | 19.2 | 36.0 | 32.02 |

[a] Trade balance = exports minus imports; negative value = net importing country; positive value = net exporting country. This table displays post-simulation values of the agricultural and food trade balance and the percentage changes compared to pre-simulation value.
[b] Please refer to Table 1 for more information on the set of databases and the scenario design. The number 100 indicates the share of the SFP that is shifted from the initial distribution according to land to the distribution according to a sector's factor usage to capital, labor and land. The coupling degree is increasing as the number increases.
[c] Please refer to Table A1 in the Appendix for more details on the regional aggregation.
[d] The mean (m) and the range (rng) are calculated across the 21 databases.
[e] The mean (m_reg) and the standard deviation (std_reg) calculated across regions are determined accounting for total EU trade.

*Source: Authors' elaboration.*

**Table B2. Effects of eliminating domestic support under different assumptions of the SFP's degree of decoupling on the Herfindahl-Hirschman Indexes calculated for agricultural commodities[a,b,c]**

| | Market concentration (HHMCI) | | | | | | Product concentration (HHPCI) | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Partial decoupling - 100 | | Fully decoupling | | Statistics | | Partial decoupling - 100 | | Fully decoupling | | Statistics | |
| | HHMCI | Change (%) | HHMCI | Change (%) | m[d] | rng[d] | HHPCI | Change (%) | HHPCI | Change (%) | m[d] | rng[d] |
| EU | 0.67 | 9.3 | 0.63 | 2.9 | 6.2 | 6.4 | 0.16 | 5.2 | 0.16 | 1.4 | 3.4 | 3.8 |
| Canada | 0.16 | -5.9 | 0.17 | -1.1 | -3.6 | 4.8 | 0.12 | 4.8 | 0.11 | 0.5 | 2.6 | 4.3 |
| US | 0.14 | -3.6 | 0.15 | -1.0 | -2.3 | 2.6 | 0.09 | -2.6 | 0.09 | -1.4 | -2.0 | 1.1 |
| Japan | 0.13 | -6.5 | 0.13 | -1.2 | -4.0 | 5.3 | 0.24 | 3.8 | 0.24 | 0.3 | 2.0 | 3.6 |
| Developed countries | 0.10 | -0.1 | 0.10 | -0.4 | -0.3 | 0.3 | 0.07 | -1.5 | 0.07 | -0.8 | -1.2 | 0.7 |
| Brazil | 0.24 | 18.4 | 0.21 | 2.8 | 10.6 | 15.5 | 0.24 | 0.4 | 0.24 | -0.6 | -0.1 | 1.0 |
| South Africa | 0.29 | 16.3 | 0.26 | 4.5 | 10.4 | 11.8 | 0.50 | 3.9 | 0.48 | 1.3 | 2.6 | 2.6 |
| China | 0.11 | 1.8 | 0.11 | 0.3 | 1.0 | 1.4 | 0.17 | -2.2 | 0.17 | -0.3 | -1.3 | 1.8 |
| Developing countries | 0.14 | 16.2 | 0.12 | 3.6 | 9.8 | 12.6 | 0.21 | 1.0 | 0.20 | -0.1 | 0.4 | 1.1 |
| Bangladesh | 0.37 | -6.3 | 0.39 | -1.6 | -4.0 | 4.6 | 0.47 | -6.9 | 0.50 | -1.5 | -4.2 | 5.5 |
| Ethiopia | 0.18 | 21.6 | 0.15 | 3.8 | 12.5 | 17.8 | 0.33 | 7.3 | 0.31 | 0.6 | 4.0 | 6.7 |
| Least developed countries | 0.21 | 2.7 | 0.20 | 0.4 | 1.4 | 2.2 | 0.17 | 7.2 | 0.16 | 0.4 | 3.8 | 6.9 |
| Russia | 0.45 | -9.3 | 0.49 | -1.9 | -5.6 | 7.4 | 0.61 | 2.0 | 0.60 | 0.4 | 1.2 | 1.6 |
| Rest of the world | 0.09 | 10.3 | 0.08 | 2.3 | 6.1 | 8.1 | 0.15 | -4.0 | 0.16 | -1.2 | -2.6 | 2.8 |
| m_reg[e] | 0.23 | 4.6 | 0.23 | 1.0 | 2.7 | 7.2 | 0.25 | 1.3 | 0.25 | -0.1 | 0.6 | 3.1 |
| std_reg[e] | 0.16 | 10.6 | 0.16 | 2.3 | 6.4 | 5.4 | 0.17 | 4.34 | 0.17 | 0.9 | 2.6 | 2.1 |

[a] Please refer to Table 1 for more information on the set of databases and the scenario design. The number 100 indicates the share of the SFP that is shifted from the initial distribution according to land to the distribution according to a sector's factor usage to capital, labor and land. The coupling degree is increasing as the number increases.
[b] Please refer to Table A1 in the Appendix for more details on the regional aggregation.
[c] Herfindahl-Hirschman Market Concentration Index (HHMCI): 0 = trade is equally distributed; 1 = trade is concentrated in one market. Herfindahl-Hirschman Product Concentration Index (HHPCI): 0 = trade is equally distributed across products - not vulnerable to trade shocks; 1 = trade is concentrated on one product -vulnerable to trade shocks. This table displays post-simulation values of the HHMCI and HHPCI and the percentage changes compared to pre-simulation values.
[d] The mean (m) and the range (rng) are calculated across the 21 databases.
[e] The mean (m_reg) and the standard deviation (std_reg) are calculated across all regions.

*Source: Authors' elaboration.*

**Table B3. Effects of eliminating domestic support under different assumptions of the SFP's degree of decoupling on welfare in selected countries[a,b]**

| | Full decoupling | Partial decoupling - 100 | Change[c] | Mean[d] | Range[d] |
|---|---|---|---|---|---|
| | (USD millions) | (USD millions) | % | (USD millions) | (USD millions) |
| EU | 1,346 | 3,019 | 124 | 2,032 | 1,673 |
| Canada | 61 | 222 | 264 | 140 | 161 |
| US | 377 | 1,077 | 186 | 724 | 700 |
| Japan | -151 | -567 | 276 | -361 | 718 |
| Developed countries | -262 | -895 | 242 | -590 | 633 |
| Brazil | 211 | 703 | 233 | 455 | 492 |
| South Africa | 17 | 56 | 240 | 36 | 40 |
| China | -243 | -830 | 242 | -539 | 587 |
| Developing countries | 68 | 369 | 440 | 195 | 300 |
| Bangladesh | -13 | -49 | 271 | -31 | 49 |
| Ethiopia | 14 | 67 | 374 | 40 | 53 |
| Least developed countries | -11 | -18 | 69 | -16 | 7 |
| Russia | -244 | -674 | 177 | -463 | 431 |
| Rest of the world | -18 | -53 | 198 | -37 | 35 |

[a] Please refer to Table 1 for more information on the set of databases and the scenario design. The number 100 indicates the share of the SFP that is shifted from the initial distribution according to land to the distribution according to a sector's factor usage to capital, labor and land. The coupling degree is increasing as the number increases.
[b] Please refer to Table A1 in the Appendix for more details on the regional aggregation.
[c] The percentage number gives the percentage change between scenario full decoupling and partial decoupling - 100.
[d] The mean and the range are calculated across the 21 databases.

*Source: Authors' elaboration.*

**Table B4. Effects of eliminating domestic support under different assumptions of the SFP's degree of decoupling on countries' export share[a,b]**

| | Partial decoupling - 100 | | Full decoupling | | Statistics | |
|---|---|---|---|---|---|---|
| | Export share | Change (%) | Export share | Change (%) | Mean (%)[c] | Range (%)[c] |
| EU | 0.83 | 4.28 | 0.81 | 1.35 | 2.89 | 2.93 |
| Canada | 0.13 | 35.65 | 0.10 | 6.91 | 21.00 | 28.74 |
| US | 0.14 | 25.78 | 0.12 | 6.54 | 16.08 | 19.24 |
| Japan | 0.11 | 26.84 | 0.09 | 4.35 | 15.52 | 22.49 |
| Developed countries | 0.19 | 16.08 | 0.17 | 4.79 | 10.41 | 11.29 |
| Brazil | 0.50 | 11.48 | 0.45 | 1.95 | 6.82 | 9.53 |
| South Africa | 0.54 | 8.89 | 0.51 | 2.58 | 5.80 | 6.31 |
| China | 0.20 | 13.67 | 0.18 | 3.32 | 8.52 | 10.35 |
| Developing countries | 0.35 | 16.59 | 0.31 | 4.24 | 10.51 | 12.35 |
| Bangladesh | 0.15 | 30.28 | 0.12 | 9.36 | 19.93 | 20.92 |
| Ethiopia | 0.41 | 15.81 | 0.37 | 3.03 | 9.53 | 12.78 |
| Least developed countries | 0.33 | 18.54 | 0.29 | 4.36 | 11.58 | 14.18 |
| Russia | 0.16 | 44.53 | 0.12 | 8.65 | 26.11 | 35.88 |
| Rest of the world | 0.23 | 25.98 | 0.20 | 7.87 | 16.98 | 18.11 |
| m_reg[d] | 0.31 | 21.03 | 0.27 | 4.95 | 12.98 | 16.08 |
| std_reg[d] | 0.21 | 11.04 | 0.20 | 2.53 | 6.53 | 8.89 |

[a] Please refer to Table 1 for more information on the set of databases and the scenario design. The number 100 indicates the share of the SFP that is shifted from the initial distribution according to land to the distribution according to a sector's factor usage to capital, labor and land. The coupling degree is increasing as the number in the legend increases.
[b] Please refer to Table A1 in the Appendix for more details on the regional aggregation.
[c] The mean and the range of the percentage changes are calculated across the 21 databases.
[d] The mean (m_reg) and the standard deviation (std_reg) are calculated across all regions.

*Source: Authors' elaboration.*

**Table B5. Effects of eliminating domestic support under different assumptions of the SFP's degree of decoupling on aggregated output (% change)[a,b]**

| | Agricultural commodities | | Food commodities | |
|---|---|---|---|---|
| | Partial decoupling -100 | Full decoupling | Partial decoupling -100 | Full decoupling |
| EU | -6.25 | -1.95 | -1.82 | -0.71 |
| Canada | 2.90 | 0.84 | 0.53 | 0.21 |
| US | 1.09 | 0.33 | 0.10 | 0.05 |
| Japan | 0.46 | 0.14 | 0.08 | 0.03 |
| Developed countries | 1.27 | 0.54 | 0.63 | 0.32 |
| Brazil | 2.25 | 0.55 | 0.52 | 0.33 |
| South Africa | 2.83 | 0.79 | 0.31 | 0.11 |
| China | 0.30 | 0.09 | 0.14 | 0.05 |
| Developing countries | 0.98 | 0.26 | 0.19 | 0.08 |
| Bangladesh | 0.33 | 0.10 | 0.06 | 0.02 |
| Ethiopia | 0.94 | 0.21 | 0.14 | 0.04 |
| Least developed countries | 1.12 | 0.30 | 0.23 | 0.10 |
| Russia | 0.65 | 0.19 | 0.41 | 0.18 |
| Rest of the world | 1.28 | 0.39 | 0.39 | 0.14 |

[a] Please refer to Table 1 for more information on the set of databases and the scenario design. The number 100 indicates the share of the SFP that is shifted from the initial distribution according to land to the distribution according to a sector's factor usage to capital, labor and land. The coupling degree is increasing as the number in the legend increases.

[b] Please refer to Table A1 in the Appendix for more details on the regional aggregation.

*Source: Authors' elaboration.*

**Table B6. Comparison of the effects of eliminating domestic support under different assumptions of the SFP's degree of decoupling on commodity specific output (range between full and partial decoupling – 100 in %)[a,b]**

| | EU | can | usa | IC | bra | zaf | chn | DC | bgd | eth | LDC |
|---|---|---|---|---|---|---|---|---|---|---|---|
| pdr | -23.38 | 0.25 | 1.14 | -0.38 | 0.01 | 2.83 | 0.11 | 0.36 | 0.02 | -0.66 | -0.18 |
| wht | -7.49 | 7.78 | 4.81 | 3.07 | -0.18 | 1.69 | 0.60 | 1.62 | 2.18 | 1.15 | 2.75 |
| gro | -3.52 | 0.84 | 0.47 | 0.46 | 2.90 | 0.24 | 0.27 | 0.39 | 0.24 | 0.10 | 0.13 |
| v_f | -5.55 | 1.43 | 0.64 | 0.66 | 2.20 | 4.30 | 0.17 | 0.74 | 0.30 | 0.20 | 0.34 |
| osd | -9.01 | 2.49 | 1.41 | 0.56 | 3.02 | 0.80 | 0.92 | 0.66 | 0.86 | -0.64 | 0.52 |
| c_b | -0.98 | 0.29 | 0.03 | 0.41 | -0.32 | 0.21 | 0.07 | 0.00 | 0.16 | 0.15 | 0.21 |
| pfb | -18.13 | 0.47 | 0.70 | 0.72 | -0.37 | 2.00 | 0.17 | 0.28 | 0.53 | -0.20 | 2.14 |
| ocr | -5.32 | 2.82 | 2.18 | 1.75 | 3.66 | 7.42 | 5.10 | 2.49 | 0.74 | 4.68 | 5.50 |
| ctl | -1.70 | 0.52 | 0.17 | 0.29 | -0.01 | 0.11 | 0.01 | 0.18 | 0.03 | -0.05 | 0.06 |
| oap | -2.45 | 0.80 | 0.36 | 0.75 | 0.85 | 0.78 | 0.11 | 0.16 | -0.07 | 0.42 | 0.21 |
| rmk | -1.42 | 0.12 | 0.04 | 0.75 | -0.11 | 0.12 | 0.15 | -0.09 | 0.03 | 0.04 | 0.04 |
| wol | -16.60 | -0.32 | -0.16 | 0.35 | 0.33 | 1.17 | 0.57 | -0.22 | 7.12 | -0.72 | -0.05 |
| cmt | -1.65 | 0.13 | -0.02 | 0.17 | -0.09 | 0.06 | 0.10 | 0.05 | 2.93 | 0.03 | -0.01 |
| omt | -2.00 | 1.21 | 0.28 | 0.72 | 1.56 | 0.52 | 0.14 | 0.20 | 6.17 | 0.02 | 0.52 |
| vol | -4.50 | 1.73 | 0.37 | 0.77 | 0.86 | 0.89 | 0.19 | 0.83 | 0.27 | -2.77 | 1.16 |
| mil | -1.44 | 0.08 | 0.04 | 0.88 | -0.08 | 0.35 | 0.15 | 0.19 | 0.61 | 0.59 | 0.48 |
| pcr | -1.65 | -0.05 | 0.59 | -0.34 | -0.02 | 0.74 | 0.11 | -0.04 | -0.01 | -2.35 | -0.44 |
| sgr | -1.24 | 0.03 | 0.03 | 0.65 | -0.23 | 0.44 | 0.07 | 0.00 | 0.19 | 0.20 | 0.41 |
| ofd | -0.78 | 0.20 | 0.03 | 0.20 | -0.03 | 0.16 | 0.10 | -0.01 | 0.06 | 0.11 | 0.06 |
| b_t | -0.49 | 0.09 | 0.02 | 0.00 | -0.07 | 0.06 | -0.02 | 0.01 | -0.05 | 0.07 | 0.00 |
| MNFC | 0.36 | -0.20 | -0.10 | -0.06 | -0.56 | -0.25 | -0.06 | -0.20 | -0.09 | -1.23 | -0.32 |
| SERV | 0.09 | 0.00 | 0.00 | -0.01 | -0.02 | -0.02 | -0.02 | -0.03 | -0.02 | -0.44 | -0.09 |

[a] Please refer to Table 1 for more information on the set of databases and the scenario design. The number 100 indicates the share of the SFP that is shifted from the initial distribution according to land to the distribution according to a sector's factor usage to capital, labor and land. The coupling degree is increasing as the number in the legend increases.
[b] IC = developed countries, DC = developing countries, LDC = least developed countries. Please refer to Table A1 in the Appendix for more details on the regional and sectoral aggregation.

*Source: Authors' elaboration.*

**Table B7. Comparison of the effects of eliminating domestic support under different assumptions of the SFP's degree of decoupling on commodity specific output in the EU[a,b]**

| | Full decoupling | Partial decoupling-100 |
|---|---|---|
| Paddy rice | -21.6 | -45.0 |
| Wheat | -2.4 | -9.9 |
| Grains | -1.4 | -4.9 |
| Vegetables, fruits | -2.3 | -7.8 |
| Oilseeds | -1.3 | -10.3 |
| Raw sugar | -0.1 | -1.1 |
| Fibers | -20.4 | -38.5 |
| Other crops | -1.5 | -6.8 |
| Ruminants | -4.0 | -5.7 |
| Non-ruminants | -1.5 | -4.0 |
| Raw milk | -0.7 | -2.2 |
| Wool | -7.5 | -24.1 |
| Ruminant meat | -4.7 | -6.4 |
| Non-rum. Meat | -1.4 | -3.4 |
| Veg. oils and fats | -0.7 | -5.2 |
| Dairy products | -0.7 | -2.2 |
| Processed rice | -2.0 | -3.6 |
| Refined sugar | -0.1 | -1.4 |
| Other food | -0.4 | -1.2 |
| Beverages, tobacco | -0.2 | -0.7 |
| Manufacturing | 0.2 | 0.5 |
| Services | 0.0 | 0.1 |

[a] Please refer to Table 1 for more information on the set of databases and the scenario design. The number 100 indicates the share of the SFP that is shifted from the initial distribution according to land to the distribution according to a sector's factor usage to capital, labor and land. The coupling degree is increasing as the number in the legend increases.
[b] Please refer to Table A1 in the Appendix for more details on the sectoral aggregation.

*Source: Authors' elaboration.*

**Table B8. Effects of eliminating domestic support under different assumptions of the SFP's degree of decoupling on world market prices (% change)[a,b]**

| | Full decoupling | Partial decoupling-100 |
|---|---|---|
| Paddy rice | 0.60 | 1.59 |
| Wheat | 0.95 | 3.61 |
| Grains | 0.72 | 2.78 |
| Vegetables, fruits | 0.74 | 2.23 |
| Oilseeds | 0.60 | 2.59 |
| Raw sugar | 0.54 | 2.12 |
| Fibers | 0.97 | 2.22 |
| Other crops | 0.99 | 4.52 |
| Ruminants | 2.48 | 3.87 |
| Non-ruminants | 0.85 | 2.36 |
| Raw milk | 1.24 | 3.65 |
| Wool | 0.37 | 0.92 |
| Ruminant meat | 0.96 | 1.49 |
| Non-rum. Meat | 0.82 | 1.86 |
| Veg. oils and fats | 0.36 | 1.21 |
| Dairy products | 0.62 | 1.58 |
| Processed rice | 0.40 | 0.96 |
| Refined sugar | 0.28 | 0.75 |
| Other food | 0.32 | 0.70 |
| Beverages, tobacco | 0.28 | 0.61 |
| Manufacturing | 0.13 | 0.03 |
| Services | 0.13 | 0.04 |

[a] Please refer to Table 1 for more information on the set of databases and the scenario design. The number 100 indicates the share of the SFP that is shifted from the initial distribution according to land to the distribution according to a sector's factor usage to capital, labor and land. The coupling degree is increasing as the number in the legend increases.
[b] Please refer to Table A1 in the Appendix for more details on the sector aggregation.

*Source: Authors' elaboration.*

# 4 Measuring the trade restrictiveness of domestic support using the EU Common Agricultural Policy as an example

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# Measuring the Trade Restrictiveness of Domestic Support using the EU Common Agricultural Policy as an Example

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**Abstract:**

We use the Mercantilist Trade Restrictiveness Index (MTRI) to develop an extended index that measures the overall trade effects of domestic support payments in a general equilibrium framework environment. Our index is capable of analyzing the development of the trade restrictiveness of domestic support payments over time and across countries and of comparing these payments with other protection instruments. Furthermore, our index helps evaluate agricultural policy reforms that introduce changes into the composition of domestic support payments. We conduct this analysis with an extended version of the GTAP model and database using the EU as an example. Thus, we incorporate detailed EU domestic support payments taken from the OECD Producer Support Estimate (PSE) tables in the GTAP framework and reconcile PSE data with the WTO classification scheme. Although our index slightly increases from 2004 to 2007, the results indicate a decrease in trade distortion stemming from the implementation of decoupled support in the EU. The trade-equivalent protection rate determined under the index shows that domestic support payments restrict trade more than tariffs and export subsidies. Additionally, the index indicates that reducing WTO amber box domestic support payments would lead to decreased trade restrictiveness.

**Keywords:** domestic distortions, agricultural policies, trade restrictiveness, simulation models

**JEL classification:** D58, F13, F14, Q17, Q18

## 1 Introduction

Recent years have witnessed an ongoing debate regarding the trade-distorting effects of domestic support in agriculture. Typically, domestic support is based on a variety of different and country-specific agricultural policy instruments, which makes the impact on trade difficult to address. The importance of such payments has grown as the more detailed reduction requirements for domestic support from the Doha Round have been implemented. As a consequence, several countries have initiated reforms of their agricultural policies to meet WTO criteria. New instruments have been developed to reduce production-distorting incentives of such payments, such as the Single Farm Payment (SFP) in the EU. Nevertheless, these new instruments, including the SFP, are controversial because payments decoupled from production may still create incentives to produce based on other coupling channels, including uncertainty, imperfect credit markets, land and labor markets, and farmers' expectations about future payments (Bhaskar and Beghin 2009). Thus, the trade-distorting effects of decoupled domestic support remain unclear.

Over the years, two prevailing sets of indicators have been developed to provide information regarding domestic support in the agricultural sector, and these indicators have become accepted worldwide. One of these indicators is the Producer Support Estimate (PSE) from the OECD, which has been calculated since 1986 and is typically accompanied by several other composite measures, such as the Percentage PSE (%PSE), the Nominal Rate of Assistance (NRA) and the Effective Rate of Assistance (ERA). The aim of the OECD in using the PSE is to quantify the effects of national distortions consistently and to establish a common basis for a policy dialogue among countries (OECD 2010). Beginning from the same basis as the PSE, the WTO established the Aggregate Measurement of Support (AMS) concurrently with its amber, blue, and green box subsidy classification scheme in the Agreement on Agriculture (AoA) (WTO 1994). In the Doha Round, the WTO introduced an additional criterion, the overall base level of all trade-distorting domestic support (OTDS) (WTO 2004), to compare the amount of domestic support between countries and to facilitate the negotiation of commitments to reducing domestic support.

Indicators such as the PSE can be classified as traditional weighted aggregates of price distortions and are thus not appropriate for analyzing the trade restrictiveness or economic welfare losses associated with policies (Anderson and Croser 2011). However, aggregation problems persist in quantifying domestic distortions and in other areas. Anderson and Neary (2003) point to the lack of a theoretical foundation in criticizing measures such as arithmetic or trade-weighted average tariffs, non-tariff barrier coverage ratios and measures of tariff dispersion that are frequently used to compare international trade polices over time and across countries. Nonetheless, researchers have developed several theoretically sound aggregation procedures to overcome the aggregation problems that arise from different types and variations of policies across sectors and regions. The general objective is to produce a single index that captures the overall effects of different policy instruments using a consistent theoretical aggregation method. This index should be capable of evaluating trade policies across policy measures, sectors, regions and, in particular, over time. Initial and influential theoretical work in this area has been published by Corden (1966), Feenstra (1995) and, in particular, by Anderson and Neary (1994; 2003; 2005), who developed two theory-based indexes, the Trade Restrictiveness Index (TRI) and the Mercantilist Trade Restrictiveness Index (MTRI).

Several studies apply and further develop the concepts of the TRI and MTRI for tariff analysis in a partial or general equilibrium environment (Pelikan and Brockmeier 2008a; 2008b; Bureau and Salvatici 2005; Antimiani and Salvatici 2005; Kee et al. 2009). However, the literature on the adjustments and applications that measure the impact of domestic support payments remains scarce. The exceptions in the literature include Anderson, Bannister and Neary (1995) and Anderson and Neary (2005), who adjust their TRI concept to account for factor market distortions and thereby generate an index that consistently quantifies the effects of domestic distortions on welfare. With respect to the MTRI, Anderson and Neary (2005) provide a rough adjustment to cover domestic distortions, but there have been no applications as of yet to validate this methodology. Salvatici (2001) extends the TRI approach to evaluate the EU common agricultural policy by using an adjusted version of the GTAP model that includes modifications in the computation of equivalent variation. Also building on the TRI and MTRI, Anderson and Croser (2011), Croser and Anderson (2011), Croser et al. (2010), and Lloyd and MacLaren (2010) offer a methodological approach that is restricted to a partial equilibrium environment and estimates the relative contribution of different agricultural policy instruments to the overall trade and welfare effect. Utilizing the World Bank's distortions data set, they apply this methodology to generate time series of indexes for agricultural products that can be used to evaluate national policy development and make cross-country comparisons. One caveat regarding their approach is that the estimated indexes include neither non-product-specific domestic support payments as input subsidies not distributed at the product level nor, in particular, decoupled support. Lloyd and MacLaren (2010) contend that partial equilibrium estimates underestimate the true value of the indexes due to the neglect of general equilibrium effects. To overcome this bias, they apply semi–general equilibrium measures that account for input-output relationships.

Although research has addressed certain domestic support issues, other important questions remain unanswered. How harmful is agricultural domestic support for international trade? Are domestic subsidies even more restrictive than tariffs? Has the introduction of decoupled support, such as the EU's SFP, decreased the magnitude of this effect? Additionally, country-specific domestic support typically consists of different categories and types of payments. Consequently, an evaluation tool is required that compares the trade restrictiveness of different policies according to the type and classification of support across countries and that evaluates their development over time. Furthermore, the WTO modalities paper defines commitments to reduce the OTDS and places reduction requirements on the AMS and blue box subsidies. However, most global equilibrium models evaluate the level of domestic support through the OECD PSE. Employing global equilibrium models in the analysis of domestic support reduction, as suggested in the WTO negotiations, requires the WTO amber, blue and green box support classification scheme and the PSE data to be reconciled.

Against this backdrop, our objective is to provide a theoretically based index to evaluate different domestic support payment categories and types over time and across countries that can also serve as an evaluation tool for WTO criteria. In addition, this index should enable us to compare the trade restrictiveness of domestic support, import tariffs, and other protection instruments. To the best of our knowledge, this type of index is not currently available in the literature. Thus, this research contributes to filling the gap of applied analyses measuring the trade restrictiveness of domestic distortions.

Specifically, this study extends the standard GTAP framework to incorporate detailed domestic support categories and payment types. Furthermore, we match the OECD PSE data in the underlying GTAP database with the WTO amber, blue, and green box support classification scheme to reconcile the representations of both important measures of domestic support payments and then integrate them into the GTAP model. We also respond to the question of how this extended GTAP framework can be utilized to calculate domestic support indexes. For this purpose, we build on the work of Anderson and Neary (2005) and Lloyd and MacLaren (2010) and introduce an adaptation of the MTRI that is adjusted to account for domestic distortions into the GTAP model. The methodological approach introduced in this article extends the standard computable general equilibrium (CGE) analyses of international trade liberalization and country-specific policy reforms by employing a CGE model that accurately covers domestic support payments and the corresponding trade restrictiveness using a theoretically sound index.

This article is organized as follows. In section 2, we explain how we adapted the MTRI to measure the tariff equivalent of domestic support payments, which is followed by a description of the extended GTAP modeling framework in section 3. Section 4 introduces the experiment design and simulation results. The closing section discusses our findings, offers political conclusions, and suggests directions for future research.

## 2 Existing indicators of domestic distortions for the EU

The EU agricultural sector is heavily subsidized. The starting point of the common agricultural policy (CAP) of the EU consisted of policy instruments, such as intervention prices and output subsidies, that primarily created production incentives. Such policies enhanced EU agricultural production on the domestic market, led to oversupplies on the world market, and replaced imports. The EU substantially modified the CAP to address its impact and to meet WTO criteria. In general, these reforms induced reductions in market price supports and output subsidies, and increased decoupled subsidies, such as the SFP.

Figure 1 shows the development of the CAP using OECD PSE data. The PSE consists of market price support (MPS) and budgetary transfers that are subdivided into single commodity transfer (SCT) payments, group commodity transfer (GCT) payments, all commodity transfer (ACT) payments, and other transfers to producers (OTP) payments that comprise the SFP. The graph displays only slight variations of domestic support payments in the 1986-2012 period, whereas it clearly depicts a change in the composition of the PSE.

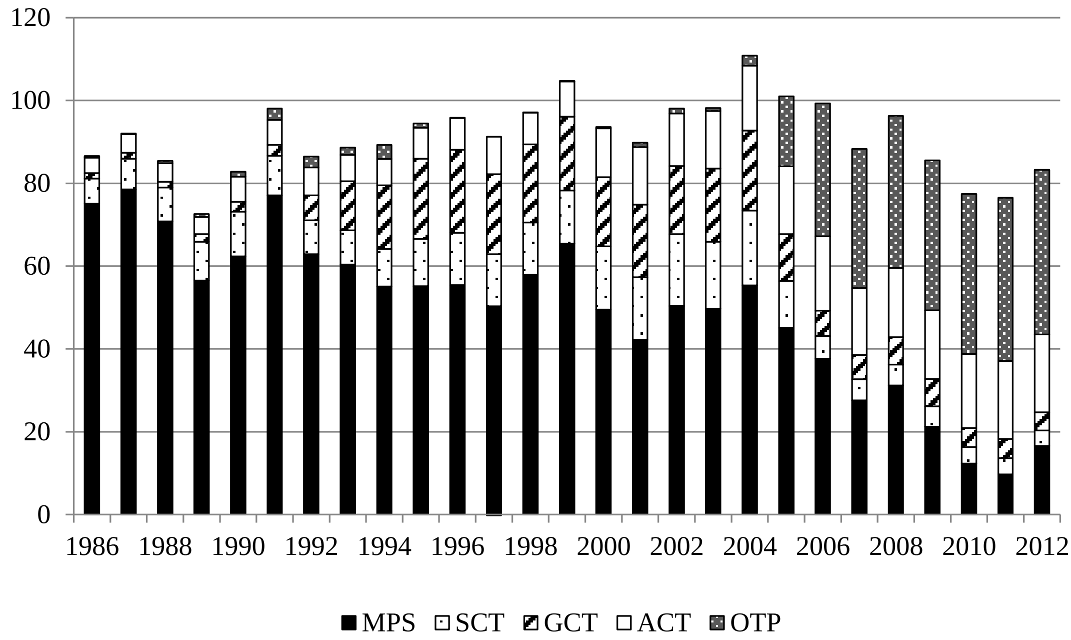


**Figure 1. Development of the PSE composition of the EU (in € million)**

*Source: Authors' elaboration based on OECD PSE database (OECD 2014)*

The MPS share of the PSE decreases from more than 90% in 1986 to less than 20% in 2012. The share of budgetary transfers rises accordingly. Furthermore, the composition of budgetary transfers reveals the changes induced by CAP reforms. Figure 1 presents the increase in product-specific (SCT) and group-specific (GCT) domestic support, introduced in 1992 with the McSharry reform, which remains coupled to production. The EU initiated the first attempt toward decoupled support with the Agenda 2000 reform, which is shown in the larger shares of support allocated to all primary agricultural commodities (ACT) in figure 1. In 2005, the EU introduced the SFP (OTP), which was declared to be decoupled from production. The graph highlights that decoupled support has increased considerably since 2005, whereas coupled support has obviously diminished.

The PSE payments are further subdivided according to subsidy types, such as output, input use, land, labor, and capital. Table 1 decomposes the PSE budgetary transfers of the EU25 into payment categories and types for the years 2004 and 2007 to identify the development of these categories and types. The first column in the years 2004 and 2007 present the values for each category (SCT, GCT, ACT, OTP), which are further subdivided into values for each payment type. The second column shows the shares of each category of the total PSE and the shares of each payment type of the corresponding category. The last column of table 1 depicts changes from 2004 to 2007. The total value of PSE budgetary transfers rises by 7% from 2004 to 2007. Furthermore, table 1 emphasizes the significant increase in OTP, which accounts for only € 1,455 million in 2004 but rises to € 31,382 million in 2007. As a result, 53% of the PSE budgetary transfers are classified as decoupled from production.

Additionally, coupled support in the form of product- and group-specific support (SCT, GCT) clearly decreases to values that are less than one-third of their 2004 values, whereas the less-coupled non-product-specific category ACT increases by approximately 9%.

In addition, table 1 depicts considerable changes in the allocation of payments within each category. The composition of SCT shows a move toward payments based on land and away from payments based on output and input use. By contrast, the structure of GCT moves toward subsidies allocated according to input and labor use, whereas ACT shifts toward subsidies allocated according to labor and capital use. Both categories show reduced payments based on land. These changes reflect an increase in production incentives through GCT and ACT payments and a decrease in production effects due to SCT payments.

**Table 1. Composition of the EU25's PSE in 2004 and 2007 Excluding MPS (in € million)**

| | 2004 | | 2007 | | change |
|---|---|---|---|---|---|
| Budgetary transfer | € | % share of PSE category | € | % share of PSE category | % |
| **SCT** | **18,012** | **33** | **4,632** | **8** | **-74** |
| Output | 243 | 1 | 2 | 0 | -99 |
| Input | 5,542 | 31 | 922 | 20 | -83 |
| Land | 2,061 | 11 | 1,173 | 25 | -43 |
| Labor | - | - | - | - | - |
| Capital | 10,167 | 56 | 2,534 | 55 | -75 |
| **GCT** | **19,331** | **35** | **5,529** | **9** | **-71** |
| Output | - | - | - | - | - |
| Input | 1,304 | 7 | 1,190 | 22 | -9 |
| Land | 17,479 | 90 | 3,633 | 66 | -79 |
| Labor | 67 | 0 | 768 | 14 | 1,046 |
| Capital | 482 | 2 | - | - | -100 |
| **ACT** | **15,785** | **29** | **17,131** | **29** | **9** |
| Output | - | - | - | - | - |
| Input | 4,553 | 29 | 4,627 | 27 | 2 |
| Land | 7,732 | 49 | 6,812 | 40 | -12 |
| Labor | 237 | 2 | 481 | 3 | 103 |
| Capital | 3,263 | 21 | 5,212 | 30 | 60 |
| **OTP / SFP** | **1,455** | **3** | **31,382** | **53** | **2,057** |
| **PSE excl. MPS** | **54,583** | | **58,674** | | **7** |

*Source: OECD PSE tables 2004, 2007(OECD 2014) and own calculations*

Note: Here we allocated the PSE classification of policy instruments according payment types (output, input, land, labor, and capital) that are used in GTAP.

The WTO scheme classifies subsidies coupled to production as AMS support (AoA Article 6.2) consisting of MPS and non-exempted direct payments (amber box support) or direct payments meeting the criteria of AoA Article 6.5 (blue box support), depending on the extent to which they create production incentives. Decoupled support and other direct payments given to agricultural producers as defined in AoA Annex 2, paras. 5 and 6 are categorized as green box support because they are only minimally trade distorting. Figure 2 shows the development of domestic support classified according to the WTO scheme from the 1999/2000 – 2009/2010 marketing years. This graph highlights the reduction of trade-distorting amber and blue box support, and the rise of only minimally trade-distorting green box support. Thus, it reflects the movement from market price support schemes to decoupled support schemes. Hence, domestic support categorized according to this WTO scheme shows the same changes that can be seen in the PSE data from the OECD. Josling and Mittenzwei (2013) provide a reconstruction of WTO notification tables using the PSE categories and support types.

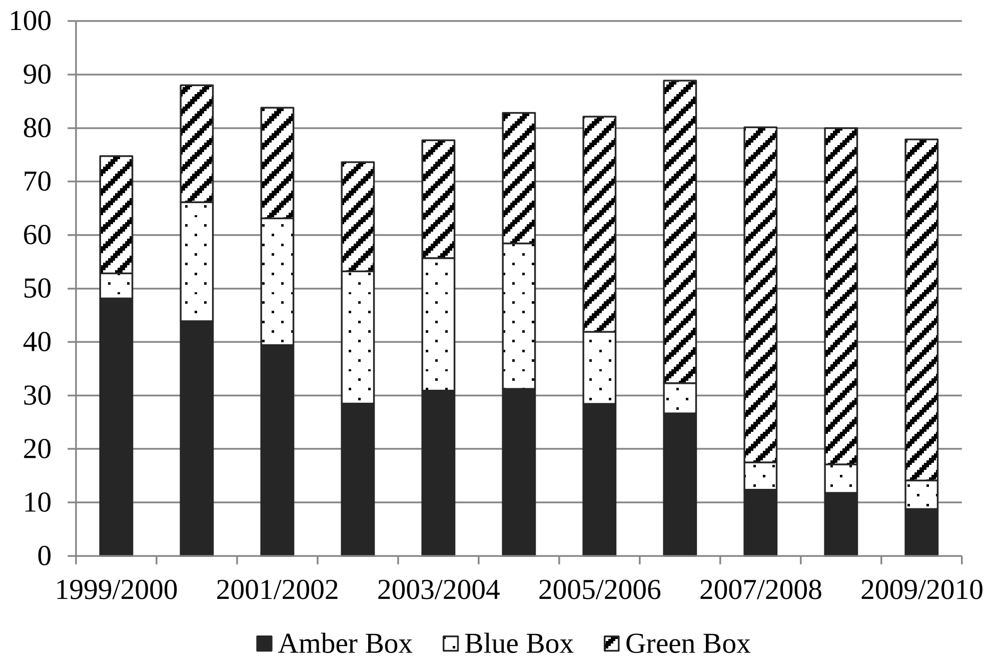


**Figure 2. Development of EU domestic support according to the WTO classification scheme (in € million)**

*Source: Authors' elaboration based on WTO notification tables for domestic support (WTO ; WTO 2014)*

In addition, Josling and Mittenzwei (2013) analyze and discuss the production requirement and the related trade-distorting effects of green box support and conclude that the PSE database is not only suited to rebuild but also to improve the policy details of the WTO notification tables. Many support programs that fulfill the WTO requirements defined in Article 6 and Annex 2 of the AoA imply that there is a need for production. Josling and Mittenzwei (2013), in particular, stress the benefit of utilizing both databases regarding the extent to which green box payments require production that is provided by the PSE. Furthermore, they emphasize that the two datasets, the OECD PSE tables and the WTO classification scheme, can be regarded as complementary resources and use OECD PSE data to build pre-notification tables to overcome the delay in countries' submission of notification tables.

The PSE and the WTO classification scheme are both important measures that monitor changes in the composition of countries' agricultural policy instruments and are thus both well suited to evaluate such changes. Nevertheless, neither the PSE nor the WTO classification scheme enable a quantification of the impact on trade or a comparison with other trade-distorting policy instruments, such as tariffs or export subsidies.

## 3 Mercantilist Trade Restrictiveness Index of domestic support payments

The MTRI developed by Anderson and Neary (2003; 2005) is a theoretically based index that measures import volume-equivalent protection, which is defined as the uniform tariff $\tau^{\mu}$ that results in the same import volume $M(p^0, b^0)$ at world prices $\pi$ of tariff-restricted imports, such as the initial sector-specific tariffs when domestic prices equal $p$ and the economies' exogenous income $b$:

$$(1)\quad \tau^{\mu}\left(p^0, b^0\right): M\left[(1+\tau^{\mu})\pi, b^0\right] = M\left(p^0, b^0\right)$$

Following Anderson and Neary (2005), the import volume is given by world market prices times net import demand. The exogenous balance-of-payments surplus is assumed to be the same during both periods. Anderson and Neary (2005) considered a small open economy that produces and consumes $n+1$ commodities that are traded at exogenous prices with the rest of the world. All agents within this economy face the same domestic prices, which differ from world prices due to the country's trade policies.

This characteristic of accounting for protection in terms of import equivalences enables the MTRI to be an appropriate starting point for the development of our index, which measures the distortive effects of domestic support payments.

In figure 3, we use a small country to illustrate an application of the MTRI approach to domestic support. We assume that this net-importing country provides a product-specific output subsidy, that the market is not protected by tariffs in the initial situation, and that there are no consumer subsidies. Abolishing the output subsidy shifts the auxiliary supply curve $S_0$ back to the actual supply curve $S_1$ and decreases the agent's price from $p^0$ to $\pi$, which is accompanied by a reduction in the quantity supplied from $q_s^0$ to $q^\pi$. The world market price for this product is not affected. The import demand quantity given by $q_d^0 - q_s^0$ rises to $q_d^0 - q_s^\pi$.

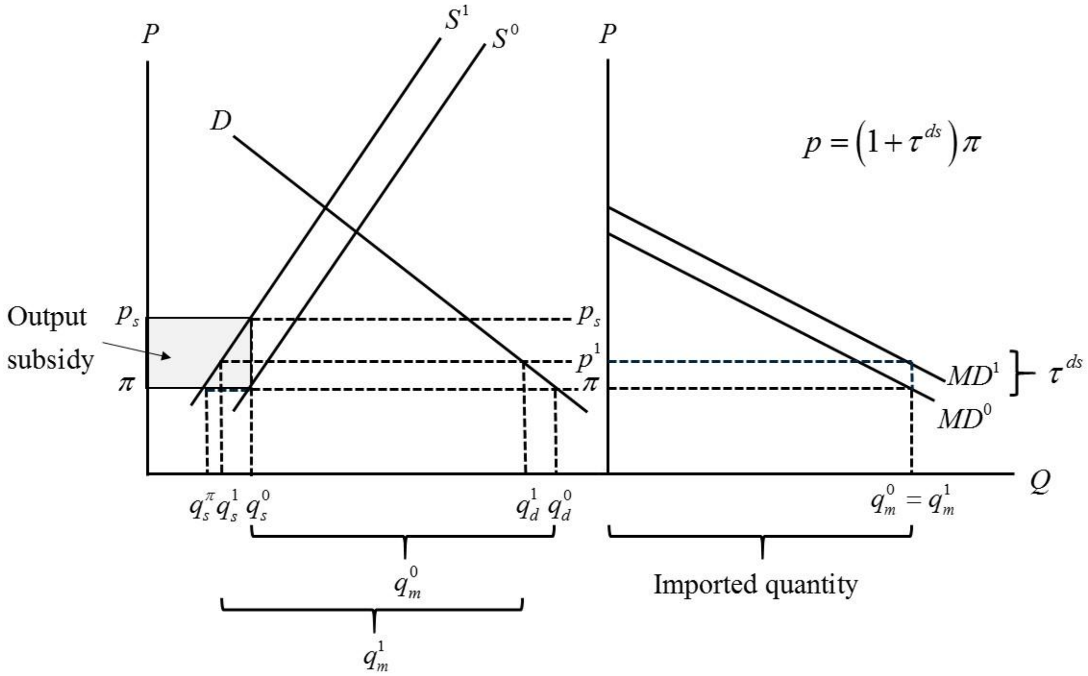


**Figure 3. Implication of a removal of output subsidies - small country case**

*Source: Authors' elaboration*

Note: The initial situation with an output subsidy in place is indicated with superscript 0 whereas the new situation after the removal of the output subsidy and the uniform protection rate is indicated with superscript 1.

Following the MTRI concept, the removal of an output subsidy subject to a constant import volume leads to the new market price, $p^1$, by implementing a uniform tariff, $\tau^{ds}$. Both producers and consumers are faced with new market price $p^1 = (1+\tau^{ds})\pi$, which leads to a decrease in quantity supplied, $q_s^1$, and demanded, $q_d^1$. Because the world market price remains unchanged due to the small country assumption, the new import volume given by $(q_d^1 - q_s^1)\pi$ equals the initial import volume given by $(q_d^0 - q_s^0)\pi$.

In the multi-good case, the implemented tariff, $\tau^{ds}$, reflects the uniform tariff that keeps the total import volume of the aggregated commodities constant, as all domestic support payments are removed.

We adapt the theoretical concept of Anderson and Neary (2005) to domestic support by quantifying the trade-distortive effect of these subsidies. As shown in figure 3, the idea of applying the MTRI as a measure of the distortions of domestic support is to remove domestic subsidies and quantify a uniform protection rate that keeps trade volume constant. To evaluate the trade-restrictiveness of domestic support payments with the help of a theoretically sound index, we must consider the effect on both import demand and export supply. Furthermore, consumers and producers receive domestic support payments such that the net import demand function $m\left(p^p, p^c\right)$ is determined as a function of producer $p^p$ and consumer prices $p^c$ (Anderson and Neary 2005).

(2) $$m\left(p^p, p^c\right) = d\left(p^c\right) - s\left(p^p\right)$$

Assuming that there are no other trade policies in place, the distorted domestic producer price is given for commodity $i$ by $p_i^p = \left(1+\tau_i^p\right)\pi_i$, where $\tau_i^p$ is the rate of producer distortions. However, the distorted domestic consumer price is given by $p_i^c = \left(1+\tau_i^c\right)\pi_i$, where $\tau_i^c$ is the rate of consumer distortions.[1] If $\tau_i^p = \tau_i^c = 0$, there are no distortions.

The aggregated vector of net imports is given by $M\left(p^p, p^c\right)$:

(3) $$M\left(p^p, p^c\right) = \pi m\left(p^p, p^c\right)$$

Thus, the MTRI for domestic support payments (MTRI-DS) $\tau^{ds}$ is determined through the following identity:

(4) $$\tau^{ds}\left(p^p, p^c\right) : M\left[\left(1+\tau^{ds}\right)\pi, \left(1+\tau^{ds}\right)\pi\right] = M\left[\left(1+\tau^p\right)\pi, \left(1+\tau^c\right)\pi\right] = M\left(p^p, p^c\right)$$

Following Lloyd and MacLaren (2010), equation (5) represents the change in the value of imports from the free-trade situation for a small country.

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[11] Assuming initial import tariffs in place, e.g., the producer price is given by $p_i^p = \left(1+\tau_i^p\right)\left(1+\tau_i\right)\pi_i$ and the consumer price is given by $p_i^c = \left(1+\tau_i^c\right)\left(1+\tau_i\right)\pi_i$, which would affect the height of the uniform protection rate.

(5) $$\Delta M = (\pi)'\Delta m\left(p^p, p^c\right) = (\pi)'\Delta d\left(p^p, p^c\right) - (\pi)'\Delta s\left(p^p, p^c\right)$$

Accordingly, the MTRI-DS, $\tau^{ds}$, is implicitly given by equations (6) and (7), where we equate this change with the situation with a uniform protection rate. Hence, the MTRI-DS quantifies the homogeneous protection rate that results in the same change in the import value as the initial consumer and producer distortions.

(6) $$(\pi)'\Delta m\left(p^p, p^c\right) = (\pi)'\Delta m\left[\left(1+\tau^p\right)\pi, \left(1+\tau^c\right)\pi\right] = (\pi)'\Delta m\left[\left(1+\tau^{ds}\right)\pi, \left(1+\tau^{ds}\right)\pi\right]$$

In general, because the rate of producer distortion differs from the rate of consumer distortions, it is important to distinguish between consumer and producer distortions. Nevertheless, assuming $\tau^c = \tau^p$ and linear import demand functions implying constant slopes of the demand and supply curves, equations (6) and (7) can be solved for $\tau^{ds}$ to obtain the general equilibrium form of the MTRI-DS, based on Lloyd and MacLaren (2010), with commodity $i = 1, ...., n$ and commodity $j = 1, ...., n$, where $i \neq j$ are complements/substitutes reflecting cross-price effects.

(7) $$\left(\pi_i\ \pi_j\right)\begin{bmatrix} \frac{\partial d_i}{\partial p_i} & \frac{\partial d_i}{\partial p_j} \\ \frac{\partial d_j}{\partial p_i} & \frac{\partial d_j}{\partial p_j} \end{bmatrix}\begin{pmatrix} \pi_u \tau^{ds} \\ \pi_j \tau^{ds} \end{pmatrix} - \left(\pi_i\ \pi_j\right)\begin{bmatrix} \frac{\partial s_i}{\partial p_i} & \frac{\partial s_i}{\partial p_j} \\ \frac{\partial s_j}{\partial p_i} & \frac{\partial s_j}{\partial p_j} \end{bmatrix}\begin{pmatrix} \pi_u \tau^{ds} \\ \pi_j \tau^{ds} \end{pmatrix}$$
$$= \left(\pi_i\ \pi_j\right)\begin{bmatrix} \frac{\partial d_i}{\partial p_i} & \frac{\partial d_i}{\partial p_j} \\ \frac{\partial d_j}{\partial p_i} & \frac{\partial d_j}{\partial p_j} \end{bmatrix}\begin{pmatrix} \pi_i \tau_i^c \\ \pi_j \tau_j^c \end{pmatrix} - \left(\pi_i\ \pi_j\right)\begin{bmatrix} \frac{\partial s_i}{\partial p_i} & \frac{\partial s_i}{\partial p_j} \\ \frac{\partial s_j}{\partial p_i} & \frac{\partial s_j}{\partial p_j} \end{bmatrix}\begin{pmatrix} \pi_i \tau_i^p \\ \pi_j \tau_j^p \end{pmatrix}$$

The MTRI-DS accounts for cross-price effects on both consumption and production sides and considers both producer and consumer distortion rates. Equation (8) shows the general equilibrium solution of the MTRI-DS.

(8) $$\tau^{ds} = \left(\sum_i \sum_j \tau_j^c w_{ij}\right)(a) + \left(\sum_i \sum_j \tau_j^p v_{ij}\right)(b)$$

The consumer distortion rate, $w_{ij}$, and the producer distortion rate, $v_{ij}$, are expressed by the equations (9) and (10) separating own- and cross-price effects.

(9) $$w_{ij} = \pi_i \pi_j (\partial d_i / \partial p_j) \Big/ \sum_i \sum_j \pi_i \pi_j (\partial d_i / \partial p_j)$$

(10) $$v_{ij} = \pi_i \pi_j (\partial s_i / \partial p_j) \Big/ \sum_i \sum_j \pi_i \pi_j (\partial s_i / \partial p_j)$$

Equation (8) divides the total import responses into two shares: consumption responses denoted by $a$ and production responses denoted by $b$ (equations (11) and (12)). These shares weight the total production and consumption effects that are given in parentheses in equation (8). All weights sum to unity.

(11) $$a = \sum_i \sum_j \pi_i \pi_j \left( \partial d_i / \partial p_j \right) \Big/ \sum_i \sum_j \pi_i \pi_j \left( \partial m_i / \partial p_j \right)$$

(12) $$b = -\sum_i \sum_j \pi_i \pi_j \left( \partial s_i / \partial p_j \right) \Big/ \sum_i \sum_j \pi_i \pi_j \left( \partial m_i / \partial p_j \right)$$

In this article, we apply a CGE model to determine the MTRI for domestic support provided to agricultural producers. Deviating from the small country approach introduced above, the CGE approach allows us to account for effects on world market prices and considers diverging consumer and producer distortion rates.

## 4 Extended GTAP modeling framework

The analysis in this article is based upon an extended version of the standard GTAP model and updated versions of the underlying GTAP database Version 8.1 that are well documented in Hertel (1997) and Narayanan et al. (2012). Following Urban et al. (2014), we update the domestic support payments in the GTAP database to consider the structure of these payments.2 The application of a complex updating procedure with a modified version of the Altertax program (Malcolm 1998) enables us to integrate the PSE data according to the SCT, ACT, GCT,

[2] Market price support is implicitly included in the GTAP model via border measures. To avoid double counting, we only incorporated PSE budgetary payments into the GTAP database and model.

and OTP categories and the payment types, i.e., output, input, land, labor and capital. The various agricultural policy instruments are mirrored in the GTAP model in the form of the five price wedges affecting the transactions of producers at agents' and market prices for output, intermediate inputs, land, capital, and labor, respectively. We implement additional policy instruments to subdivide each of these price wedges according to the four PSE categories to achieve a detailed representation of domestic support in the underlying value flows and the corresponding price-linkage equations. The SCT payments are linked to a specific product, whereas ACT and GCT payments are given to a group of commodities and are therefore allocated with a homogenous rate across the commodities belonging to these product groups. OTP payments are not linked to production. Hence, they are distributed at a homogeneous rate across primary agricultural commodities according to land utilization (Urban et al. 2014), which reflects effectively fully decoupled payments (Cahill 1997).

The introduction of additional policy instruments enables the relocation of domestic support payments in the updated database according to the WTO classification scheme. To achieve this, we subdivide each of the newly integrated domestic support price wedges in the GTAP model into amber, blue and green box supports, which results in a complex structure of domestic support payments in the GTAP model and database that represents both important measures of domestic support payments, the PSE concept and the WTO classification scheme.

Modeling the MTRI for domestic support payments builds on an approach developed by Antimiani and Salvatici (2005) and Pelikan and Brockmeier (2008a). This approach introduces new variables that measure the imported quantity of all commodities by source and destination and define the newly implemented quantity variables as exogenous in the model to calculate the endogenously adjusted uniform tariff equivalent.

The GTAP model represents trade through bilateral trade matrices based on the Armington assumption (Armington 1969). The elasticity of substitution therefor determines the similarity of commodities from different countries to allow all products to be differentiated by country of origin. The import demand is modeled in GTAP using a two-stage nested CES functional form (Hertel 1997). Consequently, a country both imports and exports in the same sector.

To capture the trade-distorting effect of domestic support payments, we must keep track of the effect on both import and export flows. Considering this, we introduce the new policy variable "MTRI-DS" in both the market price and export price equations. Adapting the approach of Antimiani and Salvatici (2005) and Pelikan and Brockmeier (2008a), we capture domestic support by introducing new variables to quantify the trade volume of commodities by source and destination by determining the value of net imports in the model. Similar to their approach, we define trade volume variables as exogenous such that the adjusting uniform protection rate takes the changes on both the import and export sides into account, while we remove domestic support subsidies.

In contrast to the simplified formal approach based on the small country assumption (compare section 3), the general equilibrium environment of the GTAP model allows us to account for the effects of removing domestic support on world market prices.

## 5 Experiment design

The GTAP database Version 8.1 includes bilateral trade and protection matrices and additional data from the OECD PSE tables and links 57 sectors in 129 regions in the year 2007. This database is aggregated to the EU and to the Rest of the World and to 22 sectors (compare tables A1 and A2 in the appendix). The highly aggregated regional setting is chosen to avoid aggregation effects that might lead to a bias in the analysis. The aggregate of the EU consists of 25 EU member states. However, Bulgaria and Romania joined the EU in 2007. Therefore, we have excluded both from the EU aggregate to allow consistent comparison of the regional aggregation and the PSE tables of the EU in the years 2004 and 2007.

Decoupled payments are controversially discussed in the literature. Important issues include capitalization of direct payments in land rents as well as various coupling channels through which a farmer's production decision might be influenced (Bhaskar and Beghin 2009; Goodwin and Mishra 2005; Key and Roberts 2009; Latruffe and Le Mouel 2009). However, the extent to which this incentive occurs remains unclear, and we thus choose to follow Urban et al. (2014) in our analysis.

We create a set of deviating GTAP databases to enable our evaluation of domestic support development (table 2). Therefore, we implement domestic support payments originating from OECD PSE tables for 2004 and 2007 (OECD 2014) in the GTAP database (version 8.1, base year, 2007). In so doing, we vary the assumptions regarding the degree of decoupling of the SFP. The first (PSE04-SFPland100) and second (PSE07-SFPland100) database represent a full capitalization of the SFP in land rents, whereby the SFP is allocated with a homogeneous rate across primary agricultural commodities to land. In the first database (PSE04-SFPland100), we integrate the levels of domestic support from the PSE tables of 2004 into Version 8.1, base year 2007, of the GTAP database.

**Table 2: Database Setting**

| | | Name of the database | | | |
|---|---|---|---|---|---|
| | | **PSE04-SFPland100** | **PSE07-SFPland100** | **PSE07-SFPland90** | **PSE07-SFPland80** |
| Baseyear PSE table | 2004 | X | | | |
| | 2007 | | X | X | X |
| SFP allocation | Land | 100% | 100% | Land usage + 90% of labor, capital usage | Land usage + 80% of labor, capital usage |
| | Labor, capital | | | 10% of factor usage | 20% of factor usage |
| Effect on production | Fully decoupled | X | X | | |
| | Partially decoupled | | | X | X |

*Source: Authors' elaboration*

This procedure allows us to compare domestic support over different years but does not create a bias through deviating parameters in different base years, such as changing trade protection data would, for example. For the third database (PSE07-SFPland90), we assume that the SFP is not fully capitalized in land rents but nonetheless creates production incentives through other coupling channels. Here, we begin from an allocation of the SFP according to factor usage and shift 90% of the SFP initially distributed to labor and capital onto land. This seems appropriate because Goodwin and Mishra (2005), for example, state that the effect of other coupling channels is rather modest. In the fourth database (PSE07-SFPland80), we account for a lower degree of decoupling, as in PSE07_SFPland90, and shift only 80% to land.

We use the four databases as starting points to run the scenarios summarized in table 3. The database PSE07-SFPland100 is applied to first run a simulation that completely removes domestic support payments given to primary agricultural commodities. This scenario serves as a benchmark to evaluate the effectiveness of the extended MTRI at capturing the effects and restrictiveness of domestic support payments. Second, three scenarios (table 3) are simulated to either eliminate domestic support, import tariffs or export subsidies and to determine the uniform equivalent protection rate. The remaining three databases are used to determine the MTRI-DS, applying scenario DS–UPR

**Table 3. Overview of Applied Scenarios**

| | | Name of scenario | | |
|---|---|---|---|---|
| | | **DS-UPR** | **TMS-UPR** | **TXS-UPR** |
| **Abolishment of:** | Domestic support payments | X | | |
| | Import tariffs | | X | |
| | Export subsidies | | | X |
| **UPR included in:** | Market price equation | X | X | |
| | Export price equation | X | | X |
| **UPR:** | Swapped with net-imports | X | X | X |

*Source: Authors' elaboration*

Note: UPR stands for uniform protection rate

Finally, to validate the concept of the MTRI-DS, in particular the effects of domestic support payments on downstream sectors of the value chain, we calculate the MTRI-DS not only for a specific sector but also for aggregated primary and downstream sectors. In so doing, we analyze how different commodity aggregations affect the index number and the allocation effects in the EU due to removal of subsidies. We begin with eliminating domestic support payments given to all primary agricultural commodities, while we determine the uniform protection equivalent first for primary agricultural commodities and second for all food commodities to account for effects along the value chain.

## 6 Results

Abolishing EU domestic support payments causes the well-known effect of a decrease in output and exports, while imports and the world market price increase (compare table A3 in the appendix). Although the trade-distorting effect of EU domestic support is obvious, we are not able to identify the overall level of trade restrictiveness of these policy instruments used for domestic support. Therefore, we describe in the following subsections the results of our applied MTRI-DS in the GTAP model.

### 6.1 MTRI-DS compared with border measures

We utilize the three scenarios (DS-UPR, TMS-UPR und TXS-UPR) described in table 3 to assess this issue. Following the defined scenarios, we compare the results of completely removing domestic support, import tariffs, or export subsidies for primary agricultural commodities utilizing database PSE07-SFPland100 in table 4. In the first column of the table, we present the uniform equivalent protection for removing domestic subsidies and the decomposition of the overall change in the MTRI-DS by primary agricultural commodities. The second and third columns show the uniform protection rate and the decomposition for the removal of import tariffs and exports subsidies, respectively.

Three points are notable. First, the MTRI-DS equals a uniform protection rate of 3.66, compared with 2.98 for import tariffs and only 0.29 for export subsidies, which indicates that domestic support payments are more trade restrictive than are import tariffs and export subsidies. Second, the decomposition reveals that the MTRI-DS is mainly driven by removing domestic support payments given to other crops, followed by fruits and vegetables; however, with respect to removing import tariffs, the fruits and vegetables sector contributes the most to the MTRI-DS.

Third, table 4 clearly shows that import tariffs are more trade restrictive in arable crops than domestic support payments, whereas domestic support payments are more trade distorting in the oilseeds and other crops sectors. Domestic support payments and import tariffs show almost the same level of trade restrictiveness only in the fruits and vegetables sector. Thus, the impact on trade caused by the applied protection instruments varies significantly between sectors.

**Table 4. Comparison of the MTRI-DS with other Border Measures in 2007**

| | Removal of: Domestic support | Import tariffs | Export subsidies |
|---|---|---|---|
| **MTRI-DS / UPR for primary agricultural commodities** | **3.66** | **2.98** | **0.29** |
| **Decomposition of results:** | | | |
| All crops: | | | |
| Arable crops | 0.56 | 0.75 | 0.00 |
| Oilseeds | 0.13 | 0.00 | 0.00 |
| Other crops | 2.42 | 0.50 | 0.00 |
| Fruits and vegetables | 1.68 | 1.62 | 0.11 |
| Livestock: | | | |
| Ruminants | -0.66 | 0.04 | 0.18 |
| Non-ruminants | -0.46 | 0.07 | 0.00 |

*Source: Authors' calculation*

Note: GTAP Version 8.1 adapted to PSE07-SFPland100 as described in table 2. Compare table A 4 to A 5 in the appendix for the effect of the elasticity of substitution and the underlying protection data on the MTRI of domestic distortion. For the representation of the results, we aggregated the primary agricultural sectors as shown in the table. The arable crops aggregate comprises paddy rise, wheat, cereal grains as corn, barley, rye, oats, sugar cane and sugar beet, and plant-based fibers. The Oilseed sector includes oil seed and oleaginous fruits, soybeans and copra. Aggregated other crops considers other crops as live plants, cut flowers, beverage and spice crops, tobacco, seeds, protein crops as clover, lupines, and alfalfa, fodder and forage products. The fruits and vegetables sector contains vegetables, fruits, nuts, potatoes, cassava, and truffles. The ruminants sector includes cattle, sheep, goats, horses, and raw milk and wool whereas the non-ruminants sector consists of other animal products as swine, poultry, other live animals, and eggs.

## 6.2 Development of the MTRI-DS

How does implementing decoupled support affect the results? In table 5, we compare the effects of the deviating GTAP databases (columns 1 to 4) regarding distribution of the SFP for base year 2007 (compare table 2). Furthermore, table 5 decomposes the results according to the effects of payment categories, payment types, different sectors, and the WTO classification scheme on the uniform protection equivalent.

**Table 5. Development of the MTRI-DS for Agricultural Commodities and its Components**

| | **PSE04-SFPland100** | **PSE07-SFPland100** | **PSE07-SFPland90** | **PSE07-SFPland80** |
|---|---|---|---|---|
| **1. MTRI-DS** | **3.42** | **3.66** | **4.64** | **5.62** |
| 2. Payment category: | | | | |
| Single commodity transfer (SCT) | 2.38 | 0.75 | 0.76 | 0.76 |
| Group commodity transfer GCT) | -0.65 | 0.30 | 0.30 | 0.30 |
| All commodity transfer (ACT) | 1.68 | 2.59 | 2.60 | 2.61 |
| Other transfer to producers (OTP /SFP) | 0.00 | 0.02 | 0.99 | 1.95 |
| 3. Payment type: | | | | |
| Output | 1.73 | 0.39 | 0.39 | 0.39 |
| Input | 0.74 | 0.70 | 0.70 | 0.69 |
| Land | -0.72 | 0.28 | 0.28 | 0.28 |
| Labor | 0.10 | 0.18 | 0.95 | 1.72 |
| Capital | 1.58 | 2.11 | 2.32 | 2.54 |
| 4. Primary agricultural commodities: | | | | |
| Arable crops | -0.70 | 0.56 | 0.74 | 0.93 |
| Oilseeds | 0.94 | 0.13 | 0.23 | 0.23 |
| Other crops | 1.96 | 2.42 | 2.79 | 3.15 |
| Fruits and vegetables | 0.98 | 1.68 | 1.96 | 2.25 |
| Ruminants | 0.26 | -0.66 | -0.61 | -0.55 |
| Non-ruminants | -0.02 | -0.46 | -0.42 | -0.38 |
| 5. WTO box classification: | | | | |
| Amber box | 2.31 | 0.79 | 0.78 | 0.78 |
| Blue box | -0.60 | 0.26 | 0.26 | 0.26 |
| Green Box | 1.71 | 2.61 | 3.59 | 4.57 |

*Source: Authors' calculations*

Note: GTAP version 8.1, base year 2007.

The MTRI-DS shows a slight increase of 7% from 3.42 in 2004 to 3.66 in 2007 based on growth of the total PSE from 54.583 to 58.674 Mio. € (compare table 1). However, a decrease in MTRI-DS from 2004 to 2007 would be expected to reflect the higher share of decoupled support in 2007 because the CAP introduced the SFP in 2005, accounting for 53% (3%) of domestic support payments in 2007 (2004).

As anticipated, the decrease in the degree of decoupling (columns 2 to 4) leads to a rise in the MTRI-DS. The integration of the SFP as effectively fully decoupled payments into the model results in the smallest uniform protection rate, whereas databases considering the SFP as only partially decoupled show a MTRI-DS that is increasing from database PSE07-SFPland90 to PSE07-SFPland80, which corresponds to an increasing degree of coupling. Thus, the MTRI-DS reflects the impact on trade restrictiveness of deviating underlying assumptions about the SFP.

The second and third part of table 5 presents the MTRI-DS differentiated into categories and types of support. This depiction indicates that the SFP has no effect on the MTRI-DS when payments are modeled with a homogeneous rate across commodities allocated to land.

This decomposition shows that SCT and ACT payments govern the uniform equivalent protection rate. SCT comprises product-specific subsidies and therefore obviously affects production decisions. The effect of the SCT on the MTRI-DS declines from 2.38 (2004) to 0.75 (2007) because of the reduction in SCT payments from 18.012 to 4.632 Mio. €. The change in composition of the SCT away from subsidies based on output or input use strengthens this effect (compare table 1).

### 6.3 Impact of the payment category and payment type on the MTRI-DS

The composition of ACT payments explains the impact on the MTRI-DS. In 2004, only 49% of ACT payments are allocated to land. Payments to land are expected to have the least effect on production, particularly when distributed at a homogeneous rate across all primary agricultural commodities. Furthermore, the contribution of ACT payments to the MTRI-DS rises from 1.68 (2004) to 2.59 (2007) due to reduced payments allocated to land in favor of payments distributed to labor and capital.

In contrast to ACT, GCT is provided in the form of group-specific subsidies; hence, GCT may create higher production incentives. Table 5 displays contrasting effects on the MTRI-DS in 2004 compared with 2007. In 2004, contribution to the MTRI-DS is negative, whereas it is positive in 2007, although the share of GCT payments shrinks considerably. In 2004, 90% of

GCT payments are provided as subsidies based on land. Additionally, the homogeneous distribution across groups of commodities harms all commodities equally and does not boost factor re-allocation. Consequently, reducing those payments affects production decisions less than SCT and ACT payments affect such decisions. Furthermore, GCT subsidies based on land substantially decrease in 2007 whereas the distribution to labor clearly increases, which explains the reverse effect (0.3) on the MTRI-DS.

Payment types affect the MTRI-DS differently. Output subsidies apparently create production incentives shown by the highest contribution to the MTRI-DS in 2004 (1.73). The substantial removal of output subsidies until 2007 explains the reduced contribution in 2007. The determined effect for intermediate inputs is almost the same in 2004 as in 2007. According to the PSE tables, product-specific input subsidies are reduced considerably, followed by moderate decreases of input subsidies in the GCT category and only a slight reduction in the ACT category. However, the contribution of intermediate inputs to the overall MTRI-DS diminishes only slightly. Payments given to capital largely decrease, whereas the effect on the MTRI-DS increases. These results support the conclusion that payment types other than land have become more important.

## 6.4 Decomposition of the MTRI-DS according to sectoral contributions

The fourth part of table 5 shows a decomposition of the overall change in the MTRI-DS according to sectoral contribution. Clearly, the other crops sector has the greatest effect on the MTRI-DS. Its importance even increases from 2004 to 2007 due to a rise in domestic support payments involving growth of capital- and labor-based payments that exceed the decreases in output subsidies. However, the sector for fruits and vegetables also reveals a significant effect on the MTRI-DS that increases considerably from 0.98 to 1.68. Domestic support in this sector is three times as high in 2007 as in 2004, which explains the increase, particularly because payments based on output, capital, and labor rise. The effects of the arable crop sector also grow, although the total amount of subsidies declines from € 30.245 million to € 19.794 million.[3] However, in 2004, the decomposition reports a negative number for arable crops. A negative contribution to the MTRI-DS implies that an import subsidy, export tax or a combination

[3] Table 1 shows the aggregated PSE values according to payment categories and types. Sector-specific PSE values are not presented in this article.

of these policy instruments is required to keep the volume of net imports constant. In 2004, 96% of the subsidies for arable crops are allocated based on land and only 0.1% are output subsidies. Furthermore, no more than 8% are product-specific subsidies. Removing these subsidies would imply a decrease in the value of exports that is less than the increase in the value of imports. Consequently, an import subsidy, an export tax or a combination of these policy instruments is required to keep net trade volume constant. In 2007, the share of payments allocated based on land clearly decreased, thereby necessitating an import tariff, an export subsidy or a combination of these policy instruments to fix the net trade volume by inducing a positive MTRI-DS.

By contrast, the contribution of oilseeds decreases from 0.94 in 2004 to only 0.13 in 2007 due to a decrease of domestic support of -50%; in particular, product-specific subsidies allocated on output are lowered. Additionally, the livestock sectors, in particular, show reduced trade restrictiveness. In 2007, both the ruminants and non-ruminants sectors even display a negative contribution to the uniform protection rate. The results for the sector of cattle, goats, sheep and horses demonstrate that this sector is highly subsidized. In 2004, 82% of domestic support is distributed-product specific, of which 98% is allocated based on capital. This result supports our assumption that this sector is highly trade restrictive. Nevertheless, removing domestic support leads to a decrease in export values that exceeds the increase in import values, which yields a negative MTRI-DS and implies the need for an import subsidy, an export tax or a combination of these policy instruments to maintain an unchanged net import volume. We observe such a discrepancy because the import volume of the downstream sectors, such as meat products, substantially increased.

### 6.5 Aggregation effects on the MTRI-DS

Table 6 emphasizes the impact of sectoral aggregation on the MTRI-DS. The first column shows the effects explained in the previous sections, whereas the second column illustrates the uniform protection rate that is necessary to keep the net import volume of all food commodities constant to account for forward linkages. This net import equivalent clearly varies depending on the aggregation. The deviations are induced by changes in the downstream sectors because the removal of domestic support leads to higher input prices. In so doing, eliminating subsidies given to the livestock sector results in reduced output, higher market prices and, consequently, decreased exports and increased imports.

Thus, downstream sectors, such as meat products, are faced with higher input prices that cause market prices for meat products to rise and results in increased meat imports and reductions in the livestock inputs used in the meat industry. Consequently, a simulation that also retains the import volume of the forward-linked sectors yields an MTRI-DS for livestock that is positive; therefore, the trade restrictiveness of subsidies given to livestock producers is notable.

**Table 6. Impact of the Sectoral Aggregation on the MTRI-DS in 2007**

| | Primary agricultural commodities | Food commodities |
|---|---|---|
| **MTRI-DS** | **3.66** | **1.97** |
| **Decomposition of results:** | | |
| All crops: | | |
| Arable crops | 0.56 | 0.04 |
| Oilseeds | 0.13 | 0.46 |
| Other crops | 2.42 | 0.64 |
| Fruits and vegetables | 1.68 | 0.33 |
| Livestock: | | |
| Ruminants | -0.66 | 0.40 |
| Non-ruminants | -0.46 | 0.11 |

*Source: Authors' calculation*

Note: GTAP Version 8.1 adapted to PSE07-SFPland100 as described in Table 2.

### 6.6 Decomposition of the MTRI-DS according to the WTO classification scheme

The last part of table 5 shows the results of the reconciliation of PSE data with the WTO classification scheme. Here, the achievement of the CAP reform in lowering the trade-distortive effects of domestic support is evident. In our representation, the amber box comprises only non-exempt direct payments. The highly trade-distortive amber box support decreases substantially from 2004 to 2007, which is reflected in a decline of the contribution to the MTRI-DS from 2.31 to 0.79. Furthermore, the EU cut payments classified as blue box support. However, in table 5 the contribution of blue box support to the overall MTRI-DS changes from -0.6 to 0.26. The effect of the removal of domestic support on forward linkages as described for the livestock and meat sector in the previous paragraph explains this result. The trade-distortive effect of green box support increases from 1.71 to 2.61. Our application of the MTRI-DS reveals that payments assigned to the green box other than the SFP have a clear effect on trade. In 2004, the green box includes 32% of the PSE budgetary transfers, of which 9% are SFP, whereas in 2007, the green box increases to 84% of the PSE budgetary transfers and 66% of these are now SFP. Non-SFP green box support based on the PSE increased by more than 6% from 2004 to 2007. Green box payments other than SFP are modeled in GTAP by their PSE category, and the PSE concept distinguishes policy instruments according to their production requirement. ACT contains most of the non-SFP green box payments. Only half of these payments are distributed to land whereas the other half is provided as mainly capital, labor and input subsidies. They attract more capital, labor and intermediate inputs to be employed in the agricultural sector and are trade distorting, as a consequence. The rise from 2004 to 2007 can therefore be traced back to substantial growth of green box payments allocated to output, capital, and labor.

## 7 Discussion and conclusion

The objective of this article is to provide a theoretically sound index that enables the evaluation of the trade restrictiveness of domestic support payments and the application of this index in a CGE framework. Specifically, we build on the work of Anderson and Neary (2005) to derive an index based on their MTRI. We name our index MTRI-DS and implement it in the GTAP framework. The adopted model is an extended version of the GTAP framework that considers domestic support payments in detail and includes a reconciled representation of two important measures of domestic support payments: the PSE concept and the WTO classification scheme. We employ this framework to determine the tariff equivalent of EU domestic support payments while accounting for the general equilibrium effects, including all intersectoral linkages and interdependencies with world markets.

This tariff equivalent of domestic support payments is appropriate for comparing different protection policies, such as import tariffs, export subsidies, and domestic support payments. The simulation results reveal that domestic support payments in the EU (3.66) are more trade restrictive than import tariffs (2.98) or export subsidies (0.29). Hence, our new MTRI-DS allows a rating of the trade-distortive effect of different protection instruments based on quantitative results. Furthermore, the resulting uniform protection rate demonstrates the development of domestic support payments in the EU over time, including the effect of the implementation of decoupled support. Our MTRI-DS tracks changes in the composition of CAP policy instruments and is therefore suited to assess the effect of policy reforms. Additionally, our MTRI-DS allows evaluation of policy reforms with respect to their contribution to meeting WTO requirements. In other words, the MTRI-DS helps to assess the effect of countries' policy reforms over time, indicating a movement toward less-distortive policy instruments, and is therefore suited to support trade negotiations. Finally, the MTRI-DS figures are meaningful for comparisons across countries.

Our MTRI is thus useful for policy analysis in which the relevancies of different policy instruments are considered and compared, such as in simulations to analyze WTO negotiations, which requires a comparison of the trade restrictiveness of domestic support payments, other protection instruments for market access, and export subsidies.

Although this index already operates as an effective tool for analyzing domestic support payments, it also provides a springboard for further research. The PSE concept classifies domestic support payments according to production requirements and thus results in a higher trade-distortive effect than does green box support under the WTO framework. Our current method of incorporating non-SFP green box payments based on the PSE into the GTAP model is clearly trade distorting and might, as a result, overestimate the effect on trade. De Gorter, Ingko and Nash (2004), however, refer to the definition of trade-distorting measures in the AoA, noting that not all policy instruments are appropriately categorized by their production requirements, which leads to underemphasized green box support. Consequently, delving deeper into the definition and quantification of trade-distorting measures would help to reveal whether our representation of non-SFP green box support correctly reproduces the non-SFP green box in terms of distortions.

Second, aggregation bias can change the results and might, therefore, cause an over- or underestimation of the trade restrictiveness of domestic support payments. In fact, in our analysis, we detect such an aggregation bias. The results clearly demonstrate that the MTRI-DS is affected by the inclusion of forward-linked sectors. Therefore, focusing future research on analyzing the effect of sectoral aggregation on the MTRI-DS would lead to improvements in the validation of results.

In the CGE application, we shift the focus toward producer subsidies, ignoring the potential implications of changes in consumer subsidies, although we theoretically derive the MTRI-DS from the import volume function, depending on consumer and producer prices. This derivation is based on the theoretical approach of Anderson and Neary (2005) and Lloyd and MacLaren

(2010). The reason to exclude consumer subsidies is the modeling of households as one representative household in the GTAP model, which makes the model inappropriate for analyzing the effects of consumer support. This exclusion provides another interesting avenue for future research, as embedding consumer subsidies into the analysis would afford the model more applicability.

The focus of the MTRI approach and subsequently our MTRI-DS is on foreign trade, whereas the implications for welfare and other effects within a country are not covered. Eliminating domestic support reduces government spending whereas introducing the uniform tariff rate creates additional tax revenue in our application. Thus, this forces the question of how much this increase in government income affects production, consumption, and welfare. Elaborating a comparison of our MTRI-DS and the TRI of domestic distortion (Anderson and Neary, 2005) following the GTAP application of Salvatici (2001) for the EU would therefore complete the assessment of the impact of domestic support payments.

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## Appendix

**Table A 1. Regional Aggregation of the GTAP Database**

| Countries and Regions | | Abbreviation |
|---|---|---|
| 1 | **EU:** Austria, Belgium, Denmark, Finland, France, Germany, Ireland, United Kingdom, Greece, Italy, Luxembourg, Netherlands, Portugal, Spain, Sweden, Czech Republic, Cyprus, Hungary, Malta, Poland, Slovakia, Slovenia, Estonia, Latvia, Lithuania | **EU25** |
| 2 | **Rest of the World:** United States, Canada, Japan, Australia, New Zealand, Bulgaria, Romania, 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: Authors' elaboration*

**Table A 2 Sectoral Aggregation of the GTAP Database**

| 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 | omt |
| 15 | Vegetable oils and fats | vol |
| 16 | Dairy products | mil |
| 17 | Processed rice | pcr |
| 18 | Sugar | sgr |
| 19 | Other food | ofd |
| 20 | Beverages and tobacco products | b_t |
| 21 | Manufacturing:<br>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:<br>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: Authors' elaboration*

**Table A 3. Effects of an Elimination of Domestic Support Payments in the EU**

| | Output | EU imports | EU exports | Domestic prices | World market prices |
|---|---|---|---|---|---|
| **pdr** | -21.85 | 52.37 | -64.78 | 12.53 | 0.71 |
| **wht** | -3.68 | 24.15 | -21.11 | 3.70 | 1.24 |
| **gro** | -1.82 | 5.25 | -6.52 | 3.40 | 0.85 |
| **v_f** | -2.16 | 5.73 | -6.64 | 2.91 | 0.77 |
| **osd** | -3.71 | 4.80 | -9.58 | 2.95 | 0.84 |
| **c_b** | -0.15 | 3.79 | -3.90 | 1.41 | 0.56 |
| **pfb** | -20.35 | 26.20 | -51.35 | 17.25 | 0.91 |
| **ocr** | -2.40 | 8.77 | -10.29 | 2.74 | 1.35 |
| **ctl** | -4.21 | 38.30 | -29.04 | 10.92 | 2.31 |
| **oap** | -1.58 | 4.31 | -5.21 | 2.98 | 0.84 |
| **rmk** | -0.70 | 5.39 | -19.10 | 3.48 | 1.14 |
| **wol** | -16.90 | 2.65 | -18.90 | 2.16 | 0.43 |
| **cmt** | -4.81 | 22.74 | -22.55 | 4.18 | 0.94 |
| **omt** | -1.58 | 10.82 | -9.74 | 1.73 | 0.78 |
| **vol** | -2.43 | 3.63 | -5.80 | 1.36 | 0.47 |
| **mil** | -0.67 | 4.27 | -3.70 | 0.96 | 0.59 |
| **pcr** | -1.99 | 5.50 | -7.12 | 2.09 | 0.46 |
| **sgr** | -0.21 | -0.20 | 0.00 | 0.29 | 0.28 |
| **ofd** | -0.49 | 0.73 | -0.99 | 0.57 | 0.35 |
| **b_t** | -0.22 | 0.31 | -0.39 | 0.45 | 0.31 |
| **Mnfc** | 0.20 | -0.33 | 0.47 | 0.07 | 0.13 |
| **Services** | 0.04 | -0.22 | 0.28 | 0.06 | 0.13 |

*Source: Authors' calculation*

**Table A 4. Effect of the Initial Protection on the Results of the MTRI-DS**

| Protection | reduced by | | default | increased by | |
|---|---|---|---|---|---|
| | 100% | 50% | | 50% | 100% |
| **Primary agricultural commodities** | **3.51** | **3.59** | **3.66** | **3.71** | **3.73** |
| All crops: | | | | | |
| Arable crops | 0.72 | 0.64 | 0.56 | 0.47 | 0.37 |
| Oilseeds | 0.06 | 0.09 | 0.13 | 0.16 | 0.20 |
| Other crops | 2.17 | 2.30 | 2.42 | 2.53 | 2.63 |
| Fruits and vegetables | 1.68 | 1.68 | 1.68 | 1.67 | 1.65 |
| Lifestock: | | | | | |
| Ruminants | -0.66 | -0.66 | -0.66 | -0.66 | -0.66 |
| Non-ruminants | -0.46 | -0.47 | -0.46 | -0.46 | -0.46 |

*Source: Authors' calculation*

Note: GTAP Version 8.1, base year 2007, PSE 2007, SFP allocated 100% to land. In addition, the validation of results requires an analysis of the implications of changes in the underlying border protection, because of the modeling of the MTRI-DS. We implement the MTRI-DS in the price linkage equations for exports and imports. In the price linkage equation for imports (13) the market price is determined.

(13) $$p_m = (1+\tau_i)(1+\tau^{ds})\, p_{cif}$$

The multiplication of the specific tariff rate $(1+\tau_i)$ with the uniform protection rate $(1+\tau^{ds})$ might lead to an effect of the initial tariff rate on the MTRI-DS. Hence, we conduct a second sensitivity analysis where import tariffs and export subsidies are decreased (increased) for all traded commodities by 50% and 100% to validate the impact of varying initial protection data. This analysis reveals that the impact on results is rather modest.

**Table A 5. Effect of the Elasticity of Substitution on the Results of the MTRI-DS**

| **Elasticity of substitution** | **Reduced by 50%** | **default** | **Increased by 50%** | **esubm = esubd** |
|---|---|---|---|---|
| **Primary agricultural commodities** | **3.70** | **3.66** | **3.54** | **3.70** |
| All crops: | | | | |
| Arable crops | 0.55 | 0.56 | 0.53 | 0.47 |
| Oilseeds | 0.24 | 0.13 | 0.05 | 0.25 |
| Other crops | 2.55 | 2.42 | 2.35 | 2.58 |
| Fruits and vegetables | 1.64 | 1.68 | 1.71 | 1.55 |
| Lifestock: | | | | |
| Ruminants | -0.71 | -0.66 | -0.66 | -0.68 |
| Non-ruminants | -0.56 | -0.46 | -0.44 | -0.47 |

*Source: Authors' calculation*

Note: GTAP Version 8.1, base year 2007, PSE 2007, SFP allocated 100% to land. Applying the concept of the MTRI-DS in a CGE framework, we are concerned about the Armington assumption. Therefore, we conduct a sensitivity analysis to assess the effect of the elasticity of substitution on the MTRI-DS. We distinguish between two cases in this sensitivity analysis. First, the nested case, where the elasticity of substitution among sources of imports (ESUBM) is equal to two times the elasticity of substitution between domestic and imported goods (ESUBD), which is the default option in the standard GTAP model. We increase (decrease) the elasticity of substitution for 50% in this nested structure. Second, we assume a non-nested case, where ESUBM is equal to ESUBD (Francois and Reinert 1997). The results confirm minor impact for most of the commodities, although the direction varies between sectors. Oilseeds are much more sensible than other commodities.

# 5 Discussion and conclusion

Industrialized economies, criticized for their trade-distorting domestic support provided to agricultural producers, initiated several reforms of their agricultural policies to fulfill World Trade Organization (WTO) domestic support reduction criteria. By contrast, emerging countries just have started to expand their agricultural domestic support programs and are still far from exceeding their WTO commitment levels. This disparity indicates that domestic support remains a significant topic of debate in trade negotiations.

In addition, the literature reveals an ongoing debate regarding the extent to which policy instruments that are supposedly decoupled from farm-level output decisions still create production incentives. These production stimulating effects stem from other coupling channels such as uncertainty, imperfect credit, land and labor markets, and farmer's expectations about future payments. Therefore, the extent to which decoupled support capitalizes in land rents remain unclear, and analyses of domestic support effects need to rely on assumptions, expert opinion and the best available estimates.

Analyses of multilateral trade liberalization are commonly conducted using Computable General Equilibrium (CGE) models. Methodologies to analyze the effects of market access policies and their restrictiveness to trade are sophisticated and well established, whereas the detailed representation of different and country-specific domestic support payments, and in particular decoupled payments, has received only little attention to date.

With regard to these shortcomings of CGE modeling and analyses of domestic support, this thesis achieves the following methodological advances:

1. Development of the standard GTAP database and model into an extended CGE modeling framework that represents domestic support payments at a very detailed level. This detailed coverage of domestic support payments accounts for different payment types, such as payments given on the basis of output, input and factor use, and different payment categories specifying particular production requirements that regulate the eligibility for support. Reconciliation of the OECD Producer Support Estimate (PSE) data in the underlying database with the WTO amber, blue, and green box support classification

scheme, which enables both of these important measures of domestic support payments to be present simultaneously in the GTAP database and model.

2. Introduction of a complex updating procedure to systematically modify the assumptions regarding production incentives induced by, e.g., decoupled payments that underlie the database and model.
3. Derivation of a theory-based index and its integration into the extended GTAP modeling framework to measure the trade restrictiveness of domestic support in a single number. This index therefore enables the comparison of distortions caused by domestic support across policy instruments, regions and over time.

This comprehensive and elaborate CGE modeling framework is generally applicable to analyze the effects on industry and trade structure, and welfare, and also the distortions caused by countries' domestic support payments. The applicability and relevance of this extended modeling framework is validated by applying this approach to analyze the effects of domestic support payments, particularly decoupled payments, taking the Common Agricultural Policy (CAP) of the European Union (EU) as an example. This concluding chapter first summarizes and discusses the main findings that answer the posed empirical research questions in chapter 1. Second, this chapter compares the extended GTAP modeling framework with other CGE modeling frameworks and comments on the way decoupled payments are introduced in applied models, and data availability. Finally, this section provides an outlook regarding future research.

### 5.1 Discussion of the empirical results

Based on the EU CAP, this thesis discusses the effect of different assumptions about the degree of decoupling of support payments and the corresponding modeling on policy simulation results at the national and global level. Therefore, this thesis simulates the effects of either a removal of decoupled support – the EU Single Farm Payment (SFP) - or total domestic support payments. Applying the extended GTAP modeling framework and complex domestic support updating procedure, the assumptions about the support payment's degree of decoupling in the underlying GTAP database are systematically altered. This updating procedure gradually reduces the share of decoupled support allocated to labor and capital and moves this amount to land. This way, the procedure creates a set of databases that covers the range of decoupled support allocated according to the factor usage with a homogeneous rate across commodities up to decoupled support distributed at a homogeneous rate across commodities to land.

In general, the results clearly indicate that the assumption about a support payment's degree of decoupling and its modeling is an important determinant of policy simulation results. The higher the degree of decoupling is, the lower the effects on factor relocation, industry output, trade and welfare. If the payment is fully decoupled, it causes no effects.

1. At EU member state level, the effect on industry output, trade and welfare diminishes with an increasing degree of decoupling. The extent of these effects clearly depends on the ratio of the SFP to the production value. In addition, the factor reallocation from less competitive to more efficient agricultural sectors, manufacturing and services explains why the output changes across sectors are affected differently in EU member states. The majority of countries reveals a decrease in output. Regarding the trade balance, all EU member states show a decrease in the share of agricultural exports to imports. Accordingly, the aggregated EU exhibits decreased agricultural output, an increased negative trade balance for agricultural and food commodities, and an increase in welfare.
2. The analysis of trade liberalization including domestic support turns out to be highly sensitive to the mode through which decoupled support is integrated and modeled in a CGE framework. These assumptions significantly affect the results and thus clearly matter for international trade analysis particularly in developing countries. The variance of the results measured across regions considerably increases with a decrease in the degree of decoupling. It becomes apparent, that the degree of decoupling significantly influences the results for net-food exporters of agricultural commodities, in particular developing countries. Depending on the EU SFP's degree of decoupling, the effects on results are four or five times as high when domestic support payments are removed. The impact of the degree of decoupling is lower in net-food importing countries. Removing EU domestic support payments causes welfare gains in net-food exporting countries and welfare losses in net-food importing countries. The effect on welfare diminishes by up to 80% with an increasing degree of decoupling.
3. The MTRI of domestic support payments reveals that the degree of trade distortion caused by the EU CAP is considerably affected by the extent to which the SFP is capitalized in land rents. The index value increases with a decrease in the degree of decoupling. The evaluation of the development over time indicates a movement towards less trade distorting CAP instruments. Thus, this analysis demonstrates that the MTRI of domestic distortions captures changes in the composition of CAP policy instruments

and is thus suited to assess the effect of such policy reforms and their impacts on trade distortion.

Because the impact of the degree of decoupling of payments, such as the SFP, is not yet empirically known, expert knowledge and the best available estimates determine the assumptions about a support payment's degree of decoupling in trade analysis. The use of estimates might lead to over- or underestimation caused by the effect of domestic support payments. To overcome this problem, this thesis delivers insights into the effects of removing domestic support payments, considering the entire range of underlying assumptions about the degree of decoupling. Therefore, this analysis helps to validate results by providing a range for the actual impact. The results, furthermore, highlight the importance of incorporating detailed domestic support payments with regard to the specific production requirements that regulate the eligibility for support in CGE modeling frameworks.

Besides accounting for the effect of different assumptions of a country's decoupled support, this updating procedure can also be applied to consider differences in the eligibility criteria of countries' policy instruments that are classified in the same PSE category.

## 5.2 Discussion of the extended GTAP modeling framework

### 5.2.1 Extensions to include detailed domestic support payments

The elaborate procedure to extend the GTAP modeling framework enables the integration of domestic support payments at a very detailed level, distinguishing different PSE payment categories and types according to their effect on farm-level output decisions. In addition, this thesis introduces two different options of modeling decoupled support. Option 1 models this payment category as a homogenous subsidy rate given to primary agricultural commodities that is distributed solely according to the factor land and reflects effectively full decoupling in the GTAP model and database. Only primary agricultural sectors employ land and furthermore, the supply of land is pre-determined. Therefore, a subsidy distributed at a homogenous rate to land in the GTAP model shows the same supply response as if the subsidy were abolished. By contrast, option 2 distributes decoupled support at a homogenous rate across primary agricultural commodities to land, labor, and capital and enables a general link to production without facilitating the production of a specific commodity and thus is partially decoupled. The literature includes several analyses proceeding in similar ways. However, the assumptions according to the underlying degree of decoupling differ significantly. The standard GTAP database and model currently represents decoupled support as partially decoupled, which therefore significantly stimulates production, whereas other models treat decoupled support as fully decoupled.

Other approaches incorporate decoupled support in the form of direct income support modeled as a lump sum transfer given to households. To implement such an approach, the domestic subsidies need to be allocated within the social accounting matrix (SAM). Corresponding studies in the literature primarily use single country CGE models or address only a specific region of a multi-regional CGE model because data from statistical- and household surveys need to be reconciled. Such approaches require the processing of huge amounts of country-specific data and disaggregate farm households and thus appear to be inappropriate for integrating domestic support payments for all countries in a multi-regional model that, in this particular case, depicts only one representative household. Such a global multi-regional model requires a corresponding general approach that is applicable to all countries.

These differences in modeling decoupled payments emphasize the potential relevance to account for the effect of different assumptions about the support payment's degree of decoupling in the underlying database on policy simulation results when analyzing domestic support.

The empirical analysis focusses on the EU CAP. In recent years, the EU has pioneered to push support policies towards sustainable development, environmental protection, nature conservation and rural development, which are referred to as second pillar instruments of the CAP. Global CGE models, such as the GTAP model, are less suitable for analyzing the very region-specific effects of second pillar policy instruments. An exception is the Modular Applied GeNeral Equilibrium Tool (MAGNET)[1] that is highly specialized in modeling EU CAP policy instruments. This thesis aims at an assessment of domestic support in a CGE modeling framework that is general and applicable to other countries. Due to the extreme region specificity of the EU CAP second pillar measures this is beyond the scope of this thesis.

The centerpiece of this thesis is a consistent modeling and integration procedure to represent detailed domestic support payments in the standard GTAP modeling framework using the EU PSE data as an example. This approach can be extended to update the domestic support pay-

[1] MAGNET based on the standard GTAP model and database. Detailed information regarding the extension of GTAP provided by MAGNET are available from: https://www.wageningenur.nl/de/Publicatie-details.htm?publicationId=publication-way-343535383037

ments of other countries and therefore enables a sophisticated and comparable analysis of countries' domestic support. In addition, this approach can be transferred to other CGE modeling frameworks based on OECD PSE data. The extended modeling framework developed in this thesis is generally subject to the availability of OECD PSE data. The OECD PSE concept is a well-established and widely used measure of domestic support. The OECD provides PSE data for 14 OECD member countries and 7 other, in particular, emerging countries covering the period 1986 to 2013. In addition, other organizations such as the Inter-American Development Bank have just started to apply this well-documented approach to provide PSE data for, e.g., Central- and South America. Several applied CGE model databases incorporate OECD PSE data, such as the GTAP database.

### 5.2.2 MTRI of domestic support payments

To analyze the possible outcome of WTO multilateral trade negotiations, the approach developed in this thesis introduces additional policy instruments into the GTAP model that enable the relocation of domestic support payments according to the WTO classification schemes. Thus, this approach results in a complex structure of domestic support payments representing both important measures of domestic support.

Although both measures (OECD PSE concept and WTO classification scheme) are well suited to quantify the amount of support, they fail to measure the level of trade distortion due to aggregation problems. To overcome this problem, this thesis further develops a theoretically sound index measuring the trade restrictiveness of domestic support payments and integrates it into the extended GTAP model. This index enables the evaluation of domestic support considering different policy instruments over time and allows cross-country comparison. As a result, the extended modeling framework developed is much more suitable for analyzing agricultural policy reforms or the impact of WTO negotiations than other CGE models. This modeling framework quantifies the effects caused by domestic support on industry output and trade and the redistribution of welfare considering much more detailed domestic policy instruments and their requirements regarding production, which trigger the eligibility for specific subsidies. In addition, this framework quantifies the level of trade restrictiveness of domestic support payments, and thus allows a rating of the trade-distorting effects from different protection instruments. The resulting uniform protection rate can furthermore be used to evaluate the development of domestic support payments over time and can capture changes in the composition of policy instruments. The MTRI of domestic support payments provides an appealing measure to evaluate the effects of policy reforms, and thus might be of particular use in the support of trade negotiations.

## 5.3 Final remark and future research

The focus of this thesis lies on the methodological extensions of the GTAP modeling framework to generally capture domestic support payments on a very detailed level and to integrate a new index, the MTRI of domestic support payments to provide a sophisticated tool for the evaluation of policy reforms. The EU CAP serves as a prime example to demonstrate the effectiveness of the methods developed here. The multitude of different policy instruments, and in particular the SFP with its still empirically unclear effect on production, highlights the extent to which policy analysis results, such as on industry and trade structure, and on the redistribution of welfare, are affected by different assumptions about the degree of decoupling of support payments. In addition, the MTRI of domestic support payments clearly shows that an increasing support payment's degree of decoupling decreases the restrictiveness to trade. Accordingly, this operational approach helps to complete the tools for multilateral trade policy impact analysis accounting for market access policies, export subsidies, and domestic support payments.

Such a detailed representation of domestic support payments in the GTAP modeling framework creates the required prerequisites to facilitate a much more in-depth analysis of the level of trade distortions. This framework enables a comparison across countries and across the development of a country's domestic support over time, and thus provides scope for future research.

Several high-income countries have reformed the support they provided to agricultural producers, whereas emerging countries such as Brazil, India, China, and South Africa have started to expand their support programs. Accordingly, to analyze the effect of multilateral trade liberalization, it would be worthwhile to extend this analysis to cover at least all countries providing a significant amount of domestic support with a particular focus on uncertain assumptions regarding payments' impact on farm-level output decisions.

The focus of this thesis is on budgetary transfers. In the standard GTAP model, market price support is implicitly included via border measures. EU market price support has significantly decreased in recent years, and thus is, in the case of the EU, negligible. However, emerging countries, such as China, predominantly use market price support to stimulate agricultural production. Thus, an analysis of Chinese domestic support effects would require the integration of market price support into the approach. Therefore, a supplementary sub-module that singles out market price support in the GTAP model considering intervention prices is required. The extension to depict market price support enables the computation of the total Aggregate Measurement of Support (AMS), a measure that is used by the WTO to set a limit on countries' domestic support. The availability of such as measure would then facilitate the analysis of effects when countries, such as China, start to exhaust their limit of domestic support.

This thesis analyzes the effect of domestic support in isolation from effects caused by other protection instruments, such as tariffs, non-tariff barriers, or export subsidies. The impact of country-specific border measures might affect the gain or loss resulting from removing EU domestic support payments and thus might affect the impact of domestic support payments in the conducted analyses. An analysis evaluating the extent to which countries' border measures weaken or boost the effect caused by other countries' domestic support would therefore be highly interesting. In addition, an analysis also considering countries' border measures would contribute to the discussion of whether policy reforms, such as the reforms of the EU CAP, are coherent with development objectives.

The sensitivity analysis examining the extent to which the underlying protection data and the elasticity of substitution affect the MTRI of domestic support payments reveals rather uninteresting results. By contrast, a first analysis of the impact of the sectoral aggregation of products included in the MTRI of domestic support points out that the index is affected by the inclusion of forward-linked sectors. Therefore, focusing future research on analyzing aggregation effects would improve the validation of results.

# Appendix

**Mathematical appendix to chapter 4**

The MTRI-DS developed in chapter 4 is defined as:

$$\tau^{ds}\left[p^p, p^c\right]: M\left[\left(1+\tau^{ds}\right)\pi, \left(1+\tau^{ds}\right)\pi\right] = M\left[\left(1+\tau^p\right)\pi, \left(1+\tau^c\right)\pi\right] = M\left[p^p, p^c\right]$$

with:

| | |
|---|---|
| $\tau^{ds}$ | Mercantilist Trade Restrictiveness Index of domestic support, uniform tariff |
| $\pi$ | World market price |
| $\tau^p$ | Rate of producer distortion |
| $\tau^c$ | Rate of consumer distortion |
| $p^p = \left(1+\tau^p\right)\pi$ | Domestic producer price |
| $p^c = \left(1+\tau^c\right)\pi$ | Domestic consumer price |
| $M$ | Import volume |

The MTRI, M, is defined implicitly by the equation:

$$(\pi)'\Delta m(p,u) = (\pi)'\Delta m\left([1+M]\,p,u\right)$$

Be definition net import demand *m* is given by the equation:

$$m_i(p) = d_i(p) - s_i(p)$$

The demand *d* and supply *s* for the good are functions of all prices *p*:

$$\frac{\partial m_i}{\partial p_j} = \frac{\partial d_i}{\partial p_j} - \frac{\partial s_i}{\partial p_j}$$

Assuming that there are no other trade policies in place, the distorted domestic producer price is given for commodity $i$ by $p_i^p = \left(1+\tau_i^p\right)\pi_i$, where $\tau_i^p$ is the rate of producer distortions. However, the distorted domestic consumer price is given by $p_i^c = \left(1+\tau_i^c\right)\pi_i$, where $\tau_i^c$ is the rate of consumer distortions. If $\tau_i^p = \tau_i^c = 0$, there are no distortions. If a tariff $t_i$ is the only border measure for a good, then $\tau_i^p = \tau_i^c = t_i$

The loss of the value of imports from the free trade situation for a small country is given as:

Partial equilibrium approach, ignoring cross price effects:

$$\begin{aligned}\Delta M &= \left(\pi_i\right)'\Delta m\left(p_i^p, p_i^c\right)\\ &= \pi_i \Delta d_i - \pi_i \Delta s_i\\ &= \pi_i \Delta \frac{\partial d_i}{\partial p_i^c} p_i^c - \pi_i \Delta \frac{\partial s_i}{\partial p_i^p} p_i^p\\ &= \pi_i \Delta \frac{\partial d_i}{\partial \pi\left(1+\tau_i^c\right)} \pi_i \left(1+\tau_i^c\right) - \pi_i \Delta \frac{\partial s_i}{\partial \pi\left(1+\tau_i^p\right)} \pi_i \left(1+\tau_i^p\right)\\ &= \pi_i^2 \Delta \frac{\partial d_i}{\partial \pi\left(1+\tau_i^c\right)} \left(1+\tau_i^c\right) - \pi_i^2 \Delta \frac{\partial s_i}{\partial \pi\left(1+\tau_i^p\right)} \left(1+\tau_i^p\right)\end{aligned}$$

General equilibrium approach:

$$\begin{aligned}\Delta M &= \left(\pi\right)'\Delta m\left(p^p, p^c\right)\\ &= \left(\pi\right)'\Delta M\left(p^p, p^c\right)\\ &= \left(\pi\right)'\Delta D\left(p^c\right) - \left(\pi\right)'\Delta S\left(p^p\right)\\ &= \left(\pi_1\,\pi_2\right)\Delta \begin{bmatrix} \frac{\partial d_1}{\partial p_1} & \frac{\partial d_1}{\partial p_2} \\ \frac{\partial d_2}{\partial p_1} & \frac{\partial d_2}{\partial p_2} \end{bmatrix} \begin{pmatrix} \pi_1^* \tau_1^c \\ \pi_2^* \tau_2^c \end{pmatrix} - \left(\pi_1\,\pi_2\right)\Delta \begin{bmatrix} \frac{\partial d_1}{\partial p_1} & \frac{\partial d_1}{\partial p_2} \\ \frac{\partial d_2}{\partial p_1} & \frac{\partial d_2}{\partial p_2} \end{bmatrix} \begin{pmatrix} \pi_1^* \tau_1^c \\ \pi_2^* \tau_2^c \end{pmatrix}\end{aligned}$$

Where $M$ is a $\left(n x n\right)$ symmetric and negative semi-definite matrix of the partial derivatives of the import demand functions $m\left(p,u\right)$ that are income-compensated, thus $\frac{\partial m_1}{\partial p_2} = \frac{\partial m_2}{\partial p_1}$

Using this approach to determine the MTRI-DS according to the following equation:

$$(\pi)'\Delta m\left(p^{p}, p^{c}\right)=(\pi)'\Delta m\left(\left[1+\tau^{p}\right]\pi,\left[1+\tau^{c}\right]\pi\right)=(\pi)'\Delta m\left(\left[1+\tau^{ds}\right]\pi,\left[1+\tau^{ds}\right]\pi\right)$$

We can derive the general equilibrium form of the MTRI-DS:

since $\tau_i^c = \tau_i^p, \pi_i\tau_i^c = \pi_i\tau_i^p = p_i$

$$(\pi_1\,\pi_2)\begin{bmatrix}\frac{\partial d_1}{\partial p_1} & \frac{\partial d_1}{\partial p_2}\\ \frac{\partial d_2}{\partial p_1} & \frac{\partial d_2}{\partial p_2}\end{bmatrix}\begin{pmatrix}\pi_1\tau^{ds}\\ \pi_2\tau^{ds}\end{pmatrix}-(\pi_1\,\pi_2)\begin{bmatrix}\frac{\partial s_1}{\partial p_1} & \frac{\partial s_1}{\partial p_2}\\ \frac{\partial s_2}{\partial p_1} & \frac{\partial s_2}{\partial p_2}\end{bmatrix}\begin{pmatrix}\pi_1\tau^{ds}\\ \pi_2\tau^{ds}\end{pmatrix}$$

$$= (\pi_1\,\pi_2)\begin{bmatrix}\frac{\partial d_1}{\partial p_1} & \frac{\partial d_1}{\partial p_2}\\ \frac{\partial d_2}{\partial p_1} & \frac{\partial d_2}{\partial p_2}\end{bmatrix}\begin{pmatrix}\pi_1\tau_1^{c}\\ \pi_2\tau_2^{c}\end{pmatrix}-(\pi_1\,\pi_2)\begin{bmatrix}\frac{\partial s_1}{\partial p_1} & \frac{\partial s_1}{\partial p_2}\\ \frac{\partial s_2}{\partial p_1} & \frac{\partial s_2}{\partial p_2}\end{bmatrix}\begin{pmatrix}\pi_1\tau_1^{p}\\ \pi_2\tau_2^{p}\end{pmatrix}$$

$$\Leftrightarrow (\pi_1\,\pi_2)\begin{bmatrix}\frac{\partial d_1}{\partial p_1} & \frac{\partial d_1}{\partial p_2}\\ \frac{\partial d_2}{\partial p_1} & \frac{\partial d_2}{\partial p_2}\end{bmatrix}\begin{pmatrix}\pi_1\\ \pi_2\end{pmatrix}\tau^{ds}-(\pi_1\,\pi_2)\begin{bmatrix}\frac{\partial s_1}{\partial p_1} & \frac{\partial s_1}{\partial p_2}\\ \frac{\partial s_2}{\partial p_1} & \frac{\partial s_2}{\partial p_2}\end{bmatrix}\begin{pmatrix}\pi_1\\ \pi_2\end{pmatrix}\tau^{ds}$$

$$= (\pi_1\,\pi_2)\begin{bmatrix}\frac{\partial d_1}{\partial p_1} & \frac{\partial d_1}{\partial p_2}\\ \frac{\partial d_2}{\partial p_1} & \frac{\partial d_2}{\partial p_2}\end{bmatrix}\begin{pmatrix}\pi_1\tau_1^{c}\\ \pi_2\tau_2^{c}\end{pmatrix}-(\pi_1\,\pi_2)\begin{bmatrix}\frac{\partial s_1}{\partial p_1} & \frac{\partial s_1}{\partial p_2}\\ \frac{\partial s_2}{\partial p_1} & \frac{\partial s_2}{\partial p_2}\end{bmatrix}\begin{pmatrix}\pi_1\tau_1^{p}\\ \pi_2\tau_2^{p}\end{pmatrix}$$

$$\Leftrightarrow \quad (\pi_1\ \pi_2)\begin{bmatrix} \frac{\partial d_1}{\partial p_1}\pi_1 & \frac{\partial d_1}{\partial p_2}\pi_2 \\ \frac{\partial d_2}{\partial p_1}\pi_1 & \frac{\partial d_2}{\partial p_2}\pi_2 \end{bmatrix}\tau^{ds} - (\pi_1\ \pi_2)\begin{bmatrix} \frac{\partial s_1}{\partial p_1}\pi_1 & \frac{\partial s_1}{\partial p_2}\pi_2 \\ \frac{\partial s_2}{\partial p_1}\pi_1 & \frac{\partial s_2}{\partial p_2}\pi_2 \end{bmatrix}\tau^{ds}$$

$$= \quad (\pi_1\ \pi_2)\begin{bmatrix} \frac{\partial d_1}{\partial p_1}\pi_1\tau_1^c & \frac{\partial d_1}{\partial p_2}\pi_2\tau_2^c \\ \frac{\partial d_2}{\partial p_1}\pi_1\tau_1^c & \frac{\partial d_2}{\partial p_2}\pi_2\tau_2^c \end{bmatrix} - (\pi_1\ \pi_2)\begin{bmatrix} \frac{\partial s_1}{\partial p_1}\pi_1\tau_1^p & \frac{\partial s_1}{\partial p_2}\pi_2\tau_2^p \\ \frac{\partial s_2}{\partial p_1}\pi_1\tau_1^p & \frac{\partial s_2}{\partial p_2}\pi_2\tau_2^p \end{bmatrix}$$

$$\Leftrightarrow \left[\left(\pi_1\left(\frac{\partial d_1}{\partial p_1}\pi_1 + \frac{\partial d_1}{\partial p_2}\pi_2\right) + \pi_2\left(\frac{\partial d_2}{\partial p_1}\pi_1 + \frac{\partial d_2}{\partial p_2}\pi_2\right)\right) - \left(\pi_1\left(\frac{\partial s_1}{\partial p_1}\pi_1 + \frac{\partial s_1}{\partial p_2}\pi_2\right) + \pi_2\left(\frac{\partial s_2}{\partial p_1}\pi_1 + \frac{\partial s_2}{\partial p_2}\pi_2\right)\right)\right]\tau^{ds}$$

$$= \quad \left(\pi_1\left(\frac{\partial d_1}{\partial p_1}\pi_1\tau_1^c + \frac{\partial d_1}{\partial p_2}\pi_2\tau_2^c\right) + \pi_2\left(\frac{\partial d_2}{\partial p_1}\pi_1\tau_1^c + \frac{\partial d_2}{\partial p_2}\pi_2\tau_2^c\right)\right)$$

$$-\left(\pi_1\left(\frac{\partial s_1}{\partial p_1}\pi_1\tau_1^p + \frac{\partial s_1}{\partial p_2}\pi_2\tau_2^p\right) + \pi_2\left(\frac{\partial s_2}{\partial p_1}\pi_1\tau_1^p + \frac{\partial s_2}{\partial p_2}\pi_2\tau_2^p\right)\right)$$

$$\Leftrightarrow \left[\pi_1\pi_1\frac{\partial d_1}{\partial p_1} + \pi_1\pi_2\frac{\partial d_1}{\partial p_2} + \pi_2\pi_1\frac{\partial d_2}{\partial p_1} + \pi_2\pi_2\frac{\partial d_2}{\partial p_2} - \pi_1\pi_1\frac{\partial s_1}{\partial p_1} - \pi_1\pi_2\frac{\partial s_1}{\partial p_2} - \pi_2\pi_1\frac{\partial s_2}{\partial p_1} - \pi_2\pi_2\frac{\partial s_2}{\partial p_2}\right]\tau^{ds}$$

$$= \quad \tau_1^c\pi_1\pi_1\frac{\partial d_1}{\partial p_1} + \tau_2^c\pi_1\pi_2\frac{\partial d_1}{\partial p_2} + \tau_1^c\pi_2\pi_1\frac{\partial d_2}{\partial p_1} + \tau_2^c\pi_2\pi_2\frac{\partial d_2}{\partial p_2}$$

$$-\tau_1^p\pi_1\pi_1\frac{\partial s_1}{\partial p_1} - \tau_2^p\pi_1\pi_2\frac{\partial s_1}{\partial p_2} - \tau_1^p\pi_2\pi_1\frac{\partial s_2}{\partial p_1} - \tau_2^p\pi_2\pi_2\frac{\partial s_2}{\partial p_2}$$

$$\Leftrightarrow \quad \tau^{ds}$$

$$= \frac{\tau_1^c\pi_1\pi_1\frac{\partial d_1}{\partial p_1} + \tau_2^c\pi_1\pi_2\frac{\partial d_1}{\partial p_2} + \tau_1^c\pi_2\pi_1\frac{\partial d_2}{\partial p_1} + \tau_2^c\pi_2\pi_2\frac{\partial d_2}{\partial p_2} - \left(\tau_1^p\pi_1\pi_1\frac{\partial s_1}{\partial p_1} + \tau_2^p\pi_1\pi_2\frac{\partial s_1}{\partial p_2} + \tau_1^p\pi_2\pi_1\frac{\partial s_2}{\partial p_1} + \tau_2^p\pi_2\pi_2\frac{\partial s_2}{\partial p_2}\right)}{\pi_1\pi_1\frac{\partial d_1}{\partial p_1} + \pi_1\pi_2\frac{\partial d_1}{\partial p_2} + \pi_2\pi_1\frac{\partial d_2}{\partial p_1} + \pi_2\pi_2\frac{\partial d_2}{\partial p_2} - \left(\pi_1\pi_1\frac{\partial s_1}{\partial p_1} + \pi_1\pi_2\frac{\partial s_1}{\partial p_2} + \pi_2\pi_1\frac{\partial s_2}{\partial p_1} + \pi_2\pi_2\frac{\partial s_2}{\partial p_2}\right)}$$

$$\Leftrightarrow \quad \tau^{ds} = \frac{\sum_i\sum_j \tau_j^c\pi_i\pi_j\frac{\partial d_i}{\partial p_j} - \sum_i\sum_j \tau_j^p\pi_i\pi_j\frac{\partial s_i}{\partial p_j}}{\sum_i\sum_j \pi_i\pi_j\frac{\partial d_i}{\partial p_j} - \sum_i\sum_j \pi_i\pi_j\frac{\partial s_i}{\partial p_j}}$$

$$\Leftrightarrow \quad \tau^{ds} = \sum_i\sum_j \tau_j^c \frac{\pi_i\pi_j\frac{\partial d_i}{\partial p_j}}{\sum_i\sum_j \pi_i\pi_j\frac{\partial d_i}{\partial p_j} - \sum_i\sum_j \pi_i\pi_j\frac{\partial s_i}{\partial p_j}} - \sum_i\sum_j \tau_j^p \frac{\pi_i\pi_j\frac{\partial s_i}{\partial p_j}}{\sum_i\sum_j \pi_i\pi_j\frac{\partial d_i}{\partial p_j} - \sum_i\sum_j \pi_i\pi_j\frac{\partial s_i}{\partial p_j}}$$

$$\Leftrightarrow \tau^{ds} = \sum_i \sum_j \tau_j^c \frac{\pi_i \pi_j \frac{\partial d_i}{\partial p_j}}{\sum_i \sum_j \pi_i \pi_j \frac{\partial d_i}{\partial p_j} - \sum_i \sum_j \pi_i \pi_j \frac{\partial s_i}{\partial p_j}} - \sum_i \sum_j \tau_j^p \frac{\pi_i \pi_j \frac{\partial s_i}{\partial p_j}}{\sum_i \sum_j \pi_i \pi_j \frac{\partial d_i}{\partial p_j} - \sum_i \sum_j \pi_i \pi_j \frac{\partial s_i}{\partial p_j}}$$

enlarge with: $\frac{\sum_i \sum_j \pi_i \pi_j \frac{\partial d_i}{\partial p_j}}{\sum_i \sum_j \pi_i \pi_j \frac{\partial d_i}{\partial p_j}};\frac{\sum_i \sum_j \pi_i \pi_j \frac{\partial s_i}{\partial p_j}}{\sum_i \sum_j \pi_i \pi_j \frac{\partial s_i}{\partial p_j}}$

$$\Leftrightarrow \tau^{ds} = \sum_i \sum_j \tau_j^c \frac{\pi_i \pi_j \frac{\partial d_i}{\partial p_j} \sum_i \sum_j \pi_i \pi_j \frac{\partial d_i}{\partial p_j}}{\left(\sum_i \sum_j \pi_i \pi_j \frac{\partial m_i}{\partial p_j}\right)\left(\sum_i \sum_j \pi_i \pi_j \frac{\partial d_i}{\partial p_j}\right)} - \sum_i \sum_j \tau_j^p \frac{\pi_i \pi_j \frac{\partial s_i}{\partial p_j} \sum_i \sum_j \pi_i \pi_j \frac{\partial s_i}{\partial p_j}}{\left(\sum_i \sum_j \pi_i \pi_j \frac{\partial s_i}{\partial p_j}\right)\left(\sum_i \sum_j \pi_i \pi_j \frac{\partial m_i}{\partial p_j}\right)}$$

$$\Leftrightarrow \tau^{ds} = \left(\sum_i \sum_j \tau_j^c \frac{\pi_i \pi_j \frac{\partial d_i}{\partial p_j}}{\sum_i \sum_j \pi_i \pi_j \frac{\partial d_i}{\partial p_j}}\right) \frac{\sum_i \sum_j \pi_i \pi_j \frac{\partial d_i}{\partial p_j}}{\sum_i \sum_j \pi_i \pi_j \frac{\partial m_i}{\partial p_j}} - \left(\sum_i \sum_j \tau_j^p \frac{\pi_i \pi_j \frac{\partial s_i}{\partial p_j}}{\sum_i \sum_j \pi_i \pi_j \frac{\partial s_i}{\partial p_j}}\right) \frac{\sum_i \sum_j \pi_i \pi_j \frac{\partial s_i}{\partial p_j}}{\sum_i \sum_j \pi_i \pi_j \frac{\partial m_i}{\partial p_j}}$$

to finally obtain:

$$\tau^{ds} = \left(\sum_i \sum_j \tau_j^c w_{ij}\right)(a) + \left(\sum_i \sum_j \tau_j^p v_{ij}\right)(b)$$

$$w_{ij} = \pi_i \, \pi_j \frac{\partial d_i}{\partial p_j} \Big/ \sum_i \sum_j \pi_i \pi_j \frac{\partial d_i}{\partial p_j}$$

$$v_{ij} = \pi_i \pi_j \frac{\partial s_i}{\partial p_j} \Big/ \sum_i \sum_j \pi_i \pi_j \frac{\partial s_i}{\partial p_j}$$

$$a = \sum_i \sum_j \pi_i \pi_j \frac{\partial d_i}{\partial p_j} \Big/ \sum_i \sum_j \pi_i \pi_j \frac{\partial m_i}{\partial p_j}$$

$$b = -\sum_i \sum_j \pi_i \pi_j \frac{\partial s_i}{\partial p_j} \Big/ \sum_i \sum_j \pi_i \pi_j \frac{\partial m_i}{\partial p_j}$$