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Assessing the Impact of Data Disaggregation Level and Non-Tariff Barriers in Regional Trade Agreements Utilizing the Global Trade Analysis Project Framework

Dissertation

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Declaration

I hereby declare that I have completed the dissertation independently, and this research is original. I have not been supported by a commercial agent in writing this dissertation. Additionally, no aids other than the indicated sources and resources have been used. Furthermore, I assure that all quotations and statements have been inferred literally or in a general manner from published or unpublished writing are marked as such. This work has not been previously used neither completely nor in parts to achieve any other academic degrees.

Stuttgart, Hohenheim, December 2014

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Brief Contents

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Abbreviations

AVE	Ad-valorem Equivalent
CAFTA	Central America Free Trade Agreement
CEPII	Centre d'Etudes Prospectives et d'Informations
CES	Constant Elasticity of Substitution
CGE	Computable General Equilibrium
CPC	Central Product Classification
EEU	Eastern European Countries
EU	European Union
EV	Equivalent Variation
FSU	Former Soviet Union
FTA	Free Trade Agreement
GAFTA	Greater Arab Free Trade Area
GDP	Gross Domestic Product
GE	General Equilibrium
GEMPACK	General Equilibrium Modelling PACKage
GTAP	Global Trade Analysis Project
ICTSD	International Centre for Trade and Sustainable Development
IDIA	Institute for Domestic and International Affairs
ITC	International Trade Centre
MENA	Middle East and North Africa
MFN	Most-Favored-Nation
MRT	Multilateral Resistance Terms
MSE	Mean Squared Error
MTRI	Mercantalistic Trade Restrictiveness Index
NAFTA	North American Free Trade Agreement
NB	Negative Binominal
NTB	Non-Tariff Barrier
OLS	Ordinary Least Squares
PE	Partial Equilibrium
PPML	Poisson Pseudo-Maximum Likelihood
RASFF	Rapid Alert System for Food and Feed
ROW	Rest of the World
RTA	Regional Trade Agreement
SSA	Sub-Saharan Africa
TOT	Terms of Trade
TRAINS	Trade Analysis and Information System
TRI	Trade Restrictiveness Index
TTIP	Transatlantic Trade and Investment Partnership
UN COMTRADE	United Nations Commodity Trade Statistics
UNCTAD	United Nations Conference on Trade and Development
US	The United States of America
USTR	Office of the United States Trade Representative

WTO	World Trade Organization

Summary

Computable general equilibrium (CGE) models have been extensively used by economists for trade policy analysis due to their ability to quantify the impact of a shock on an entire economy. Providing economy-wide numerical results, and including linkages and interactions among main economic variables, agents, sectors, and regions make CGE models preferable in addressing a wide range of economic problems. Among various comparative static, multi-sector and multi-region general equilibrium models, Global Trade Analysis Project (GTAP) is one of the most extensively used. However, despite the widespread use of CGE models in trade policy analysis, there are still debates among researchers about the right choice of the model to apply. The discussions are frequently about the data aggregation level. The degree of data disaggregation within the CGE models has direct impact on policy simulation results stemming from the aggregation bias. Against this background, one of the focal points of this dissertation is the impact of aggregation bias occurring in GTAP simulations and the reasons behind this bias.

Another focal point of this dissertation is the estimation of the ad-valorem equivalents (AVEs) of non-tariff barriers (NTBs) on food and agricultural sector through gravity approach and their subsequent implementation into the GTAP framework for thorough analysis of regional trade agreements (RTAs). With the increasing number of economic integration agreements and multilateral trade negotiations of the World Trade Organization, the importance of import tariffs has declined, while that of NTBs has risen, since NTBs are harder to address due to their complex structure. However, the welfare gains through the reduction of restrictive NTBs due to RTAs are not negligible. We either use the border effect approach or the free trade agreement (FTA) approach to identify NTBs in the trade between respective countries. NTBs are originally not considered in the standard GTAP framework. However, they can be implemented into the GTAP model in several ways (i.e., as export taxes, import tariffs or as efficiency losses) depending on the policies with which they are related. Due to our focus on the agro-food sector in our articles and the predominance of technical NTBs on this sector, we mainly account for the efficiency-decreasing effect of NTBs. Hence, we model a majority of them using the efficiency approach. For the remaining part of trade costs we utilize the import-tariff approach.

In this context, the objective of this cumulative dissertation is threefold: (1) to reveal the impact of data aggregation level in trade policy analysis with the GTAP framework, (2) to expose the importance of NTBs in the evaluation of RTAs, (3) to demonstrate the effect of data aggregation level in gravity estimates of NTBs and its subsequent impact on trade policy simulations. Hence, this dissertation consists of four articles which are published or submitted to journals.

In our first article entitled "*Model Structure or Data Aggregation Level: Which Leads to Greater Bias of Results?*", we focus on two fundamental characteristics of CGE models, i.e., the model structure and the data aggregation level. Our results demonstrate that there are substantial differences in results due to the use of GE or PE model structure or data disaggregation level. However, the deviations in results caused by sectoral breakdown are much more pronounced than those stemmed from the model structure. While the economy-wide setting of GE models causes differences across the results of GE and PE models, tariff averaging and false competition ground the reason for deviations in results due to data aggregation level.

Following our theoretical work in the first article, in our second article, "*Moving toward the EU or the Middle East? An Assessment of Alternative Turkish Foreign Policies Utilizing the GTAP Framework*", we focus on more applied analysis. In this article, we analyze Turkey's two different policy options by considering the

simultaneous elimination of NTBs and import tariffs in the case of Turkey's membership either to the European Union (EU) or Greater Arab Free Trade Area (GAFTA). For both experiments, gains from NTB removal outweigh the gains due to the elimination of import tariffs. Hence, based on our simulation results, we are able to confirm the importance of NTBs in the evaluation of RTAs.

After indicating the importance of aggregation bias in our first article and confirming the impact of NTBs in the evaluation of RTAs in the second, in our third article, "*The Effect of Aggregation Bias: An NTB-Modelling Analysis of Turkey's Agro-Food Trade with the EU*", we expound the magnitude of aggregation bias in the calculation of AVEs of NTBs. Our estimations demonstrate that using aggregated gravity model to estimate the AVEs of NTBs results in overestimation of trade costs. Hence, the transfer of overestimated trade costs to the GTAP model also leads to overestimation in the simulation results of the EU's extension to include Turkey.

Our last article, "*Keep Calm and Disaggregate: The Importance of Agro-Food Sector Disaggregation in CGE Analysis of TTIP*", is designed as a follow-up to our first article; however, it also includes the key findings from the second and third articles. We create five different versions of the GTAP database, which are aggregated at different sector levels. Thereafter, we simulate the Transatlantic Trade and Investment Partnership (TTIP) between the EU and the United States (US). In addition to what we constructed in our first article, in this article we also consider the reduction NTBs for each version of the GTAP database. Hence, in addition to averaging of tariffs and false competition, estimation of AVEs of NTBs at different data aggregation levels also has an impact on deviations in simulation results across five versions of the GTAP database.

As we have presented in our articles, the use of higher data disaggregation level commonly results in greater welfare and trade effects, but cases also exit in which more aggregated version of the GTAP database leads to larger changes in simulation results. The atheoretic method of trade-weighted tariff aggregation given in the GTAP database is the trigger of lower trade and welfare effects. By calculating of the Mercantalistic Trade Restrictiveness Index (MTRI) for bilateral import tariffs, and comparing them with the initial trade-weighted tariffs in the GTAP database, we are able to verify the underestimation effect of "tariff averaging". In contrast, "false competition" causes overestimation of trade and welfare effects when higher level of data aggregation is used in the simulations. False competition arises in such situations when competition for a particular subsector does not initially exist between two exporting countries, but this subsector can be aggregated with others in which competition actually exists. Hence, this situation leads to wrongly applied weights, and results in false substitution effects, which causes overestimation of results. The estimation of AVEs of NTBs at higher data aggregation levels also reduces the variation across sectors, and commonly leads to higher trade and welfare results. However, the contribution of tariffs to the deviation of results across versions is generally higher than the contribution of NTBs. Hence, based on our simulation results, we exhibit that aggregation of tariffs is more important than the NTBs.

This dissertation concludes that neither the impact of aggregation bias nor the importance of NTBs in the evaluation of RTAs on trade policy analysis is negligible. There are considerable differences across simulation results depending on the data aggregation level used. The differences in results occur both in the estimation of trade costs of NTBs and also in the policy simulation results on the GTAP level. Hence, the selection of data aggregation level can be critical for thorough analysis of trade agreements, especially for the detailed examination of policy changes at the product level. Aggregation bias cannot be entirely overcome in econometric estimates or in CGE analysis; however, the extent of its possible effect can be born in mind. Depending on the aim of the policy analysis, the appropriate level of data disaggregation should be chosen.

Zusammenfassung

Allgemeine Gleichgewichtsmodelle (CGE-Modelle) werden in der Literatur, aufgrund ihrer Fähigkeit, die Auswirkungen eines Schocks auf eine ganze Volkswirtschaft zu quantifizieren, ausgiebig genutzt. Da sie numerische Ergebnisse für eine ganze Volkswirtschaft liefern und Verbindungen und Interaktionen zwischen den wichtigsten ökonomischen Variablen, Agenten, Sektoren und Regionen einschließen, sind CGE-Modelle das Mittel der Wahl für die Analyse eines breiten Spektrums ökonomischer Probleme. Unter den verschiedenen vergleichenden statischen, mehrsektoralen und mehrregionalen CGE-Modellen, ist das Global Trade Analysis Project (GTAP) Modell eines der meistgenutzten. Trotz des weit verbreiteten Gebrauchs von CGE-Modellen bei der Analyse der Außenhandelspolitik, gibt es unter Forschern noch immer Diskussionen über die richtige Wahl des anzuwendenden Modells. Insbesondere stellt die Datenaggregationsebene einen wichtigen Diskussionspunkt dar. Der Grad der Disaggregation der Daten innerhalb des CGE-Modells hat direkte Auswirkungen auf die Ergebnisse der Politiksimulationen. Vor diesem Hintergrund ist einer der Schwerpunkte dieser Dissertation die Untersuchung der Auswirkungen der Aggregationsverzerrung in den GTAP Simulationsergebnissen und die Ursachen für diese Verzerrung.

Einen anderen Schwerpunkt der Dissertation bildet die Analyse von regionalen Handelsabkommen (RTAs) unter Berücksichtigung von nicht-tarifären Handelshemmnissen (NTBs). Hierbei wird ein Zwei-Schritte Ansatz verfolgt. Im ersten Schritt, wird das Gravitationsmodell herangezogen, um Ad-Valorem Äquivalente (AVEs) von NTBs ökonometrisch zu schätzen. Im zweiten Schritt, werden diese AVEs von NTBs in das GTAP Modell integriert. Mit der steigenden Anzahl an Abkommen zur wirtschaftlichen Integration und den multilateralen Handelsgesprächen der Welthandelsorganisation, hat die Bedeutung von Zöllen abgenommen, während NTBs an Bedeutung gewonnen haben. Aus diesem Grund sind die Effekte von NTBs in der Analyse von RTAs nicht zu vernachlässigen. Um NTBs in der empirischen Gravitationsgleichung zu identifizieren, wird entweder der Grenzeffekt-Ansatz oder eine Freihandelsabkommen- Dummyvariable als ein implizites Maß verwendet. NTBs finden im Standard GTAP Modell keine Berücksichtigung. Allerdings können sie auf unterschiedliche Art und Weise in das GTAP-Modell eingefügt werden (z.B. als Exportsteuern, Importzölle oder Effizienzverluste), abhängig von den in Bezug stehenden Politiken. Da der Fokus der vorliegenden Arbeit auf dem Agrar- und Ernährungssektor liegt und vornehmlich technische NTBs in diesem Sektor implementiert werden, erfassen die Analysen hauptsächlich den Effizienz verringernden Effekt von NTBs. Folglich wird ein Großteil der NTBs mit dem Effizienzansatz modelliert. Für den verbleibenden Anteil an NTBs wird der Importzoll-Ansatz verwendet.

In diesem Zusammenhang verfolgt diese kumulative Dissertation drei Ziele: (1) die Auswirkungen der Datenaggregation in der Analyse von Handelspolitiken mit dem GTAP-Modell aufzuzeigen, (2) die Bedeutung von NTBs bei der Evaluierung von RTAs herauszustellen, und (3) den Effekt der Datenaggregationsebene auf die Schätzungen der NTBs mit dem Gravitationsmodell und deren folgende Auswirkungen auf Analysen von Handelspolitiken darzustellen. Diese Dissertation besteht aus vier Artikeln, die bereits in Fachzeitschriften veröffentlicht oder eingereicht wurden.

In dem ersten Artikel „*Model Structure or Data Aggregation Level: Which Leads to Greater Bias of Results?*“ werden zwei fundamentale Charakteristika der CGE-Modelle behandelt, die Modellstruktur und die Datenaggregationsebene. Die Analyse demonstriert substantielle Unterschiede in den Ergebnissen, die durch die Wahl der Modellstruktur, entweder allgemeines oder partielles Gleichgewicht, und Datenaggregationsebene bestimmt werden. Allerdings sind die Abweichungen in den Ergebnissen durch den sektoralen Anteil viel stärker ausgeprägt als die aus der Modellstruktur stammenden Abweichungen. Während die wirtschaftsweiten Rahmenbedingungen der allgemeinen Gleichgewichtsmodelle die Unterschiede in den Ergebnissen zwischen partiellen und allgemeinen Gleichgewichtsmodellen erklären, begründen die „Durchschnittsberechnung der Zölle“ und „falscher Wettbewerb“ die Abweichungen in den Ergebnissen hinsichtlich der Datenaggregationsebene.

Nach der theoretischen Aufarbeitung des ersten Artikels, konzentriert sich der zweite Artikel „*Moving toward the EU or the Middle East? An Assessment of Alternative Turkish Foreign Policies Utilizing the GTAP Framework*“ verstärkt auf die angewandte Analyse. Dieser Artikel analysiert zwei politische Optionen der Türkei, und zwar einerseits die Mitgliedschaft in der Europäischen Union (EU) und andererseits in die Greater Arab Free Trade Area (GAFTA). Unter der Berücksichtigung der simultanen Reduzierung von NTBs und Importzöllen werden die zwei Politiksimulationen durchgeführt. In beiden Experimenten übertreffen die Gewinne aus dem Wegfall von NTBs die Gewinne aus der Reduzierung der Importzölle. Basierend auf den Simulationsergebnissen lässt sich die hohe Bedeutung von NTBs bei der Evaluierung von RTAs bestätigen.

Nachdem der erste Artikel die Bedeutung der Aggregationsverzerrung und der zweite Artikel den Einfluss von NTBs bei der Evaluierung von RTAs enthüllt haben, beschäftigt sich der dritte Artikel „*The Effect of Aggregation Bias: An NTB-Modelling Analysis of Turkey's Agro-Food Trade with the EU*“ mit den Auswirkungen der Aggregationsverzerrung auf die Schätzung von AVEs von NTBs. Die Schätzergebnisse demonstrieren, dass die Verwendung aggregierter Daten zu einer Überschätzung der AVEs von NTBs führt. Demzufolge hat die Integration der überschätzten AVEs von NTBs in das GTAP-Modell starke Auswirkungen auf die Simulationsergebnisse wenn der EU-Beitritt der Türkei simuliert wird.

Der letzte Artikel “*Keep Calm and Disaggregate: The Importance of Agro-Food Sector Disaggregation in CGE Analysis of TTIP*” ist als Fortsetzung des ersten Artikels konzipiert; allerdings enthält er auch Schlüsselerkenntnisse aus dem zweiten und dritten Artikel. Fünf verschiedene Versionen der GTAP Datenbank werden erstellt, die jeweils auf unterschiedlichen Sektorebenen aggregiert sind. Danach wird die Transatlantische Handels- und Investitionspartnerschaft (TTIP) zwischen der EU und den Vereinigten Staaten (USA) simuliert. Zusätzlich zu den Ausarbeitungen des ersten Artikels, wird hier auch die Reduktion der NTBs für jede Version der GTAP Datenbank betrachtet. Somit hat, zusätzlich zur Durchschnittsberechnung von Zöllen und zu dem „falschen Wettbewerb“, die Schätzung der AVEs von NTBs auf unterschiedlichen Datenaggregationsebenen einen Einfluss auf die Abweichungen in den Simulationsergebnissen über die fünf Versionen der GTAP Datenbank hinweg.

Wie die Analysen zeigen, führt die Nutzung von höheren Datendisaggregationsebenen zu höheren Wohlfahrts- und Handelseffekten. Allerdings gibt es auch Ausreißer, bei denen höher aggregierte Versionen der GTAP Datenbank zu größeren Veränderungen in den Simulationsergebnissen führen. Die in der GTAP Datenbank vorgegebene, theoretische Methode der handelsgewichteten Zollaggregation ist der Auslöser für geringere Handels- und Wohlfahrtseffekte. Durch die Kalkulation des Merkantilistischen Trade Restrictiveness Index (MTRI) für bilaterale Importzölle und der Vergleich mit den anfänglichen handelsgewichteten Zöllen in der GTAP Datenbank ist es möglich, den unterschätzenden Effekt von Durchschnittszöllen zu verifizieren. Die berechneten MTRIs sind im Wesentlichen viel höher als die handelsgewichteten Zölle. Somit ergeben sich größere Handels- und Wohlfahrtseffekte bei dem Gebrauch höherer Datendisagreggationsebenen generell aus der Durchschnittsberechnung der Zölle. Im Gegensatz dazu, führt falscher Wettbewerb zu einer Überschätzung von Handels- und Wohlfahrtseffekten, wenn ein höheres Datenaggregationsniveau für die Simulationen verwendet wird. Falscher Wettbewerb liegt dann vor, wenn Wettbewerb zwischen zwei Exportnationen in einem Untersektor ursprünglich nicht existiert, dieser Untersektor aber mit anderen aggregiert werden kann, in denen Wettbewerb stattfindet. Folglich führt diese Situation zu falsch angewandten Gewichtungen. Dadurch ergeben sich falsche Substitutionseffekte, die eine Überschätzung der Ergebnisse nach sich ziehen. Die Schätzung der AVEs der NTBs bei höheren Datenaggregationsebenen reduziert die Variation der AVEs zwischen den Sektoren, und führt somit gewöhnlich zu höheren Handels- und Wohlfahrtsergebnissen. Jedoch ist der Beitrag der Zölle zu den Ergebnisschwankungen über die Versionen im Allgemeinen höher als der Beitrag der NTBs. Auf Basis der Simulationsergebnisse folgt, dass die Aggregation der Zölle bedeutender ist als die der NTBs.

Aus den Analysen der Dissertation folgt, dass weder die Auswirkungen der Aggregationsverzerrung noch die Bedeutung von NTBs bei der Evaluierung von RTAs zu vernachlässigen sind. Es gibt beträchtliche Unterschiede über die Simulationsergebnisse hinweg, je nach verwendeter Datenaggregationsebene. Die Ergebnisunterschiede erscheinen sowohl bei der Schätzung der AVEs von NTBs als auch in den Politiksimulationen auf der GTAP Ebene. Somit kann die Wahl der Datenaggregationsebene entscheidend sein für eine ausführliche Analyse von Handelsabkommen, besonders für die detaillierte Untersuchung von Politikänderungen auf der Produktebene. Die Aggregationsverzerrung kann nicht vollständig in ökonometrischen Schätzungen oder in CGE Analysen überwunden werden; allerdings kann auf das Ausmaß des Einflusses hingewiesen werden. Je nach Ziel der Politikanalyse kann das angemessene Niveau der Datenaggregation gewählt werden.

1 Introduction

Computable general equilibrium (CGE) models have been extensively used by economists for trade policy analysis due to their ability to quantify the impact of a shock on an entire economy. Providing economy-wide numerical results, and including linkages and interactions among main economic variables, agents, sectors, and regions makes CGE models preferable in addressing a wide range of economic problems. Since their initial development in 1960, CGE models have been significantly improved. Currently the application of the pertinent models varies from environmental and energy policies to trade policies. Broad explanation of CGE models and examples of usage can be found in Francois and Reinert (1997), Hertel and Winters (2006), and Shoven and Whalley (1992). Among various comparative static, multi-sector and multi-region general equilibrium models, Global Trade Analysis Project (GTAP) is one of the most widely used. As explained in detail in Hertel (1997) and on the GTAP website[1], the standard GTAP model, which assumes perfect competition and constant returns to scale, consists of behavioral equations and accounting relationships. Non-homothetic constant difference of elasticity is used for the treatment of private household preferences and a global banking sector is included in the model. The latest version of the GTAP database (version 9) combines 140 countries and regions, and 57 sectors. One of the greatest strengths of the GTAP model is its capability for modification to account for different types of policy simulations.

Despite the widespread use of CGE models in trade policy analysis, there are still debates among researchers about the right choice of model to apply. The discussions are frequently about the data aggregation level. While the highest sectoral breakdown is preferable for in-depth policy analysis, general equilibrium (GE) models are in most cases based on more aggregated data than are partial equilibrium (PE) models. However, depending on the policy question, GE models can be superior to PE models due to GE models coverage of the entire economy. The degree of data disaggregation within the GE models has direct impact on policy simulation results stemming from the aggregation bias. Higher level of data disaggregation predominantly results in higher trade and welfare effects when utilizing CGE models. However, there are also cases where the simulations using aggregated databases can lead to greater changes in simulation results (compare Alexeeva-Talebi et al., 2012; Charteris and Winchester, 2010; Grant et al., 2008; Narayanan et al., 2010a, 2010b). As Francois and Reinert (1997) express, model structure, base data, and behavioral elasticities given in a GE model are the three most important influences on policy simulation results. Whalley and Shoven (1992) also emphasize the importance of sectoral breakdown and state that the decision on the level of aggregation is one of the hardest choices that a modeler must make. Moreover, Basevi (1971) points out how challenging data aggregation can be in CGE analysis. Against this background, one of the focal points of this dissertation is the impact of aggregation occurring in GTAP simulations and the reasons behind aggregation bias.

Another focal point of this dissertation is the estimation of the ad-valorem equivalents (AVEs) of non-tariff barriers (NTBs) on agro-food sector and their subsequent implementation into the GTAP framework. As mentioned earlier, one of the most important features of the GTAP model is that it can be easily extended according to the desired policy analysis. Hence, NTBs, which are originally not considered in the standard GTAP framework, can be incorporated into the model in several ways. With the increasing number of economic integration agreements and multilateral trade negotiations of the World Trade Organization, the importance of import tariffs has declined, while that of NTBs has risen, since NTBs are harder to address due to

[1] See https://www.gtap.org

their complex structure. Considering this situation, in recent years the number of studies focused on the impacts of NTBs on trade policy analysis has increased (e.g., Adriamananjara et al. 2003, 2004; CEPR, 2013; Chang and Hayakawa, 2010; Francois, 2001, 2007; Fox et al., 2003; Fugazza and Maur, 2008; Lejour and Mooij, 2001; Hertel et al., 2001a, 2001b; Philippidis and Carrington, 2005; Philippidis and Sanjuán, 2006, 2007, Walkenhorst and Yasui, 2005). Thus, in this dissertation, we also focus on the calculation of AVEs of NTBs and their effect on the analysis of regional trade agreements (RTAs).

We base the estimation of AVEs of NTBs on the gravity approach, which has been widely used to identify and quantify barriers to trade. On the basis of sizes of economies, distance, trade flows and other determinants to make the model transparent and more realistic, the gravity approach is extensively utilized in the analysis of free trade agreements (FTAs) and patterns of trade flows between countries and regions (Anderson and van Wincoop, 2003, 2004). For our analysis in this dissertation, we either use the border effect approach or the FTA dummy approach to identify NTBs in the trade between respective countries. After estimating the AVEs of NTBs, we incorporate these trade costs into the GTAP model.

A key point in modeling NTBs in CGE analysis is the selection of the right approach. NTBs can be modeled as export taxes or import tariffs or as efficiency losses depending on the policies with which they are related. In the cases in which trade barriers generate rents, they can be implemented into the CGE model as export taxes or import tariffs. However, when NTBs only cause efficiency losses, and thus, increase the cost of production, efficiency approach can be used. Several authors employ a combination of both NTB modeling approaches to account for the different effects of trade barriers (Adriamananjara et al. 2003, 2004; CEPR, 2013; Fox et al, 2003; Fugazza and Maur, 2008; Walkenhorst and Yasui, 2005). Due to our focus on the agro-food sector in our articles and the predominance of technical NTBs in this sector, we mainly account for the efficiency-decreasing effect of NTBs. Hence, we model a majority of them using the efficiency approach. For the remaining part of trade costs we utilize the import-tariff approach.

In this context, the objective of this cumulative dissertation is threefold: (1) to reveal the impact of data aggregation level in trade policy analysis with the GTAP framework, (2) to expose the importance of NTBs in the evaluation of RTAs, (3) to demonstrate the effect of data aggregation level in gravity estimates of NTBs and its subsequent impact on trade policy simulations. Four articles focusing on these topics, which are published or submitted to journals, are included in this dissertation. Table 1.1 gives an overview of the respective articles.

This dissertation starts with the article entitled "*Model Structure or Data Aggregation Level: Which Leads to Greater Bias of Results?*" published in Economic Modelling. This article focuses on two fundamental characteristics of CGE models, namely, the model structure and the data aggregation level. Using the GTAP framework we create two different databases that differ according to aggregation level of agro-food sectors. The first version of the GTAP database is highly aggregated and consists of four agro-food sectors. The second version is more disaggregated, and includes 20 agro-food sectors. Both versions have identical non-food and regional mapping. To reveal the effect of model structure, PE versions are obtained from the GE model for each aggregated database. As a modeling exercise, we remove export subsidies and import tariffs from the EU's food and agricultural sector. There are substantial differences in results due to the use of GE or PE model structure or data disaggregation level. However, we conclude that the deviations in results caused by sectoral breakdown are much more pronounced than those stemmed from the model structure. While the economy-wide setting of GE models causes differences across the results of GE and PE models, tariff averaging and false competition ground the reason for deviations in results due to data aggregation level. Tariff averaging leads to larger trade and welfare effects due to the use of higher data disaggregation level; whereas, false competition results in overestimation of simulation results when higher data aggregation level is employed. We are also able to expose that model structure and data aggregation level used in analysis are almost certainly independent. After revealing that data aggregation level leads to more bias than model structure, we focus on the sectoral breakdown in subsequent articles.

Table 1.1: Submitted and published articles included in the dissertation

Chapter	Title	Authors	Submitted / Published in
2	Model structure or data aggregation level: Which leads to greater bias of results?	Martina Brockmeier and Beyhan Bektasoglu	Economic Modelling (2014) 38: 238-245
3	Moving toward the EU or the Middle East? An assesment of alternative Turkish foreign policies utilizing the GTAP framework	Tanja Engelbert, Beyhan Bektasoglu and Martina Brockmeier	Food Policy (2014) 47: 46-61
4	The effect of aggregation bias: An NTB modelling analysis of Turkey's agro-food trade with the EU	Beyhan Bektasoglu, Tanja Engelbert and Martina Brockmeier	Review of World Economics, submitted (2014)
5	Keep calm and disaggregate: The importance of agro-food sector disaggregation in CGE analysis of TTIP	Beyhan Bektasoglu, Tanja Engelbert and Martina Brockmeier	Journal of Policy Modeling, submitted (2014)

Source: Author's own illustration.

Following our theoretical work in the first article, in our second article, "*Moving toward the EU or the Middle East? An Assessment of Alternative Turkish Foreign Policies Utilizing the GTAP Framework*" published in Food Policy, we focus on more applied analysis. With respect to the latest happenings in Turkey's foreign policy and considering the importance of NTBs in the evaluation of FTAs, we analyze Turkey's two different policy options. We particularly compare Turkey's potential membership in the European Union (EU) and the enlargement of the Greater Arab Free Trade Area (GAFTA) to include Turkey. By doing so, we focus on the food and agriculture sector. After moving the GTAP framework to 2020, we consider the simultaneous elimination of NTBs and import tariffs in the case of Turkey's membership either to the EU or GAFTA. We estimate the AVEs of NTBs using the theory-based gravity border effect approach. Thereafter, we employ the efficiency approach to implement trade costs of NTBs into the GTAP model. Simultaneous reduction of tariffs and non-tariff barriers as well as Turkey's adoption of the EU level tariffs show that Turkey's gain is higher in case of its membership in the EU than its membership in GAFTA. Moreover, our results indicate the importance of NTBs in the evaluation of FTAs. For both experiments and for all regions, gains from NTB removal outweigh the gains due to the elimination of import tariffs.

As noted above, we indicate the importance of the aggregation bias in our first article and reveal the magnitude of NTBs in the evaluation of FTAs in the second. In our third article, "*The Effect of Aggregation Bias: An NTB-Modelling Analysis of Turkey's Agro-Food Trade with the EU*" submitted to Review of World Economics, we expound the impact of aggregation bias in the calculation of AVEs of NTBs. Our aim is to highlight the effect of using different data aggregation levels to estimate trade costs on trade policy analysis. As our modeling exercise, we consider Turkey's potential accession to the EU. We use the gravity approach with panel data framework and implement an FTA variable in our gravity-like equation to identify and quantify the NTBs between Turkey and the EU. We calculate the trade costs of NTBs using Central Product Classification (CPC) data, which is either pooled (disaggregated gravity estimates) or aggregated (aggregated gravity estimates) over 15 GTAP agro-food sectors. Our estimations demonstrate a high variation across sectors in the disaggregated version. Moreover, the trade costs estimated using aggregated data are predominantly higher than those calculated using disaggregated data. After calculating the AVEs of NTBs both at disaggregated and aggregated levels, we incorporate the estimated trade costs into the GTAP model by using the import-tariff and the efficiency approach. We then run two experiments using the AVEs of NTBs, which are calculated at different aggregation levels. Our simulation results show that welfare and trade balance effects of the experiments are commonly higher when aggregated gravity estimates are employed. Using aggregated gravity model to estimate the AVEs of NTBs results in overestimation of trade costs. Transferring overestimated trade costs to the GTAP model directly affects the simulation results, and hence, again leads to overestimation.

Our last article, "*Keep Calm and Disaggregate: The Importance of Agro-Food Sector Disaggregation in CGE Analysis of TTIP*" submitted to Journal of Policy Modelling, is designed as a follow-up to our first article; however, it also includes the key findings from the second and third articles. In this article, we explore the potential effects of the Transatlantic Trade and Investment Partnership (TTIP) between the EU and the United States (US). Focusing on the aggregation bias, we create five differently aggregated versions of the GTAP database that differ according to the number of agro-food sectors. The first version of the GTAP model is highly aggregated and covers a single agro-food sector in which 20 food and agricultural sectors are combined. The subsequent versions are mapped to two, four, 10, and 20 agro-food sectors, respectively. In addition to what we constructed in our first article, in this article we also consider the reduction NTBs for each version of the GTAP database. We estimate the trade costs of NTBs using the gravity model, and we use an FTA variable in our gravity-like equation. We observe high deviations in welfare and trade effects of the simulations across five versions of the GTAP database. Primarily, the changes in welfare and trade balance are greater with higher level of data disaggregation, but there are also cases in which higher level of aggregation results in larger trade and welfare effects. The deviations across results based on simulations with differently aggregated versions of the GTAP database can be traced back to estimation of AVEs of NTBs at different data aggregation levels, tariff averaging, and false competition. However, our simulation results indicate that the tariff averaging is more important than applying the estimated trade costs of NTBs at different aggregation levels. Thereby, aggregation of tariffs appears to have more impact on aggregation bias than the effect of false competition.

This dissertation is divided into six chapters. The first chapter provides an introduction, the second, third, fourth and fifth chapter consist of published or submitted journal articles, and, the sixth chapter provides the conclusion.

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2 Model Structure or Data Aggregation Level: Which Leads to Greater Bias of Results?

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Model structure or data aggregation level: Which leads to greater bias of results?

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ABSTRACT

The aim of this paper is to provide a first step toward a systematic sensitivity analysis of a system of linked models. We focus on two fundamental characteristics: the model structure and the data aggregation level. Employing the Global Trade Analysis Project (GTAP) framework, we combine the general equilibrium (GE) and partial equilibrium (PE) versions of the GTAP model, each of which is then run with a highly aggregated and a highly disaggregated version of the GTAP database. Based on this experimental setting, we quantify the biases resulting from the data aggregation, the model structure and the interaction of these two model characteristics. We conclude that data aggregation as well as the related false competition and tariff averaging influence the results significantly more than the model structure, whereas the bias stemming from the interaction of the two model characteristics is negligible.

1. Introduction

Agricultural policy has become increasingly complex over the last century. Reforms and new areas of concern have led to the implementation of complex measures that influence the food and agricultural sector, from global markets to the level of individual farms. As a result, quantitative studies of food and agricultural policy have become a greater challenge that calls for increasingly comprehensive analytical tools and a modeling framework that represents the food and agricultural sector at the global, national and farm levels.

It is obvious to modelers that there is no “one-size-fits-all model” to analyze such widespread food and agricultural research questions. An integrated model that is fully consistent at all levels of data aggregation is not yet available because of computational capacity constraints. The currently preferred approach is to utilize the comparative advantages of different types of models and combine them in a strategically useful way to more accurately represent the micro and macro aspects of the food and agricultural sector. Consequently, in recent years, we have observed an increase in the development and application of systems of linked models.

The usefulness of linked models in research and particularly in policy advice is discussed at length in the literature. This discussion reveals that systems of linked models can be characterized according to (1) differences in data, parameters, policy instruments or other model structure; (2) the existence of formal or informal linkages between linked models; (3) the direction in which results are transferred between models (top down, bottom up or iteration); and (4) the approach that is employed to aggregate or disaggregate results that are transferred to the next model in the system. Systems of linked models are built with different combinations of the aforementioned options, although the choice of a specific combination significantly influences the outcome of the analysis.

To the best of our knowledge, no existing study provides quantitative estimates of the bias in results related to the approach that is used to build a system of linked models. Systematic sensitivity analysis has certainly not been used for this purpose. The predominant approach in the literature involves comparing the results of a partial equilibrium (PE) model constructed with disaggregated data to the results of a general equilibrium (GE) model developed with aggregated data. In other words, two fundamental characteristics are changed simultaneously in this comparison. This procedure clearly does not allow for the effects of different model structure to be distinguished from the effects of data aggregation. Moreover, the existing papers do not derive conditions for the optimal interaction of the employed models, including one or several characteristics of the approaches to link models mentioned above. For example, would it be most effective to align the sector disaggregation of two adjacent models or to develop a more compatible model structure to obtain unbiased results within the system of linked models?

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We contribute to the existing literature in several ways. This paper is a first attempt to conduct a systematic sensitivity analysis of systems of linked models. To illustrate the procedure, we use a simplified experimental setting by focusing on the differences between sector disaggregation and the structures of two adjacent models. In particular, we first concentrate on aggregation problems that arise as a result of the transfer of results between linked models that are aggregated differently. Second, we account for differences in the structures of PE and GE models. Our purpose is to extend beyond the well-known argument that PE models are not suited to examine policy shocks outside of their predefined domain (e.g., the use of agricultural PE models to analyze shocks in non-agricultural sectors), whereas GE models generally do not capture the necessary details of the sector of immediate interest. Rather, we seek to uniquely quantify the bias that is introduced in a system of linked models by transferring results from one model to another within one sector; an example would be the effects of global agricultural trade liberalization on global (GE model), national and farm levels (PE model). Additionally, we wish to account for the interaction of the aforementioned characteristics by examining all possible combinations of the four model features (i.e., disaggregated and aggregated data and PE and GE model structures). For this purpose, we require a tool that is sufficiently flexible to address these four characteristics, that clearly distinguishes them from one another and that therefore enables us to quantify the deviation of the outcomes of experiments from a predefined reference situation (e.g., a disaggregated GE model). These requirements are satisfied by the Global Trade Analysis Project (GTAP) framework, which we apply in this paper.

This paper is organized as follows. Section 2 briefly reviews the literature to systemize the results of papers comparing systems of linked models with respect to selected variables, namely, trade flows, prices and output. Section 3 introduces the GTAP framework and its adaption to the empirical requirements of this paper. In Section 4, we conduct a systematic sensitivity analysis to determine whether model structure or data aggregation is more important to ensure unbiased results in systems of linked models. A conclusion summarizes the main results.

2. Literature review

PE and GE models have long been used to analyze trade liberalization. Although many authors employ either PE or GE standalone models, an increasing number of researchers apply PE and GE models within a linked system. To the best of our knowledge, few papers have attempted to compare the results of linked models and used this exercise to deduce implications for how to address systems of linked models (e.g., Gohin and Moschini, 2006). The following literature review summarizes the findings of these papers by focusing on a selective number of variables representing trade, welfare, price and output effects (see Table 1). Additionally, we distinguish effects resulting from aggregation from those resulting from model structure (PE and GE models).

In the upper part of Table 1, we document the findings of papers in which the authors compare models with different levels of aggregation. For instance, Charteris and Winchester (2010) compare a GE model with a disaggregated dairy sector and joint production to an aggregated GE model without joint production. The authors argue that trade liberalization has different effects that result from the aggregation level of the database employed by the models and the protection structure. Greater variation in tariff rates and higher elasticities of substitution between disaggregated commodities increase these differences. Grant et al. (2007) combine a highly disaggregated PE and a GE model to analyze tariff rate quotas in the US dairy sector. The authors compare the performance of the linked PE/GE model with that of the standalone GE model. Their results demonstrate that the terms of trade effects are poorly predicted by the standalone GE model, whereas the welfare effects are within a similar range. Narayanan et al. (2010a) analyze the effects of different model structures and data aggregation levels using the complete liberalization of the Indian automotive industry as an example. The authors compare the outcome of three different models, namely a disaggregated PE model, an aggregated GE and a model that links these PE and GE models.[1] The results of their study reveal that a higher level of aggregation leads to larger trade effects. Nielsen (1999) also investigates the effect of data aggregation and model structure on EU enlargement with the use of six models with different closures (five PE models and one GE model). In contrast, her results demonstrate that the trade effects are generally smaller when an aggregated database is used in the simulation.

These studies also exhibit similar results in terms of welfare, price and quantity effects (see Table 1). In most cases, aggregation causes smaller changes in output and price levels as well as smaller welfare gains (Nielsen, 1999; Grant et al., 2007; Narayanan et al., 2010a; Charteris and Winchester, 2010). But Grant et al. (2007) find only minor differences between models with respect to welfare results.

The lower part of Table 1 presents a comparison of the model results with respect to model structure. Wailes and Morat (2005) employ both general and spatial partial equilibrium models to quantify the effects of the Central America Free Trade Agreement (CAFTA) on the US rice industry. The authors conclude that the trade effects that are quantified using the GE and the PE models generally point in the same direction and exhibit only small differences resulting from the level of data aggregation and model structure. Furthermore, Narayanan et al. (2010a) demonstrate that GE model estimates of changes in aggregate imports are generally larger than those obtained in PE models. Additionally, Nielsen (1999) demonstrates that the GE model structure leads to smaller changes in aggregate exports and imports.

With respect to price and output effects, some authors argue that model structure causes only minor differences (Hertel, 1992; Wailes and Morat, 2005; Gohin and Moschini, 2006). Narayanan et al. (2010a) find that quantity changes are larger but price changes are smaller in GE models. Conversely, Nielsen (1999) demonstrates that both price and quantity changes are generally smaller in GE models. Furthermore, a study by Gylfason (1995) comparing the costs of agricultural supports calculated by various models under different equilibrium conditions reveals that the GE model yields higher cost estimates than the PE model.

In the last column of the lower part of Table 1, we present the effects of the model structure on welfare results. In previous studies, Tokarick (2003) and Gohin and Moschini (2006) report a larger welfare effect when using a GE structure. In a study measuring the effects of distortions in agriculture trade using different model structures, Tokarick (2003) reports that the GE structure yields larger welfare effects through income, demand and price mechanisms. Additionally, the author shows that the welfare effects of liberalization depend on the model structure and primarily result from higher efficiency and not from the terms of trade effect. Furthermore, in a meta-analysis that is designed to compare model structures, Hess and Cramon-Taubadel (2007) report findings that contrast with those in previous papers; namely, PE models and aggregation yield greater welfare changes.

3. Modeling framework and methodology

The analysis in this paper utilizes the GTAP modeling framework. The standard GTAP model follows the typical structure of a static multi-regional general equilibrium model. As such, this model exhibits an economy-wide representation of each region or country, including the linkages between the farming, agribusiness, industrial and service sectors. Bilateral trade flows are represented by the Armington assumption, and a non-homothetic constant difference of elasticity (CDE)

[1] The choice of model structure and data aggregation in Narayanan et al. (2010a) simultaneously reflects differences resulting from model structure and data aggregation. Hence, the authors are unable to isolate the effects of different model structures and levels of data aggregation. We use their results, which are reported in Table 3 (p. 763), to obtain findings that are suitable for our comparison in Table 1.

Table 1
Comparison of trade, price and welfare effects.

Authors	Trade	Prices and output	Welfare
The aggregated version compared with the disaggregated version leads to …			
Charteris and Winchester (2010)	… lower export rates.	… smaller changes in output level resulting from product transformation effects.	… lower welfare effects resulting from lower substitution effects on the consumption side.
Grant et al. (2007)	… the underestimation of trade flows.	… smaller changes in output level.	… consistent welfare changes with the disaggregated version.
Narayanan et al. (2010a, 2010b)[a]	… larger changes in aggregate imports.	… smaller changes in price level.	… smaller welfare effects.
Nielsen (1999)	… generally smaller export and import changes.	… generally smaller changes in output level.	n.a.
The GE model structure compared with the PE model structure leads to …			
Gohin and Moschini (2006)	n.a.	… only minor differences within the 1% range.	… higher welfare results.
Gylfason (1995)	n.a.	… higher costs of CAP implementation.	n.a.
Hertel (1992)	n.a.	… only minor differences in agricultural production (in terms of a food-specific shock). … greater changes in output level (in terms of a simultaneous food and non-food specific shock).	n.a.
Hess and Cramon-Taubadel (2007)	n.a.	n.a	… lower welfare results.
Wailes and Morat (2005)	… only minor differences.	… only minor differences.	… only minor differences.
Narayanan et al. (2010a, 2010b)[b]	… greater changes in aggregate imports.	… smaller changes in price level. … greater changes in quantity level.	n.a.
Nielsen (1999)	… generally smaller changes in aggregate exports and imports.	… generally smaller changes in output levels.	n.a.
Tokarick (2003)	n.a.	n.a.	… generally higher welfare results.

[a] For the effects resulting from data aggregation, we compared only the results of the standalone GE and the standalone PE models.
[b] For the effects resulting from model structure, we compared only the results of the standalone PE and the linked disaggregated PE and aggregated GE models.

functional form depicts private household preferences. Producers and consumers are assumed to maximize profit and utility, and all markets are perfectly competitive. A global banking sector links global savings and consumption, whereas the transport sector accounts for international trade and transport margins. Policy interventions are represented by price wedges. Additional information on the general structure of GTAP can be found in the work of Hertel (1997) and on the internet (www.gtap.agecon.purdue.edu).

The fully disaggregated GTAP database (version 8, February 2012) covers 57 sectors in 129 countries and regions. This database is customizable and thus enables users to adapt it to suit the needs of their analysis. For our analysis, we create two so-called aggregations of the GTAP database that differ by the level of sectors (see Table 2).

The first aggregation of the GTAP database separately covers 20 food and agricultural sectors of the GTAP database. The second aggregation of the GTAP database is highly aggregated and combines the 20 food and agricultural sectors into four sectors, namely, crops, grains, livestock and meat products, as well as other processed food (see Table 2). Non-agricultural sectors are grouped in both databases into extraction, manufacturing and services. Both aggregations of the GTAP database also employ an identical regional disaggregation in which the 129 countries and regions of the original GTAP database are grouped as follows: EU-27, Oceania, Asia, North America, Latin America, Middle East and North Africa (MENA), Sub-Saharan Africa (SSA) and the Rest of the World (ROW).

To reveal the interaction with other model characteristics in our analysis, we conduct a pairwise combination of four characteristics (i.e., the disaggregated and aggregated databases and the PE and GE model structures). Fig. 1 presents an overview of how the different versions of the GTAP model and GTAP database are set up in our simulations.

A PE version of the GTAP model is obtained from the GE-GTAP model by adjusting the closure and omitting the relevant market clearing conditions (compare Hertel, 1992). The PE version of the GTAP model contains exogenous prices and outputs of non-food tradable commodities and assumes fixed income. Additionally, we ensure that the non-land primary factor rental rates of the mobile endowment commodities remains exogenous to define the fixed opportunity costs of capital and labor rental rates. Farmland is treated as a sector-specific agricultural input that restricts the otherwise infinitely elastic long-term supply response under the constant return-to-scale assumption at the industry level (Hertel, 1992; Hertel and Tsigas, 1997).

4. Results

This section discusses the results of four experiments. In each of these experiments, we analyze the effect of the complete removal of export subsidies and import tariffs from the EU's food and agricultural sector. The four experiments are conducted using pairwise combinations of different levels of aggregation and model structures, as presented in Fig. 1. The results are presented in US$ million for the year 2007 in the GTAP database. The calculations are performed using GEMPACK (version 11.0), RunGTAP and AnalyseGE (Harrison and Pearson, 1996) software. In discussing the results, we focus on changes in the trade balance and welfare.[2]

4.1. Trade and welfare effects

In Table 3, we present the changes in the trade balance in US$ million for the four experiments. The results in the upper part of the table are based on the GE_DIS version of the GTAP framework (compare Fig.1 and Table 2), which we choose as our reference situation. To ensure that the results are comparable across experiments, we add the results for the 20 disaggregated sectors from the GE_DIS and PE_DIS experiments to the four aggregated food and agricultural sectors provided in the AGG database for all eight regions.

As expected, the results are a straightforward representation of a liberalization experiment conducted with a standard GE model. The largest reductions in trade balance are obtained for the liberalization of the EU, and they are particularly pronounced in the meat and other livestock sectors as well as the processed food sectors. Latin America exhibits the greatest increase in relative exports in meat and other livestock products. Here, the initial EU import tariffs are the highest. Whereas this experiment produces a standard GE positive change in the trade balance in the non-food sectors of the EU, it induces a negative change for the non-food sectors of the other regions (not shown in Table 3). Thus, agricultural trade liberalization in the EU removes the implicit tax on the EU's non-food sector and the agricultural sectors in countries outside the EU. The related increase in output in the prevailing

[2] Changes in output are primarily induced by changes in the trade regime. These changes mirror the effects of the trade balance with a lag and thus exhibit a pattern that is similar to the changes in the trade balance.

Table 2
Food and agricultural sectors of the aggregations of the GTAP database.
Source: Own illustration.

Aggregation of the GTAP database with 20 food and agricultural sectors	Aggregation of the GTAP database with four food and agricultural sectors
(1) Paddy rice, (2) vegetables & fruits, (3) oil seeds, (4) sugar beet & cane, (5) plant-based fibers, (6) other crops, (7) processed rice	(1) Crops
(8) Wheat, (9) cereal & grains	(2) Grains
(10) Cattle, (11) pork & poultry, (12) raw milk, (13) wool, (14) other meat, (15) beef	(3) Meat & other livestock
(16) Beverages & tobacco, (17) other food, (18) sugar, (19) dairy products, (20) vegetable oils & fats	(4) Processed food

sectors draws labor and capital into the expanding sectors and thus exhibits the well-known GE effect of this experiment.

The middle part of Table 3 presents the results for the trade balance based on the GE_AGG version of the GTAP framework. This part also shows the absolute and percentage deviations from the results generated by the GE_DIS experiment. These deviations are solely caused by the initially more aggregated database that was used in the GE_AGG experiment. It is clear that the results of GE_AGG are significantly different. The EU crop sector exhibits particularly deviating results. Here, the trade balance decreases by 1.6 US$ billion in GE_AGG, whereas the decrease is only 76 US$ million in GE_DIS. The minor change in the EU's trade balance for crops in the reference situation implies a substantial percentage change deviation of −2043%. A similar but less distinct result is observed in the EU's processed food sector, in which the decrease amounts to 24.2 US$ billion in GE_AGG compared with 31.5 US$ billion in GE_DIS. For the EU's meat and other livestock sectors, the differences between the results of the two experiments are less pronounced but still amount to 11%. In third countries, particularly SSA, MENA and Latin America, we also observe noticeable differences between GE_DIS and GE_AGG. Here, it is interesting to note that the deviations from the reference situation GE_DIS in the processed food sector are negative in the case of SSA (−1.347 US$ billion) but positive in the case of MENA (2.440 US$ billion) and Latin America (2.083 US$ billion).

The third portion of Table 3 presents the results of the PE_DIS experiment. The results of the experiment are obtained from the PE version of the GTAP model that was developed with a disaggregated database (compare Fig. 1 and Table 2). Again, we provide the absolute and percentage deviations between the PE_DIS and GE_DIS versions of the GTAP framework, which are now exclusively initiated by the model structure. Here, the differences are particularly pronounced for EU's crops (−688%) and grain sectors (−29%), whereas the meat and livestock and processed food sectors exhibit smaller differences. This observation also applies to the regions outside the EU, but the effects in these regions are less pronounced.

In Table 4, we present an overview of the welfare effects of the EU agricultural trade liberalization in the GE_DIS, GE_AGG and PE_DIS experiments. As noted above, we select GE_DIS as our reference situation; hence, Table 4 also provides information regarding the differences between GE_DIS and GE_AGG as well as between GE_DIS and PE_DIS.

As expected, the abolition of EU agricultural tariffs and export subsidy rates leads to a welfare gain that is the highest in nearly all regions and the world in the GE_DIS experiment, whereas this gain is the lowest in the PE_DIS experiment. This finding is consistent with the results obtained by other authors and reported in Section 2 in our literature overview. It is also interesting to note that the EU welfare changes in the PE_DIS experiment are larger than those in the GE_DIS experiment.

4.2. *Effects of model structure and data aggregation on results*

How can the differences resulting from the model structure and aggregation level be explained? What are the major factors that govern these results? Is the model structure more important than the data aggregation?

The differences in results caused by the model structure can of course be traced to the factor endowment and related constraints. They are not considered in PE_DIS, whereas the accounting relationships for factor endowments in the GE version of the GTAP framework mirror the economy-wide resource restrictions. This economy-wide coverage of the GE model structure also enables us to identify a negative terms of trade (TOT) effect in the non-agricultural sector that follows the liberalization of EU agricultural trade. This highly negative TOT effect is responsible for the generally lower welfare gain in the GE_DIS experiment compared with that in the PE_DIS experiment. The initiating shock is of importance as well. It affects the food and agricultural sector of the EU-27 in our experiments directly, whereas the non-agricultural sectors are only affected indirectly. Thus, for instance non-agricultural output, which is exogenous in the PE model structure, is only marginally changed in the GE model structure. A greater shock to the agricultural sector (e.g., complete world-wide agricultural trade liberalization) or increased importance of agriculture (e.g., in developing countries) would therefore lead to a more pronounced difference between the results obtained from the PE and GE model structures. Analogously, a change in the political environment of the non-agricultural sector would result in larger differences between the results of the PE and GE specifications.

	GTAP model / GTAP database	Model structure	
		GE	**PE**
Sector aggregation	**DIS** 20 food and agricultural sectors plus extraction, manufacturing and services	GE_DIS	PE_DIS
	AGG Four food and agricultural sectors plus extraction, manufacturing and services	GE_AGG	PE_AGG

Fig. 1. Graphical presentation of the GTAP framework used in the empirical analysis.
Source: Own illustration.

Table 3
Change in trade balance resulting from EU agricultural trade liberalization based on different model structures and database aggregations (US$ million)[a].
Source: Own illustration.

	EU	Oceania	Asia	North America	Latin America	MENA	SSA	ROW
GE_DIS (results of disaggregated sectors are added to sectors of AGG)								
Crops	−76	−90	1453	995	−2185	−62	−18	−183
Grains	−455	−95	−6	944	−727	−199	−8	512
Meat & livestock	−31,291	−1283	1270	2222	27,138	327	149	147
Processed food	−31,513	6688	4581	3696	4625	4012	1899	4995
GE_AGG								
Crops	−1635	166	2426	748	−2117	655	−182	−193
Grains	−131	−2	−26	916	−975	−117	−57	387
Meat & livestock	−27,858	−556	−83	971	26,359	99	76	−185
Processed food	−24,162	2779	4886	3554	2542	1572	3246	4533
GE_DIS–GE_AGG (differences resulting from initial more aggregated database)								
Crops	1559	−256	−972	247	−68	−717	164	10
	(−2043)	(286)	(−67)	(25)	(3)	(1156)	(−912)	(−5)
Grains	−324	−93	20	28	248	−82	49	125
	(71)	(98)	(−371)	(3)	(−34)	(41)	(−625)	(24)
Meat & livestock	−3433	−727	1353	1251	780	229	73	332
	(11)	(57)	(107)	(56)	(3)	(70)	(49)	(226)
Processed food	−7351	3908	−305	142	2083	2440	−1347	463
	(23)	(58)	(−7)	(4)	(45)	(61)	(−71)	(9)
PE_DIS (results of disaggregated sectors are added to sectors of AGG)								
Crops	−602	−79	1410	879	−1739	−19	74	−181
Grains	−586	−90	−9	946	−665	−163	−1	525
Meat & livestock	−33,211	−1148	1138	2071	29,165	318	150	92
Processed food	−33,954	7201	4061	3543	6753	4123	1958	5138
GE_DIS–PE_DIS (differences resulting from model structure)								
Crops	525	−10	43	116	−445	−43	−92	−2
	(−688)	(12)	(3)	(12)	(20)	(70)	(510)	(1)
Grains	131	−4	4	−2	−62	−37	−7	−14
	(−29)	(5)	(−73)	(−0)	(9)	(18)	(92)	(−3)
Meat & livestock	1920	−135	132	151	−2026	10	−1	55
	(−6)	(11)	(10)	(7)	(−7)	(3)	(−0)	(38)
Processed food	2441	−514	520	153	−2128	−111	−58	−143
	(−8)	(−8)	(11)	(4)	(−46)	(−3)	(−3)	(−3)

[a] The numbers in brackets are the percentage deviations of the pertinent experiment from the GE_DIS; for instance, the percentage change difference in the EU crop sector between PE_DIS and GE_DIS is equal to −688%.

These effects are well known and are identified in the works of Hertel (1992), Tokarick (2003) and Gohin and Moschini (2006).

The differences in results caused by more aggregated databases are first caused by false competition (Narayanan et al., 2010a). False competition results from a situation in which competition does not initially exist between two exporting countries (e.g., in Asia and Latin America) in a subsector (e.g., soybeans). However, the trade data on this subsector may be available only in the form of an aggregated sector (e.g., crops) that also includes other competing sectors (e.g., rice). Utilizing the aggregated sector in models causes false substitution effects as a result of improperly applied weights and thus also leads to an overvalued own price and substitution elasticity. Similar effects are to be expected when transferring highly aggregated results to the adjacent models that are more disaggregated. Following Narayanan et al. (2010a, p. 763), we use Eq. (1) to represent the own-price elasticity of source-wise imports with respect to their corresponding prices to explain this effect:

$$\frac{qxs_{irs}}{pms_{irs}} = -\left(\left(1-\theta^R_{irs}\right)\cdot\sigma_M + \left(1-\theta^D_{is}\right)\cdot\theta^R_{irs}\cdot\sigma_D\right) \tag{1}$$

where

qxs_{irs} percentage change in imports of commodity *i* from region r to region *s*

pms_{irs} percentage change in the domestic price for commodity *i* supplied from *r* to region *s*

Table 4
Welfare effects of EU agricultural trade liberalization (equivalent variation, US$ million)[a].
Source: Own illustration.

	EU	Oceania	Asia	North America	Latin America	MENA	SSA	ROW	World
GE_DIS	8122	1543	−1389	998	7139	714	352	865	18,344
GE_AGG	3156	638	−570	740	6186	263	618	908	11,937
PE_DIS	9050	526	−888	61	3540	−204	−140	−587	11,358
GE_DIS–GE_AGG	4966	905	−818	258	953	450	−265	−43	6406
	(61)	(59)	(59)	(26)	(13)	(63)	(−75)	(−5)	(35)
GE_DIS–PE_DISS	−928	1018	−501	938	3599	918	492	1451	6986
	(−11)	(66)	(36)	(94)	(50)	(129)	(140)	(168)	(38)

[a] The numbers in brackets are the percentage deviations of the pertinent experiment from the GE_DIS; for instance, the percentage change difference in the EU's equivalent variation between GE_DIS and PE_DIS is equal to −11%.

θ_{irs}^R value share of source-specific imports of commodity i in aggregated imports across sources
θ_{is}^D value of imports and domestically produced commodity i in domestic consumption
σ_M elasticity of substitution among imports across sources
σ_D elasticity of substitution between domestic and imported commodity

The first term on the right-hand side of this equation represents the competition between imports of commodity i from region r to region s and imports from all other regions to region s. A lower share θ_{irs}^R is associated with a greater substitution effect and greater absolute value of the own-price elasticity.

This artificial competition and related substitution effect induced by the aggregation of sectors leads to a higher absolute value of the own-price elasticity for source-wise imports with respect to their corresponding prices in the GE_AGG version of the GTAP framework. For example, it is particularly striking that SSA's change in trade balance of the processed food sector is overestimated by 71% in GE_AGG (see Table 3).

Table 5 reports the changes in the trade balance of SSA and the corresponding exports and imports to or from all other countries. The results show that the increase in the trade balance of SSA is governed by the increase in exports to all destinations. Table 5 also provides information on the percentage change in the EU's imports from SSA (*qxs* (i, SSA, EU)) and the corresponding percentage change in the EU's domestic prices of these imports (*pms* (i, SSA, EU)). These variables are used in the final column of Table 5 to calculate the corresponding own-price elasticity of source-wise imports with respect to their corresponding prices (ε (i, SSA, EU)).

In the aggregated version of the GTAP framework (GE_AGG), this elasticity amounts to −5.04, whereas the disaggregated version (GE_DIS) yields an elasticity that is almost 50% lower (−2.71). Accordingly, we observe a much greater trade effect in the GE_AGG. The higher absolute value of the elasticity is of course the result of the value shares of source-specific imports in aggregated imports across sources (θ (i, SSA, EU)), which is close to zero for all sectors except sugar (θ (sugar, SSA, EU) = 0.166) in GE_DIS. Thus, the aggregated processed food sector in GE_AGG includes several sectors with essentially zero value shares of source-specific imports (i.e., dairy products and vegetable oils and fats) or sectors with marginal value shares of source-specific imports (i.e., other food as well as beverages and tobacco), which are combined with a sector (i.e., sugar) in which SSA is the largest exporter to the EU. Hence, the model creates false competition, which also causes differences in the results between GE_DIS and GE_AGG for other regions and sectors, such as the processed food sector in Asia, the crop sector in MENA or the meat and livestock sector in Oceania. In sum, we can conclude that the aggregation of sectors with highly varying value shares of source-specific imports in aggregated imports across sources causes substantial false competition, results in the overestimation of trade effects and thereby biases results that are then transferred to the adjacent model in the system.

The differences in the results caused by data aggregation can also be attributed to the averaging of tariffs. Anderson and Neary (1994, 1996) and other subsequent researchers clearly demonstrate that the atheoretic method of trade-weighted tariff aggregation results in an underestimation of trade and welfare effects. In our experiments, we are able to show that the aggregation of data, for example, leads to an underestimation of the EU's welfare gains of 61% (see Table 4). We find biases in similar ranges in other regions. In another study, Anderson and Neary (1994, 2003) develop the Trade Restrictiveness Index (TRI) and the Mercantilistic Trade Restrictiveness Index (MTRI), which are theoretically consistent aggregation methods. The TRI is a welfare equivalent protection index, whereas the MTRI measures protection in terms of import equivalence. Following Pelikan and Brockmeier (2008), we calculate the MTRI for the bilateral EU import tariffs and map it to the aggregated version of the GTAP database that is used in the GE_AGG and PE_AGG experiments. In Table 6, we report the MTRI and the trade-weighted average tariff rate of the aggregated GTAP database.

Tariff averaging and the resulting trade effects work in the opposite direction of the effect resulting from false competition. Therefore, the information presented in Table 6 can be used to explain the positive differences between the results of the GE_DIS and GE_AGG experiments presented in Table 3.

The differences reported in Table 3 for the processed food sectors in Oceania (3.908 US$ billion) and MENA (2.440 US$ billion) as well as for the meat and other livestock sectors in Asia (1.353 US$ billion) are particularly high. Table 6 shows that the MTRIs are more than twice as high as the trade-weighted tariff in all of these cases. This finding also applies to the meat and other livestock sectors in MENA, SSA and ROW as well as the grain sector in MENA. However, these regions export only negligible amounts to the EU; hence, the absolute difference in Table 3 is comparatively low. In contrast, the percentage deviation between GE_DIS and GE_AGG is high, particularly for the meat and livestock sector in ROW.

To separate the effect resulting from false competition from the effect resulting from trade-weighted average tariffs, we would need to calculate the bilateral MTRIs for all commodities and regions, substitute them into the aggregated database and rerun the EU agricultural trade liberalization experiment with this altered database. Such procedures are beyond the scope of the paper and would not be helpful in answering our initial question of whether model structure or database aggregation is more relevant to biasing model results within a system of linked models.

Tables 3 and 4 provide answers to this question. Based on our experimental setting and the chosen reference situation (GE_DIS), we can draw the following conclusions:

- Data aggregation influences the outcome of trade effects in agricultural trade liberalization experiments more than the model

Table 5
Change in trade[a] and prices of processed food exported from SSA to the EU.
Source: Own illustration.

		Trade balance	Export	Import	*qxs*	*pms*	*qtrs*	*e*
					(i, SSA, EU)			
		(billion US $)			(%)			
GE_AGG	Processed food	3246	3391	145	67.97	−13.5	0.024	−5.04
GE_DIS	Processed food	1899	1874	−25	36.75	−13.58	0.024	−2.71
	Beverages & tobacco	62	71	8	11.29	−5.85	0.015	−1.93
	Other food	238	276	37	7.34	−4.37	0.029	−1.68
	Sugar	1495	1491	−3	228.21	−46.72	0.166	−4.88
	Dairy products	107	40	−67	80.04	−11.34	0.001	−7.06
	Vegetable oils & fats	−3	−3	−1	−20.15	0.04	0.004	−516.69

[a] Exports are destination generic, whereas imports are source generic.

Table 6
Bilateral trade-weighted average tariff rate and MTRI of the EU.
Source: Own illustration.

		Oceania	Asia	North America	Latin America	MENA	SSA	ROW
Crops	MTRI	8.57	10.99	4.95	4.83	9.20	2.21	3.12
	Trade weighted	8.28	9.89	3.22	4.02	7.38	2.05	2.00
Grains	MTRI	7.99	15.67	8.69	5.37	3.10	2.50	17.86
	Trade weighted	7.13	12.34	6.22	3.88	2.30	0.92	10.38
Meat & livestock	MTRI	3.58	13.06	25.51	67.04	14.82	23.82	7.66
	Trade weighted	3.01	6.28	13.46	46.41	7.19	9.74	2.70
Processed food	MTRI	49.19	13.54	18.58	27.12	25.12	37.69	21.28
	Trade weighted	20.72	10.12	13.57	11.09	13.60	15.99	10.13

structure. Table 3 shows that the percentage deviation from the reference situation is higher in nearly 90% of the cases when the data is aggregated (GE_AGG) compared with experiments that are based on a different model structure (PE_DIS).

- The greater influence of data aggregation on the results is particularly evident in the region in which the shocks are implemented (in this study, the EU). Additionally, this result is even more significant when worldwide agricultural trade liberalization is simulated but is also valid for economy-wide EU trade liberalization.[3]
- Welfare effects exhibit higher percentage deviations from the reference situation as a result of data aggregation in the liberalizing region, but the model structure is more important in non-liberalizing regions (see Table 4).
- Worldwide agricultural trade liberalization increases the importance of false competition and effects resulting from trade-weighted average tariffs, such that data disaggregation becomes even more important for unbiased welfare effects. However, this finding is not valid when trade liberalization involves worldwide, economy-wide trade liberalization (e.g., the implementation of the WTO).

Thus, when considering sector-specific trade liberalizing scenarios, it is more important to disaggregate sectors than to invest in aligning the model structure to prevent the transfer of highly biased results between models in the system.

4.3. Interaction between model structure and data aggregation

Are the two fundamental characteristics of models that are most commonly employed to analyze trade policies independent? In other words, is the difference caused by aggregation greater in experiments that are based on a GE model structure than in experiments that are based on a PE model structure?[4]

To answer this question, we use the fourth experiment PE_AGG to create Table 7. The differences in results between the GE_DIS and GE_AGG experiments as well as between the PE_DIS and PE_AGG experiments are clearly attributable to data aggregation. Accordingly, we subtract these two differences from one another to obtain the effects on the results owing to the interaction of model structure and data aggregation:

$$IACT_{ir} = \left(DTBAL_{ir}^{GE\_DIS} - DTBAL_{ir}^{GE\_AGG}\right) - \left(DTBAL_{ir}^{PE\_DIS} - DTBAL_{ir}^{PE\_AGG}\right) \quad (2)$$

where

$IACT_{ir}$ effects on the results caused by the interaction of model structure and data aggregation for commodity i in region r.

$DTBAL_{ir}$ changes in the trade balance of commodity i in region r. The superscripts GE_DIS, GE_AGG, PE_DIS and PE_AGG indicate the experiments that are defined in Fig. 1.

Observing Table 7, we conclude that the effect on the changes in the trade balance resulting from an interaction of model structure and data aggregation is effectively negligible. The percentage changes observed in Table 7 are higher only for those regions that exhibit low changes in the reference situation (compared with Table 3). Thus, the two model characteristics are likely to be independent.

5. Conclusions

Systems of linked models have become increasingly popular in agricultural policy research and policy advice in recent years. Several articles note that the combination of models with different comparative advantages can provide additional value to analysis and may thus be superior to the use of standalone models. In this paper, we provide estimates of the biases that can occur when results are transferred to adjacent models in a linked system.

In an illustrative setting, we conduct a sensitivity analysis of two fundamental characteristics of the models that are most frequently used in trade policy analysis: the model structure and the aggregation of databases. We distinguish between general (GE) and partial (PE) equilibrium models as well as between disaggregated (DIS) and aggregated (AGG) agricultural sectors in a database. We utilize the GTAP framework for our analyses because this tool is sufficiently flexible to capture these four characteristics and to clearly distinguish them. We perform pairwise combinations of these four characteristics to create four experimental settings, namely, GE_AGG, GE_DIS, PE_AGG and PE_DIS, which we then use to create a complete food and agricultural trade liberalization scenario for the EU.

By selecting the GE_DIS experiment as the reference situation, we demonstrate that there are substantial deviations in the results because of the model structure and data aggregation. We are able to trace these deviations back to false competition, tariff averaging and the economy-wide setting of general equilibrium models. Throughout all of the experiments, the deviations in the results caused by data aggregation are much more important than those caused by the model structure. The greater influence of data aggregation on the outcomes of the simulations is particularly pronounced in the liberalizing region. For example, the change in the EU's trade balance for grains is underestimated by 71% when the database is more aggregated (GE_AGG), whereas we observe an overestimation of 29% for the same sector when the model structure is changed to PE (PE_DIS). We also show that data aggregation biases welfare effects in the liberalizing region to a greater extent than a non-economy-wide PE model structure. Of course, we find more significant deviations in worldwide agricultural trade liberalization scenarios, but we also show that these conclusions are valid for economy-wide EU trade liberalization. The illustrative setting also enables us to conclude that the two fundamental model characteristics (model structure and data aggregation level) are most likely independent; hence, the

[3] When we rerun the GE_DIS, GE_AGG, PE_DIS and PE_AGG experiments under worldwide agricultural trade liberalization and EU economy-wide trade liberalization, both experiments confirmed our statement. The relevant tables are not included in this paper but can be obtained from the authors upon request.

[4] Our experimental setting does not allow us to construct a contingency table that can be used for a statistical test (e.g., Pearson's chi-squared test) to test the independence of the model structure and data aggregation.

Table 7
Effects on changes in the trade balance resulting from the interaction of model structure and data aggregation.[a]
Source: Own illustration.

	EU	Oceania	Asia	North America	Latin America	MENA	SSA	ROW
Crops	−39	−4	−184	−8	195	−32	61	−12
	(52)	(5)	(−13)	(−1)	(−9)	(52)	(−338)	(7)
Grains	8	−1	−2	−37	60	−23	16	−20
	(−2)	(1)	(44)	(−4)	(−8)	(12)	(−202)	(−4)
Meat & livestock	−10	−64	7	−8	68	−22	25	11
	(0)	(5)	(1)	(−0)	(0)	(−7)	(17)	(8)
Processed food	−17	−343	253	35	−29	−70	186	−4
	(0)	(−5)	(6)	(1)	(−1)	(−2)	(10)	(−0)

[a] The numbers in Table 7 are calculated according to Eq. (2). The numbers in brackets are percentage deviations of the interaction effect of the relevant experiment from the GE_DIS experiment.

difference resulting from aggregation is not significantly higher in experiments that are based on a GE model structure than in experiments that are based on a PE model structure.

From this illustrative example, we thus conclude that it is more important to disaggregate sectors than to invest in aligning the model structure to prevent the transfer of biased results between linked models in sector trade liberalization scenarios. It would also be worthwhile to include indices in aggregation programs that identify aggregated sectors in which only one sub-sector within an aggregate is important and in which false competition most likely occurs. Additional benefits would of course be gained from an analysis of systems of linked models, for which data aggregation programs would also offer the option to regularly calculate aggregated tariffs with theoretically sound methods, such as the MTRI.

Several caveats to our analysis should be noted before we conclude the paper. First, we include only two characteristics of the models that are used in the trade liberalization analyses. Other model characteristics (e.g., the explicit representation of policy instruments, differences in parameter estimations) should gradually be incorporated into such sensitivity analyses of linked models. Second, to enable a direct comparison, we are obliged to base our simulations on standard GE and PE models. Recent research clearly demonstrates the superiority of more detailed modeling work (e.g., representation of land via differentiated agro-ecological zones, coverage of biofuels and related issues), which is currently captured by most linked model systems. The inclusion of these factors may accentuate the results of our analysis.

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3 Moving toward the EU or the Middle East? An Assessment of Alternative Turkish Foreign Policies utilizing the GTAP Framework

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Moving toward the EU or the Middle East? An assessment of alternative Turkish foreign policies utilizing the GTAP framework

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ABSTRACT

This paper assesses the new orientation in Turkish foreign policy towards the Arab world by analyzing the potential impact of Turkey's membership in either the European Union (EU) or the Greater Arab Free Trade Area (GAFTA). We utilize the most recent version of the Global Trade Analysis Project (GTAP) database, its global Computable General Equilibrium (CGE) model, and the gravity border effect approach to estimate the ad-valorem tariff equivalents (AVEs) of non-tariff barriers (NTBs). In our overall analysis, we account for 24 various sectors. However, in our evaluation, we focus primarily on the food and agricultural sectors because this sector is characterized by high tariff and non-tariff protection. In the CGE simulation analysis, we consider the removal of tariffs and NTBs simultaneously. After projecting the GTAP framework to 2020, we conclude that Turkey would gain unambiguously from EU membership, whereas Turkey's gains from GAFTA membership would be more limited. The paper also presents that the welfare gains from the removal of NTBs are of considerable importance and would generally be greater than the gains stemming from the elimination of import tariffs.

Introduction

Whether Turkey should be referred to as a European, a Middle Eastern or an Asian country has always been a crucial question. In recent years, this ongoing debate has attracted even more attention. The long-standing membership negotiations with the European Union (EU) and Turkey's so-called "axis shift" toward the Middle East have underscored the importance of this issue. There appears to be a trend in which Turkey is loosening its ties with the West and tightening its ties with the East.

The first step toward the integration of Turkey into the European community occurred in 1963 with the Ankara Association Agreement. The 1995 Customs Union Agreement continued this process with Turkey becoming an EU candidate country in 1999 and beginning its accession negotiations in 2005. Up until now the EU has always been Turkey's most important trading partner, accounting for 42% of Turkey's total trade in 2012 (Turkstat, 2013). Meanwhile, the EU continued to expand growing to its current size of 28 member countries. Since 2002, the Turkish government has restructured the direction of its foreign policy strategy becoming more politically aligned with the Arab world. The literature on Turkey's recent foreign policy seems to confirm this political shift and increasing involvement with the Middle East (e.g., Adam, 2012; Babacan, 2011; Candar, 2009; Ciftci and Ertugay, 2011; Evin et al., 2010; Sanberk, 2010). Turkey's Islamic roots, cultural and historical ties with the Arab world as well as its legacy to Ottoman Empire are identified as main triggers for this "axis shift" (e.g., Alessandri, 2010; Aybar, 2012; Habibi and Walker, 2011; Taspinar, 2008; Walker, 2011). This political realignment has directly affected the country's trade strategy. Although, the Turkish government claims that no exclusive policies are set for the Middle East and implementation of consistent foreign policies for different parts of the world are intended (Foreign Policy, 2010; Kara, 2011), the evidence clearly shows the opposite. Free trade agreements (FTAs) signed by Turkey in the last 10 years have mainly included countries in the Arab world. Currently, Turkey has eight FTAs with Middle Eastern countries.

Against this backdrop, we compare two options of the Turkish foreign policies by employing a global Computable General Equilibrium (CGE) model enriched with econometrically estimated ad-valorem tariff equivalents (AVEs) of non-tariff barriers (NTBs). Our aim is to contribute to the debate regarding whether Turkey will gain more from its political realignment toward the Middle

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East (e.g., through a potential membership in the Greater Arab Free Trade Area (GAFTA)[1]) over its potential EU membership.

There is an extensive body of literature assessing the potential impacts of Turkey's EU membership using CGE analyses (e.g., Acar et al., 2007; Eruygur and Cakmak, 2008; Philippidis and Karaca, 2009). However, only a small number of studies evaluate Turkey in terms of its FTAs as well as its integration with the Arab world (e.g., Acar and Aydin, 2011; Onthman et al., 2010; Sonmez et al., 2007). Recent literature indicates it is becoming more common to conduct a two-stage analysis by estimating the effects of NTBs and then implementing them in CGE models (e.g., Chang and Hayakawa, 2010; Fugazza and Maur, 2008; Philippidis and Sanjuán, 2006, 2007; Winchester, 2009). However, to the best of our knowledge, only Lejour and Mooij (2004) have utilized this approach to examine Turkey's potential EU membership. Zahariadis (2005) also considers technical barriers, although he does not use a gravity model to estimate the effects of NTBs. Moreover, none of the aforementioned studies reflect the economic effects of Turkey's relationship with Middle Eastern states. Therefore, this paper adds to the existing studies by assessing the impact of Turkey's relationship with its Eastern and Western neighbors and by simultaneously analyzing the removal of import tariffs and NTBs. We particularly focus on the food and agricultural sector, because in general this sector is characterized by high tariff and non-tariff protection, has therefore proven to be highly sensitive in negotiations of FTAs and is often left out when concluding an agreement of an FTA. The food and agricultural sector is also known for its heterogeneity in the tariff and non-tariff protection. We therefore work at the most disaggregated sector level to avoid aggregation bias in tariffs and NTBs (Brockmeier and Bektasoglu, 2014). Utilizing the gravity border effect approach and the Global Trade Analysis Project (GTAP) framework (Version 8), we compare Turkey's potential accession to the EU with its potential membership in GAFTA.

Our analysis is divided into two parts. In Section 'Introduction', we use the gravity border effect approach to estimate the effects of NTBs on the Turkey-EU and Turkey-GAFTA trade flows and convert the resulting effects into AVEs. In Section 'Overview of the Turkish trade structure and agreements', we incorporate these AVEs into the GTAP framework and derive economy-wide results for the enlargement of the EU and GAFTA to include Turkey. Accordingly, this paper is organized as follows. Following this introduction, we include a brief overview of the trade structure, focusing on the trade flows between Turkey and both the EU and GAFTA. We also consider Turkey's protection structure and its FTAs. In Section 'Econometric estimation with the gravity approach', we provide the theoretical and empirical framework that can be utilized to estimate AVEs of NTBs. In Section 'Simulations with the Global Trade Analysis Project (GTAP) framework', we explain how we integrate our results into the GTAP framework and present our final results. We conclude with Section 'Qualification of results'.

Overview of the Turkish trade structure and agreements

Turkey was ranked 32nd in world merchandise exports and 20th in world merchandise imports in 2011 (WTO, 2013). The most important destination for Turkish exports was the EU (46% of total Turkish exports), followed by Iraq, Russia, the United States and the United Arab Emirates. The majority of Turkish imports also originated from the EU (38% of total Turkish imports). Other important import markets for Turkey were Russia, China, the United States, and Iran (European Commission, 2013a). Although the EU share of Turkey's total trade has decreased since 1990, it has never fallen below 40%, and the EU remains a major trade partner of Turkey. Additionally, Turkey's trade share with other Middle Eastern countries in the last two decades hovered around the 10% mark; however, this share has increased in the last 5 years, reaching 22% in 2012, due to FTAs that came into effect in 2007 (Turkstat, 2013).

In Tables 1 and 2 below, we provide an overview of the commodity specific trade shares as well as source and destination specific trade shares between Turkey and its trading partners. Though we use data from 2007, the trade and protection structure of Turkey have predominantly remained unchanged. What has changed is the volume of trade from 2007 to 2013. The greatest shares of Turkey's exports to the EU and GAFTA are attributed to the light and heavy manufacturing sectors as well as services in the case of Rest of the World (ROW) (compare Table 1). Accounting for 71.47%, extraction ranks first in Turkey's imports from GAFTA. Heavy manufacturing contributes the most to Turkey's imports from the EU (58.92%).

Turkey's food and agricultural exports to the EU account for 6.03% of Turkey's total export to the EU, whereas the share of Turkish agro-food exports to GAFTA is equal to 11.13% of Turkey's total export to GAFTA. However, as shown in Table 2, the share of Turkey's agro-food imports from GAFTA (2.80%) is also not as high as the proportion of imports from the EU (30.42%). Moreover, the amount of food and agricultural exports, that is shipped to the EU, composes 44.21% of Turkey's total agro-food exports to the world, but this share is only equal to 17.45% for the Turkish agro-food exports to the GAFTA member countries (GTAP database, Version 8).

Table 3 presents the commodity-specific trade shares and applied tariff rates in the food and agricultural sector between Turkey and its trading partners. The italicized rows exhibit the sectors, in which exporters report where they most frequently face NTBs (European Commission, 2013b; Teknikengel, 2013; Önen, 2008; Özdemir, 2008). Vegetables and fruits (2.68%) and other food products (2.30%) compose the greatest share of Turkey's total exports to the EU within the agro-food sector, whereas other animal products (0.33%), other food products (0.89%) and beverages and tobacco (0.62%) comprise the largest groups of commodities imported by Turkey from the EU. In addition to the numbers given in Table 3, it is worthwhile to emphasize that Turkey already ships 52.97% of its vegetable and fruit exports and 43.55% of other food product exports to the EU. Also, 80.30% of Turkey's beverages and tobacco imports, 61.05% of other animal product imports and 56.46% of other food product imports are originating from the EU. These shares exhibit the importance of agro-food trade between Turkey and the EU.

The greatest agro-food share of Turkey's total exports to the GAFTA member countries is given for vegetables and fruits (1.74%), vegetable oils and fats (1.13%), and other food products (6.09%). Other animal products (0.15%), processed rice (0.44%) and other food products (0.15%) are the most important agro-food products in total imports from GAFTA to Turkey. Not shown in Table 3, but nevertheless important, is that Turkey ships nearly half of its other animal products and dairy exports to the GAFTA member countries. Turkey receives 65.04% of its processed rice imports and 45.26% of its sugar imports from GAFTA, whereas the shares of other animal products and other food products imports from GAFTA in total Turkish imports within these sectors are negligible (GTAP database, Version 8).

The Customs Union Agreement between the EU and Turkey provides for the free circulation of industrial goods but does not cover the food and agricultural products listed in Annex I of the Amsterdam Treaty.[2] The Turkish agro-food sector is moderately protected;

[1] GAFTA was established in 1957 and signed in 1997. It currently has 17 members, including Bahrain, Egypt, Iraq, Jordan, Kuwait, Lebanon, Libya, Morocco, Oman, West Bank and Gaza, Qatar, Saudi Arabia, Sudan, Syria, Tunisia, United Arab Emirates and Yemen.

[2] See http://.ec.europa.eu.

Table 1
Commodity specific trade shares between Turkey and trading partners (%).

	Turkey's exports to			Turkey's imports from		
	The EU	GAFTA	ROW	The EU	GAFTA	ROW
Food and agricultural products	6.03	11.13	9.31	3.04	1.43	5.99
Extraction	1.68	0.49	3.27	0.49	71.47	12.15
Light manufacturing	49.91	24.80	28.01	31.96	2.55	17.89
Heavy manufacturing	28.40	55.43	29.02	58.92	21.36	53.94
Services	13.99	8.15	30.39	5.58	3.20	10.03

Notes: please refer to Table A1 in Appendix A for the detailed regional and sector aggregation.
Source: GTAP Database, Version 8, Base Year 2007.

Table 2
Source and destination specific trade shares for commodities between Turkey and trading partners (%).

	Turkey's exports to			Turkey's imports from		
	The EU	GAFTA	ROW	The EU	GAFTA	ROW
Food and agricultural products	44.21	17.45	38.34	30.42	2.80	66.78
Extraction	46.40	2.91	50.68	1.75	49.97	48.28
Light manufacturing	70.35	7.47	22.18	61.01	0.95	38.04
Heavy manufacturing	50.22	20.95	28.83	47.82	3.40	48.78
Services	42.64	5.31	52.05	32.11	3.61	64.28

Source: GTAP Database, Version 8, Base Year 2007.

however, protection rates vary considerably at a more disaggregated level and for individual trade partners (compare Table 3). Sectors that have the greatest importance in Turkey's exports to the EU, namely vegetables and fruits and other food products, do not face high import tariffs. However, as it is reported by Turkish exporters, those are the sectors, in which the EU most frequently exhibits NTBs (highlighted in italics in Table 3). In Turkey, NTBs are reported to be high for the imports of other animal products and beverages and tobacco from the EU. Within these sectors, Turkish tariff rates are very high for beverages and tobacco imports (604.54%), whereas imports of other animal products from the EU are not restricted by tariffs. A similar picture is observed for the trade between Turkey and GAFTA. Turkey's most important exports to GAFTA (i.e., vegetables and fruits, vegetable oils and fats and other food products) are regulated by tariffs of 6.97%, 14.60% and 7.15%, respectively. However, it is also reported that Turkish exporters face NTBs specifically on these sectors. Imports of other animal products from GAFTA to Turkey are also not constrained by tariffs, although high NTBs are imposed on Turkey's exports of animal products to the GAFTA member countries (GTAP database, Version 8; European Commission, 2013b; Teknik Engel, 2013; Önen, 2008; Özdemir, 2008).

Turkey signed its first FTA with the European Free Trade Area member countries in 1991. This agreement was followed by the Customs Union Agreement between the EU and Turkey in 1996. Thereafter, several FTAs with Hungary, Romania, Lithuania, Estonia, Czech Republic, Bulgaria and Poland were signed. After the expansion of the EU in 2004 and 2007, those FTAs were modified according to Turkey's Customs Union Agreement with the EU. Turkey's recently concluded FTAs show the country's expanding relationship with the Arab world in recent years. Currently, Turkey has 8 FTAs with the Middle Eastern states. With the exception of its FTA with Israel, all of these agreements were signed after 2002.

Econometric estimation with the gravity approach

Theoretical and empirical framework

The estimation of trade costs of NTBs in this paper is based on the gravity model. The gravity model has become the standard model for empirically measuring expected bilateral trade using economy size and an additional set of control variables. The model's popularity is a function of its theoretical justification and its simple and flexible application.[3] In our analysis, we use the border effect approach to identify NTBs in the trade between Turkey and the EU and between Turkey and GAFTA member countries[4] in 2007. Originated by McCallum (1995) and theoretically advanced by Anderson and van Wincoop (2003), the border effect compares intra-national trade with international trade. The border effect reveals to what degree international trade falls below the trade within a country due to barriers resulting from an international border, i.e., tariffs, NTBs and all other border-related factors that might hinder trade. The border effect can also comprise of non-policy measures, such as transaction costs and consumer preferences for domestic products, and regulative measures which should not be eliminated. Restrictive regulative measures are a consistent subject of public debate caused by divergent perceptions of risks and different opinions on sensitive issues such as food safety and health issues. While the justifications of restrictive measures are reasonable in many cases, it might be doubtful in several others. The justification within the EU is administered within the process of achieving a Single European Market, and is, in many cases, a matter for the European Court of Justice. However, the elimination of these measures leads to higher welfare effects than the elimination of isolated border barriers related to policy measures would (Olper and Raimondi, 2008a). Although there might be an overestimation of border trade costs, the advantage of this approach is that the border effect takes into account all impediments, including those that are unobservable or that are difficult to measure directly. Particularly in agriculture, there is a dearth of reliable, updated statistics on the technical regulations and phytosanitary standards that significantly influence agro-food trade. To our knowledge, there are only a few papers that employ this border effect approach to agro-food trade in other countries; namely, Chang and Hayakawa (2010), Olper and Raimondi (2008a,b) and Winchester (2009).

Using the latest developments with regard to the specification of gravity models, we adopt the gravity-like equation developed

[3] See Anderson (2011) and Head and Mayer (2013) for a detailed review on gravity models.

[4] In our analysis, the GAFTA member countries include only 9 countries (Armenia, Bahrain, Egypt, Kuwait, Moroc-co, Oman, Qatar, Saudi Arabia and Tunisia) due to the available regional disaggregation in the GTAP database.

Table 3
Disaggregated agro-food specific trade shares in total trade and related bilateral applied tariff rates between Turkey and trading partners (%).

	Turkey's exports to				Turkey's imports from			
	The EU		GAFTA		The EU		GAFTA	
	Share of total	Tariff rate	Share of total	Tariff rate	Share of total	Tariff rate	Share of total	Tariff rate
Food and agricultural products	6.03	3.15	11.13	8.76	3.04	15.86	1.43	27.25
Wheat	0.02	4.90	0.00	6.20	0.10	92.26	0.03	116.24
Cereal grains	0.01	2.36	0.25	14.28	0.11	39.05	0.00	46.70
Vegetables and fruits	*2.68*	*3.20*	*1.74*	*6.97*	*0.06*	*1.22*	*0.13*	*6.39*
Oil seeds	0.07	0.00	0.02	29.91	0.32	0.00	0.01	17.24
Plant-based fibers	0.15	0.00	0.06	6.40	0.17	0.00	0.14	0.00
Crops	0.38	0.00	0.04	26.07	0.21	6.63	0.12	6.91
Cattle	0.01	0.31	0.00	0.32	0.02	1.84	0.00	4.43
Other animal products	*0.07*	*0.16*	*0.41*	*9.57*	*0.33*	*0.00*	*0.15*	*0.00*
Vegetable oils and fats	*0.09*	*104.48*	*1.13*	*14.60*	*0.07*	*44.92*	*0.03*	*39.62*
Dairy	0.04	25.94	0.55	2.47	0.06	102.41	0.02	127.31
Processed rice	0.00	23.84	0.00	19.94	0.03	13.60	0.44	20.73
Sugar	0.02	22.97	0.05	7.22	0.00	88.45	0.12	57.41
Other food products	*2.30*	*2.74*	*6.09*	*7.15*	*0.89*	*66.02*	*0.15*	*12.10*
Beverages and tobacco	*0.17*	*0.00*	*0.76*	*6.57*	*0.62*	*604.54*	*0.02*	*643.06*
Cattle meat	0.00	2.43	0.01	13.27	0.00	18.71	0.00	18.74
Other meat	0.01	2.16	0.02	11.02	0.02	50.41	0.00	50.49

Notes: Italicized rows exhibit the sectors, in which NTBs are most frequently reported by exporters.
Source: GTAP Database, Version 8, Base Year 2007.

by Anderson and van Wincoop (2003, 2004), in which relative prices play an important role. Their model takes the following form:

$$x_{ij} = \frac{y_j y_i}{y_w}\left(\frac{t_{ij}}{P_j \prod_i}\right)^{1-\sigma} \quad (1)$$

where x_{ij} is the value of the exports from country i to country j, y_i (y_j) is exporter (importer) production (consumption), y_w is the global output, t_{ij} is the bilateral trade resistance, σ is the elasticity of substitution between all goods, and Π_i and P_j are CES consumer price indices for i and j, respectively. The price indices in Eq. (1) represent the multilateral resistance terms (MRTs) that cannot be observed (Anderson and van Wincoop, 2003). These terms capture the costs of bilateral trade between two regions, which are affected by the average cost that each region incurs in trading with the rest of its trading partners. These MRTs form the substitutability between a country's different trading partners and make it possible to account for unobserved heterogeneity. Because each trading country has different prices for each commodity, we control for unobserved MRTs by specifying importer and exporter fixed effects (e.g., Chen, 2004; Feenstra, 2002; Olper and Raimondi, 2008a; Philippidis et al., 2013; Winchester, 2009). Thus, we include exporter and importer specific dummies. As such, the country dummies control not only for multilateral resistance but also for country-specific factors. Typically, the trade cost component t_{ij} is specified using a function of transport costs and a border variable. Replacing the cost function in Eq. (1) and taking the logarithm, we derive an empirical log-linear specification:

$$\ln x_{ij} = \alpha_i + \alpha_j + \beta_1 + \beta_2 \ln d_{ij} + \beta_3 \delta_{ij} \quad (2)$$

where $\alpha_i = \ln y_i - (1-\sigma)\ln \Pi_i$ is the fixed effect of the exporting country and $\alpha_j = \ln y_j - (1-\sigma)\ln P_j$ is the fixed effect of the importing country. Transport costs are approximated by distance (d_{ij}) between country i and j and the factor δ_{ij} takes a value of one if i and j are different countries and a value of zero if i and j are the same country; in this way, this border variable represents both international and intra-national trade (Anderson and van Wincoop, 2003). The constant β_1 is equal to $(-\ln y_w)$, $\beta_2 = (1-\sigma)\rho$ is the distant coefficient and $\beta_3 = (1-\sigma)\ln b_{ij}$ is the border effect coefficient to be estimated. Accordingly, $(b_{ij}-1)$ is the tariff equivalent of all trade barriers resulting from an international border. Following the standard procedure in the literature, we extend our equation using an additional set of continuous and dummy control variables. The whole set of independent variables are defined in Table 4. We apply Eq. (2) with the full set of independent variables to 16 agricultural disaggregated sectors[5] and to one aggregated agro-food sector by pooling over the corresponding agricultural disaggregated sectors (see Table A1 in Appendix A).[6] In the pooled regression, we include sectoral dummies to account for sectoral heterogeneity and variables for production and consumption. Due to the use of the fixed effect approach, the importer-consumption and exporter-production coefficients explain only the sectoral dimension of bilateral trade. The most important parameters to estimate are the coefficients of the border dummies. Taking the antilog of the estimated border coefficient, we obtain the border effect, which quantifies to what degree international trade falls below intra-national trade. By controlling for the differences in tariffs, distance, and other unspecified trade costs in the gravity equation, we assume that the effects of the NTBs mainly determine the border effect.

Data and estimation technique

We source data on bilateral exports, production values, consumption values, bilateral tariffs, and export subsidies from Version 8 (base year 2007) of the GTAP database. To employ the border effect approach, we must also consider intra-national trade. Following Chen (2004), Wei (1996) and other authors, we calculate a country's exports to itself by subtracting each country's aggregate exports to all international destinations from its domestic production in each sector. The GTAP database offers information about 129 regions and 57 sectors. We reduce the number of regions to 79 by omitting composite regions and countries whose trade share with Turkey is less than 0.001 of total Turkish trade; we also

[5] In estimating border effects, we only use 16 of 20 food and agricultural sectors used in the simulations by omitting the generally untraded sectors paddy rice, sugar cane and beets, raw milk and wool.

[6] To avoid effects of aggregation bias in the econometric estimates and the CGE results we follow a disaggregated sector analysis. However, we only consider disaggregation in agro-food sectors because the inclusion of disaggregated non-food sectors goes beyond the scope of the paper. Therefore, the CGE analysis only considers a uniform efficiency improvement in the non-food sectors.

Table 4
Independent variables.

Independent variable	Description
Distance	Distance between i and j
Landlocked	Dummy variable; = 1 if country i and j are both landlocked
Contiguity	Dummy variable; = 1 if country i and j share a border
Language	Dummy variable; = 1 if country i and j have a common language
RTA	Dummy variable; = 1 if country i and j both are members of the RTA
WTO	Dummy variable; = 1 if country i and j both are members of the WTO
Colony	Dummy variable; = 1 if country i and j have colonial ties
Religion	Dummy variable; = 1 if main religion is the same in country i and j
LPI	Logistic performance index
Currency	Dummy variable; = 1 if country i and j have a common currency
Political restraint	Index for political restraint
AVEtariff	Ad-valorem tariff imposed by region j on imports from i
AVEesub	Ad-valorem export subsidy paid to exporters in region i for goods shipped to country j
EU	Dummy variable; = 1 if the dependent variable measures intra-EU trade
EUTUR	Dummy variable; = 1 if the dependent variable measures the exports to Turkey from the EU
TUREU	Dummy variable; = 1 if the dependent variable measures the exports to the EU from Turkey
GAFTA	Dummy variable; = 1 if the dependent variable measures intra-GAFTA trade
GAFTATUR	Dummy variable; = 1 if the dependent variable measures the exports to Turkey from GAFTA
TURGAFTA	Dummy variable; = 1 if the dependent variable measures the exports to GAFTA from Turkey
OTHER	Dummy variable; = 1 if the dependent variable measures any other international cross-border trade
Production	Production of country i
Consumption	Consumption of country j

reduce the number of sectors to the 16 food and agricultural sectors. Our regression analysis includes 99,856 observations. Of those 99,856 observations, 98,592 (= 79 · 78 · 16) are bilateral cross-border trade observations, and 1264 (= 79 · 16) are intra-national trade observations. The information on distance, landlocked status, contiguity, common languages, currency and colonial relationships, and on membership in trade agreements and WTO membership comes from the Centre d'Etudes Prospectives et d'Informations Internationales (CEPII).[7] In our analysis, we use the population-weighted average distances between major cities in our countries of interest as the bilateral distances between countries. This enables us to use intra-national distances as well. Information on religion is gathered from the CIA Factbook[8] and on political freedom is taken from Freedom House.[9] The political freedom (political restraint) index included in the gravity equation is generated from the country-specific indices. The higher the index, the less politically free the countries are. The data on logistic performance are obtained from the World Bank.[10] The logistic performance index considered in the equation is the product of the country-specific logistic performance indices. The higher this index is, the higher the countries' logistic performance.

The presence of zero trade flows represents a serious challenge when estimating the log-linear gravity model using ordinary least squares (OLS). In our dataset, 7.3% of the total export flows are equal to zero, and the greatest percentage of zero trade flows are in the sectors oil seeds (24.6%), wheat (20.8%) and plant-based fibers (16.6%). Because the logarithm of zero is not defined, using OLS in these instances would involve the truncation or rescaling of the dependent variable. The deletion of zero trade flows and the subsequent loss of valuable information lead to biased results, particularly when those observations are non-randomly distributed. The second strategy, that of adding a small positive number to all trade values, is also theoretically and empirically inadequate. As several studies show, even small numbers can critically distort the results (Burger et al., 2009; Flowerdew and Aitkin, 1982; Linders and de Groot, 2006). An alternative way to handle zero trade values is to apply the two-stage Heckman selection procedure (Heckman, 1979). The first stage involves the use of a probit model which is the selection equation to capture the probability of trade. The second stage involves the use of an OLS regression augmented by the inverse Mills ratio, which is obtained from the first stage. A Wald test of the estimated coefficient of the inverse Mills ratio determines whether sample correction is required. The outcome equation is estimated using a dependent variable censored to nonzero values. The Heckit estimator offers a valid solution to the sample selection problem and thus has become the standard approach to specifying gravity equations (e.g., Philippidis et al., 2013; Raimondi and Olper, 2011; Xiong and Beghin, 2012). However, Santos Silva and Tenreyro (2006) show that using OLS to estimate the log-linear gravity model results in biased and inconsistent estimates in the presence of heteroskedasticity. The reason for this bias is Jensen's inequality, which implies that $E(\ln y) \neq \ln E(y)$ (Santos Silva and Tenreyro, 2006). Thus, the authors employ the more advantageous Poisson regression model derived from the Poisson distribution. This regression model deals with heteroskedasticity and addresses the skeweness and non-negativity constraint with an implicit log transformative function of the mean to adjust the critical issues. The model is estimated by maximum likelihood. Using the Poisson maximum likelihood estimator it is possible to account for zero observations making it favorable in gravity modeling. However, the equidispersion property of the Poisson distribution is very restrictive, requiring the conditional variance of the dependent variable to be equal to its conditional mean. Under weaker assumptions of correct specification of the conditional mean the Poisson pseudo-maximum likelihood (PPML) estimator provides robust estimates (Cameron and Trivedi, 2005).[11] In our econometric analysis, we proceed in three steps. First, we examine the gravity equation results for the pooled agro-food sector, comparing three different econometric specifications with a focus on the PPML estimator.[12] Second, we test the accuracy of the different estimators analyzing the out-of-sample prediction performance. Finally, we use the superior specification to further estimate the disaggregated border effects.

Estimation results

[7] Information on membership in trade agreements and in the WTO is updated using www.wto.org.
[8] See https://www.cia.gov/library/publications/the-world-factbook.
[9] See http://www.freedomhouse.org.
[10] See http://www.worldbank.org.

[11] Alternatively, Burger et al. (2009) suggest modified Poisson estimators that impose fewer restrictions on variance and allow more heterogeneity. The negative binomial (NB) specification properly accounts for overdispersion stemming from unobserved heterogeneity due to omitted variable bias by adjusting the distribution using a dispersion parameter. However, if the violation of equidispersion can be found in excess zeros, then the zip-inflated modeling techniques should be considered (the zip-inflated negative binomial or the zip-inflated Poisson model). These techniques address censored variables by specifying two equations. The first part is a logit regression that estimates the probability of zero trade values. The second part is a negative binomial or a Poisson regression. Because the NB and zero-inflated estimators have been criticized in terms of the sensitivity of the variance of their estimates (Santos Silva and Tenreyro, 2006) and convergence problems, we did not use these estimators in our study.
[12] In applying the Poisson estimation, we rearrange the gravity equation according to an exponential function.

In Table 5, we provide the estimation outcomes pooled over all observations. We use different econometric specifications. The first two columns report the OLS benchmark, and the last two columns show the Heckman and Poisson model results. Column 1 presents the OLS estimates using the logarithm of exports as a dependent variable and skips observations with zero trade flows (OLS1). Because the Breusch–Pagan test for heteroskedasticity confirms the presence of heteroskedastic estimators, we use a robust variance–covariance matrix. The results are comparable to other studies using OLS on truncated data with relatively high border effects. Column 2 shows the least squares results obtained using a rescaled dependent variable to overcome the problem of zeros (OLS2). Estimates differ slightly from the OLS1 regression and indicate a somewhat higher border effect. The third column reports the second-stage results of the Heckman regression. Like Raimondi and Olper (2011) and others, we exclude cultural dummies from the outcome equation for identification. In this way, we follow the theory of trade models with heterogeneous firms by assuming that those variables affect the fixed costs but not the variable costs of trade (Raimondi and Olper, 2011; Xiong and Beghin, 2012). The highly significant coefficient of the inverse Mills ratio provides sheds light on the sample selection problem. Using the Heckman procedure to correct for selection bias increases the effects of all variables except for currency and political restraint. The fourth column contains the Poisson model results considering all observations (PPML1). Compared to the OLS estimates, the Poisson estimates of nearly all of the variables are lower in absolute terms. The main differences are observed in the border effect coefficients. In 16 of 18 cases, the confidence intervals of the border effect estimates do not overlap. This result clearly indicates the serious bias, and thus, the overestimation of effects that is generated when OLS is used. Furthermore, the lower U-Theil statistic as a measure of forecast accuracy (Theil, 1958) supports the Poisson model. Because there is still a censoring at zero, the last column shows the results of the Poisson estimator using only positive observations (PPML2). The estimates are similar in magnitude and there is a consistent overlapping of confidence intervals. Hence, we can deduce that the zeros are not significantly dominating the results in the PPML estimation.[13] To check the robustness, we investigate the out-of-sample prediction performance of the different estimators in a Monte Carlo simulation for 50 replications. We obtain the mean squared error (MSE) as a measure for the precision of predictions[14] for a 20% random subset. The PPML1 estimator outperforms the other estimators because it presents the lowest MSE.[15] Thus, we conclude the PPML1 estimator is best indicated for use in the subsequent analysis of the disaggregated sector regressions to obtain bilateral border effects.

Most of the coefficients in Table 5 have the expected signs and are statistically significant. Production and consumption have a positive effect on trade flows in all regressions. As expected, the elasticity of trade with respect to distance is negative. According to the PPML1 regression, agro-food exports decrease by 0.81% if the distance between two countries increases by 1%. Furthermore, the coefficient of the number of landlocked countries indicates that the impact of geography on trade is very high in agro-food trade. Sharing a currency has a positive and significant effect, except in the truncated OLS and Heckman regressions. Consistent with our expectations, we find that contiguity and cultural adjacency also increase trade significantly. The effect of religious affinities is marginal and is only significant in the truncated OLS regression. Being in a mutual RTA increases trade significantly. Also as expected, we find that the membership of both countries in the WTO enhances trade. The coefficients for logistic performance and political restraint are within expectations and are highly significant. Tariffs have a significant and negative effect only in the Poisson model regressions. If tariffs increase by 1%, trade decreases by 0.4%. In the OLS regressions and in the Heckman model, tariffs and export subsidies have a significant positive effect. In contrast, the effect of export subsidies is not significant in the Poisson regression. Such contradictory and imprecise findings regarding the effects of policy variables are not uncommon in the literature and are also found by Philippidis and Sanjuán (2006, 2007), Philippidis et al. (2013) and Winchester (2009). Except for those of consumption, RTA, political restraint and logistic performance, the coefficients are greater in the OLS regressions than in the Poisson regression.

The coefficients of the border dummies are negative and highly significant. This result can be attributed to the negative effect of international borders. After controlling for distance and other trade cost, the ratio of i's exports to j to i's exports to itself is given by the exponential of the absolute value of the coefficient of the i–j border dummy (Anderson and van Wincoop, 2003). Because the value of the border coefficient for the EU in the PPML1 regression is -1.73, intra-national agricultural trade is 5.64 (= exp(1.73)) times greater than cross-border trade within the EU. This figure is similar to the results obtained by Chen (2004) and Olper and Raimondi (2008a). Intra-national agricultural trade is on average 4.9 times greater than cross-border trade among the GAFTA member countries. These numbers show that the incidence of NTBs among EU members is higher than the incidence of NTBs among GAFTA members, possibly because of European consumers' higher awareness of food safety and health issues. Furthermore, according to the PPML1 regression, the EU's exports to itself are 38.3 times greater than the EU's exports to Turkey. GAFTA's exports to itself are 39.2 times greater than GAFTA's exports to Turkey. These figures show that Turkey appears to implement similar NTBs for exports coming from the EU and GAFTA. Turkey's exports of agro-food products to itself are 18.1 times greater than Turkey's exports to the EU and 26.7 times greater than Turkey's exports to GAFTA. Thus, Turkey's exports to GAFTA face higher NTBs than Turkey's exports to EU member countries.

In Table 6, we report the border effects for the disaggregated food and agricultural sectors resulting from the PPML1 specification.[16] There are ten cases in which the coefficients of the border dummies are not significant and we thus assume a border effect of one. As expected, the border effects among EU member countries and GAFTA member countries are lower than the border effects affecting trade between Turkey and those countries. In the sectors for cattle, dairy, other food products, other meat and sugar, the border effects among EU member countries are significantly lower than those estimated for the trade between the EU and Turkey. By contrast, in the sectors beverages and tobacco, other animal products, other food products, other meat and processed rice, the border effects among GAFTA member countries are significantly lower than the border effect for GAFTA and Turkey. The greatest border effects are found to influence trade between Turkey and GAFTA, particularly when Turkey exports processed rice and cattle meat to GAFTA. Overall, the aforementioned sectors are characterized by very high border effects. The vegetables and fruits sector is subject to relatively low border effects, followed by the sectors of other food products, other animal products and cereal grains.

[13] We also analyzed the influence of zeros in the disaggregated sector regressions. In all 16 sectors the exclusion of zero trade flows does not significantly affect the PPML estimates.

[14] In order to compare the log-linear models with Poisson models we retransform the predicted values. The model producing the smallest MSE is being the better one.

[15] Detailed results on the out-of-sample prediction performance are available from the authors upon request.

[16] Detailed gravity estimation results for disaggregated sectors are available from the authors upon request.

Table 5
Regression results for pooled agro-food sector.

	OLS1 $\ln(X_{ij})$	OLS2 $\ln(1+X_{ij})$	Heckman $\ln(X_{ij})$	PPML1 X_{ij}	PPML2 $X_{ij} > 0$
ln(Production)[a]	1.0975***	1.0743***	1.0769***	0.7444***	0.7454***
	(0.0066)	(0.0059)	(0.0063)	(0.0217)	(0.0218)
ln(Consumption)[b]	0.1017***	0.1058***	0.1021***	0.3196***	0.3186***
	(0.0077)	(0.0082)	(0.0074)	(0.0233)	(0.0234)
ln(Distance)	−1.0055***	−0.9980***	−1.0315***	−0.8058***	−0.8029***
	(0.0179)	(0.0190)	(0.0149)	(0.0387)	(0.0387)
Landlocked	−0.6334***	−0.6555***	−0.6362***	−0.5759***	−0.5739***
	(0.0629)	(0.0733)	(0.0863)	(0.0441)	(0.0441)
Contiguity	1.5758***	1.6457***	1.7389***	0.4073***	0.4101***
	(0.0547)	(0.0585)	(0.0438)	(0.0690)	(0.0689)
Language	0.2684***	0.2183***		0.5679***	0.5676***
	(0.0361)	(0.0390)		(0.0634)	(0.0633)
RTA	0.3832***	0.4164***	0.3938***	0.5211***	0.5181***
	(0.0322)	(0.0342)	(0.0296)	(0.0660)	(0.0659)
WTO	0.7310***	0.7400***	0.7608***	0.3058***	0.3045***
	(0.0802)	(0.0927)	(0.1034)	(0.0678)	(0.0678)
Colony	0.8203***	0.8499***		0.3306***	0.3282***
	(0.0585)	(0.0616)		(0.0962)	(0.0962)
Religion	0.0465*	0.0416		0.0594	0.0589
	(0.0229)	(0.0249)		(0.0663)	(0.0662)
LPI	0.0965***	0.0660**	0.1178***	0.4572***	0.4583***
	(0.0213)	(0.0228)	(0.0222)	(0.0841)	(0.0841)
Currency	0.0600	0.0980	0.0203	0.4696***	0.4688***
	(0.0573)	(0.0586)	(0.0567)	(0.0678)	(0.0678)
Political restraint	−1.4123***	−1.3620***	−1.3173***	−1.9695***	−1.9587***
	(0.1416)	(0.1507)	(0.1295)	(0.5716)	(0.5712)
ln(1 + AVEtariff)	2.9233***	3.1868***	2.9390***	−0.3951*	−0.4090*
	(0.1120)	(0.1211)	(0.0629)	(0.1910)	(0.1925)
ln(1 + AVEesub)	3.8500***	3.9109***	3.9166***	0.6133	0.6085
	(0.2396)	(0.2447)	(0.2070)	(0.3541)	(0.3547)
EU	−3.0648***	−3.2345***	−3.9144***	−1.7300***	−1.7350***
	(0.1083)	(0.1148)	(0.0924)	(0.1039)	(0.1039)
EU → TUR	−4.9996***	−5.1608***	−5.7638***	−3.6445***	−3.6494***
	(0.1916)	(0.2022)	(0.1641)	(0.2125)	(0.2125)
TUR → EU	−4.8756***	−5.0351***	−5.6452***	−2.8954***	−2.8961***
	(0.1689)	(0.1760)	(0.1620)	(0.2616)	(0.2617)
GAFTA	−2.9585***	−3.2023***	−3.5178***	−1.5881***	−1.5934***
	(0.1500)	(0.1581)	(0.1194)	(0.1803)	(0.1802)
GAFTA → TUR	−4.7011***	−4.9012***	−5.2797***	−3.6688***	−3.6715***
	(0.2542)	(0.2663)	(0.2328)	(0.5261)	(0.5263)
TUR → GAFTA	−4.7254***	−4.8531***	−5.3320***	−3.2842***	−3.2848***
	(0.1788)	(0.1848)	(0.2180)	(0.2696)	(0.2698)
Other	−4.1887***	−4.3516***	−4.9911***	−2.1621***	−2.1656***
	(0.1133)	(0.1201)	(0.0979)	(0.1353)	(0.1353)
N	92,550	99,856	99,856	99,856	92,550
R^2	0.7376	0.7524			
Pseudo R^2				0.9786	0.9783
Mills ratio			−0.4961***		
U-Theil			0.9954	0.0253	

Notes: standard errors in parentheses.
a and b Denote exporter's production and importer's consumption, respectively. Country- and sector-fixed effects are not reported.
Source: authors' own calculations.
* $p < 0.05$.
** $p < 0.01$.
*** $p < 0.001$.

Calculation of tariff equivalents

The theoretical foundation of the gravity model enables us to utilize the quantitative effects of border barriers to compute border trade costs using the elasticity of substitution. The consideration of the substitution effect between domestic and foreign goods allows us to exclude consumer preferences from the border trade costs. Additionally, in controlling for transport costs approximated by distance and landlocked status as well as for other trade cost factors in the gravity equation the border trade costs are then supposed to reveal NTBs' effects (Winchester, 2009). To calculate the AVEs of non-tariff trade barriers, we use the formula $AVE_{ij} = \exp[\beta_{ij}/1-\sigma]-1$ (Anderson and van Wincoop, 2003), where AVE_{ij} is the AVE of border barriers. AVE_{ij} represents the average level of importing country protection and the minor effects of additional factors that are not captured by the trade barrier proxies in the gravity equation. The coefficient β_{ij} is applied to the border dummy δ_{ij}, and σ is the elasticity of substitution for domestic and imported goods. We employ the elasticity of substitution between goods from the GTAP database according to our disaggregated sector selection. In cases in which the border dummy coefficient is not significant, we assume that there are no border barriers or that the effects of these barriers are only marginal, which results in zero AVEs.

Table 7 reports the AVEs of the NTBs among EU and GAFTA member countries as well as the AVEs of the NTBs in the trade between the EU and Turkey and between Turkey and GAFTA. The AVEs of the NTBs among the EU member countries range from 17% for other meat to 428% for beverages and tobacco. In the total

Table 6
Border effects in disaggregated agro-food sectors.

	EU → EU	EU → TUR	TUR → EU	GAFTA → GAFTA	GAFTA → TUR	TUR → GAFTA
Wheat	4.2	25.6	30.2	161.1	115.3	2032.0
Cereal grains	5.1	14.0	121.2	17.7	46.0	21.9
Vegetables and fruits	1.0	11.9	4.7	4.7	20.7	6.8
Oil seeds	18.6	17.0	55.9	1.0	22.4	248.9
Plant-based fibers	20.9	434.8	26.2	91.4	474.5	21.5
Crops	27.0	19.8	60.8	6.1	12.2	388.5
Cattle	3.2	47.2	3.2	1.0	358.6	762.8
Other animal products	10.2	17.4	49.0	3.8	42.4	100.1
Vegetable oils and fats	1.0	22.4	28.3	1.0	537.8	36.8
Dairy	4.6	144.3	39.4	1.0	265.0	15.2
Processed rice	3.7	7.5	700.0	22.5	1.0	8920.4
Sugar	2.6	110.6	57.8	1.0	1.0	324.1
Other food products	6.0	42.3	21.3	4.6	106.5	15.7
Beverages and tobacco	8.7	25.6	17.0	16.9	1538.2	161.2
Cattle meat	3.3	449.6	118.9	39.3	510.9	1013.4
Other meat	3.5	282.9	260.2	6.0	300.8	310.2

Source: authors' own calculations.

Table 7
Ad-valorem tariff equivalents of NTBs (%).

	Among EU members	Among GAFTA members	On Turkey's exports to		On Turkey's imports from	
			The EU	GAFTA	The EU	GAFTA
Food and agricultural products	54.80	49.24	107.00	129.04	150.00	152.00
Wheat	19.89	90.28	53.91	162.26	50.78	82.38
Cereal grains	175.39	503.00	1905.54	588.56	421.41	994.83
Vegetables and fruits	0.00	77.82	77.06	103.43	150.16	207.38
Oil seeds	111.46	0.00	180.54	311.51	106.69	121.96
Plant-based fibers	113.84	209.23	126.22	115.31	356.63	366.72
Crops	82.03	38.78	111.02	195.67	72.04	57.67
Cattle	47.29	0.00	47.29	813.70	261.37	610.48
Other animal products	325.70	132.19	1038.87	1678.98	496.63	939.94
Vegetable oils and fats	0.00	0.00	81.68	90.42	74.17	207.33
Dairy	27.39	0.00	79.20	54.05	120.16	142.46
Processed rice	36.84	109.85	375.78	772.10	61.58	0.00
Sugar	24.51	0.00	151.47	272.07	191.40	0.00
Other food products	81.52	66.27	177.40	150.39	248.50	374.08
Beverages and tobacco	427.51	778.80	784.43	4889.51	1109.84	28,185.18
Cattle meat	19.76	73.00	104.05	180.95	148.85	153.64
Other meat	17.32	25.70	104.01	108.66	106.21	107.84

Source: authors' own calculations.

food and agricultural sector, the AVE of the NTBs for intra-EU trade is equal to 55%, which is nearly identical to the value of 56% that Olper and Raimondi (2008a) found in using a value of 5 for the elasticity of substitution. The AVEs of the NTBs among the GAFTA member countries vary between 26% for other meat and 779% for beverages and tobacco. In most sectors, the AVEs of the NTBs are higher among GAFTA countries than among EU member countries. The AVE of the NTBs of total food and agricultural trade is lower within GAFTA (49%) than within the EU. In seven sectors, the EU exhibits higher AVEs of NTBs than GAFTA. This is not surprising, since the EU is one of the regions with the most strict regulations and standards on food and agricultural products. Especially sensitive sectors such as sugar, meat, and milk products are highly protected by NTBs complicating the free trade flow even within the EU trade bloc. In contrast, the main obstacles for GAFTA member countries' intra-trade consist of customs and administrative inefficiencies and infrastructural problems. In spite of ambitious provisions in the agreement, there are a lot of NTBs in place which still represent massive hindrance in intra-GAFTA trade (Abedini and Peridy, 2008; IDIA, 2007; ITC, 2012). This might be reflected in our estimates showing a much higher magnitude of AVEs of NTBs among GAFTA members compared to intra-EU NTBs. In line with our results in terms of relatively high barriers in intra-bloc trade, the International Trade Center also concludes that NTBs cause many difficulties in trade and are mainly applied by partner countries within regional trade agreements (ITC, 2014).

In most sectors, Turkey's exports face higher NTBs in trade with GAFTA. The AVEs are much higher in the sectors of beverages and tobacco, cattle and other animal products. In contrast, Turkey's exports to GAFTA face much lower NTBs in the cereal grains sector. Turkey implements lower NTBs on exports from the EU than it does on products from GAFTA. The AVEs of the NTBs are much lower in the sectors of beverages and tobacco, cereal grains, other animal products and cattle. Only in three agro-food sectors (sugar, processed rice, and crops) are the AVEs of the NTBs for EU exports higher.

In general, the AVEs of the NTBs used in the trade between Turkey and the EU as well as in the trade between Turkey and GAFTA are very high. In particular, the NTBs in the trade involving GAFTA appear to be higher than the NTBs in the trade involving the EU. Very high AVEs for NTBs in food and agriculture are also estimated in other studies focused on the quantification of NTBs (e.g., Chang and Hayakawa, 2010; Philippidis and Sanjuán, 2006, 2007; Winchester, 2009). The AVEs of the NTBs in the disaggregated food and agricultural sectors that are presented in this paper are in most cases reasonably consistent with or lower than those given in the literature (Philippidis and Sanjuán, 2006, 2007; Winchester, 2009). The only exception is the strikingly high AVE of the NTBs in beverages and tobacco, which is not comparable to the value of 242.7–730.4% that was presented by Philippidis and Sanjuán (2006, 2007).

Following Winchester (2009), we use the existing border barriers among EU member countries as a benchmark for the scenario in which Turkey joins the EU. The calculated border trade costs among EU member countries mirror the current status of actual internal market barriers comprising justified, but also unjustified trade barriers (also compare Section 'Theoretical and empirical framework'). This current status of actual internal market barriers provides the most harmonized and least restrictive level of NTBs among the EU member countries compared to foreign trade (European Commission, 2013c; Weiler and Kocjan, 2005). In our analysis we assume that Turkey's integration into the EU would generate a similarly low level of NTBs for the EU and Turkey. With this approach, we furthermore assume that the current level of NTBs including a justified share related to comprehensible food safety, health concerns and cultural values, and a proportion of unjustified restrictive measures will be maintained.[17] Analogously, we also use the existing border barriers among GAFTA members as a benchmark for the scenario in which Turkey joins GAFTA, assuming that the effects of NTBs among GAFTA member countries are low and that this development would generate a similarly low level of NTBs for GAFTA and Turkey.

We calculate the AVEs of the NTBs for EU exports to Turkey by subtracting AVE_{EU} from $AVE_{EU/TUR}$ if AVE_{EU} is lower than $AVE_{EU/TUR}$. In the same way, we calculate the AVEs of the NTBs for Turkey's exports to the EU by subtracting AVE_{EU} from $AVE_{TUR/EU}$ if AVE_{EU} is lower than $AVE_{TUR/EU}$. In cases in which AVE_{EU} is greater than $AVE_{EU/TUR}$ and $AVE_{TUR/EU}$ in absolute terms, we assume that the accession of Turkey to the EU would not change the level of NTBs among the EU countries and Turkey. We also calculate the AVEs of the NTBs for GAFTA's exports to Turkey and for Turkey's exports to GAFTA in the same manner. In cases in which AVE_{GAFTA} is greater than $AVE_{GAFTA/TUR}$ and $AVE_{TUR/GAFTA}$ in absolute terms, we assume that Turkey's joining GAFTA would not change the level of NTBs between the GAFTA countries and Turkey.

Simulations with the Global Trade Analysis Project (GTAP) framework

GTAP model and data

The CGE simulations in this paper utilize GTAP which is a comparative static multi-region general equilibrium model. The standard GTAP model provides a detailed representation of the economy, including the linkages between the farming, agribusiness, industrial, and service sectors of the economy. The use of the non-homothetic constant difference of elasticity to handle private household preferences, the explicit treatment of international trade and transport margins and the inclusion of a global banking sector are innovative features of the GTAP model. Trade is represented by bilateral matrices based on the Armington assumption. Additional features of the standard GTAP model are perfect competition in all markets and the profit- and utility-maximizing behavior of producers and consumers. All policy interventions are represented by price wedges. The framework of the standard GTAP model is well documented in Hertel (1997) and is available on the Internet.[18]

Francois (1999, 2001) developed an approach in which NTBs are modeled as iceberg or dead-weight costs and used this method to study the Doha Round of the WTO negotiations. This approach has been extended by Hertel et al. (2001a,b), who also aimed to integrate NTBs into GTAP modeling, treating NTBs as unobserved trade costs that are not explicitly covered by the GTAP database. The authors introduce an additional "effective" import price that is a function of the observed import price and an exogenous unobserved technical coefficient. Hence, the removal of trade costs from a particular exporter is reflected in an increase in technology. The effective import price falls and thereby mirrors a reduction in real resource costs (Hertel et al., 2001a, p. 13). This approach to modeling the change in NTBs as a reduction in trade costs draws on the iceberg transport cost theory that was originally introduced by Samuelson (1954). An increase in technology and the corresponding efficiency enhancement furthermore implies that the effective imported quantity is increased. Thus, imports are more competitive and lead to the substitution of imports from other regions (Hertel et al., 2001a, p. 13).

In addition, NTBs also generate protection effects that might be captured via import tariffs. Andriamananjara et al. (2003, 2004) and Fugazza and Maur (2008) offer a thorough study of the impact of NTBs in regional and global CGE models comparing the iceberg cost approach and the approach that involves capturing NTBs via import tariffs. Effects of NTBs are measured by the price wedges between domestic and world prices, when NTBs are modeled with the help of import tariffs. This import-tariff approach to represent NTBs creates a rent that is associated with the NTBs and is captured by the importer. Modeling NTBs with the help of the iceberg cost approach is also referred to as the "sand in the wheels" of trade or the "efficiency approach" by the authors. In the iceberg cost approach, it is thus assumed that NTBs are efficiency losses rather than rent-creating mechanisms, and as aforementioned, by using import-augmenting technology shocks, real resource cost raising effect of NTBs are abolished. The results obtained from both papers show that there are surprisingly substantial differences in the outcomes of the experiments if NTBs are modeled with the help of import tariffs or technological change variables, although the two approaches tend to affect the terms of trade in a similar manner. The authors emphasize that the use of the import tariff approach to model NTBs and the corresponding artificial rent-creating and tariff revenue mechanism requires a very careful analysis of the resulting welfare effects (Fugazza and Maur, 2008). The authors also conclude that the efficiency modeling of NTBs tends to weigh heavily in the overall large, positive welfare gains. Chang and Hayakawa (2010), Philippidis and Carrington (2005), Philippidis and Sanjuán (2006, 2007) and Winchester (2009) obtained the same results using estimated AVEs of NTBs in a CGE model applying the iceberg cost approach. Based on these findings, we utilize the iceberg cost approach for our simulations with the GTAP model. By reducing the estimated AVEs of NTBs to the benchmark level, we try to obtain more reliable results than would be possible with the complete removal of the NTBs. However, the results obtained using this approach should still be interpreted with caution.

Experiment design

In the following GTAP analysis, we employ the most recent version of the GTAP database, Version 8. We combine the original 129 countries and regions and the original 57 sectors into a 24-sector, 14-region aggregated version. In so doing, we single out major trading partners of the EU and Turkey as well as other countries that are currently involved in FTAs with Turkey. In the sector

[17] We are unable to identify the justified and unjustified share of the trade barriers in our estimated NTBs.

[18] See https://www.gtap.org.

aggregation process, we match the sectors that are predefined in the gravity model approach. Hence, we use all available food and agricultural sectors and split the non-food sector into four sectors. Countries, regions and sectors are highlighted in more detail in Table A1 in Appendix A.

The base year in Version 8 of the GTAP database is 2007. In our study, we develop a baseline projected from the benchmark year 2007–2020. Given that the base year in this global database is 2007, it seems that the political environment is fairly up to date. The MFA quota has already been phased out (in 2005) and the 2004 and 2007 expansions of the EU have already occurred. China is a member of the WTO fulfilling its scheduled obligations.[19]

To generate a comparison with the baseline, two alternative enlargement experiments are conducted. We assume that by 2020, Turkey will be either an EU member or a GAFTA member country. We use pre-experiments to take into account political and economic changes in the environment that have taken place since 2007. In addition to changes in the political environment, economic developments, such as technical progress and the related growth of the economy, are of great importance. By considering these changes, we extend the GTAP framework to the year 2020. We include exogenous projections of GDP and factor endowments in the extended GTAP model. Technical progress is generated endogenously by the model to facilitate these projections. The data for the corresponding shocks are taken from the CEPII, the United Nations, and the World Bank. In the GAFTA simulation in which Turkey becomes a member, we simulate the FTAs with Turkey using those of Albania, Georgia, and Chile. We exclude the FTAs with Montenegro, Serbia and Jordan because these nations are part of composite regions in Version 8 of the GTAP database and thus, country-level data are not available for them. Algeria is also omitted despite having become a member of GAFTA in 2009 because Algeria is also part of a composite region in the GTAP database. In a scenario in which Turkey becomes a member of the EU, the country would need to withdraw from any FTAs with third-party nations (European Commission, 2013d; Turkish Undersecretariat of Foreign Trade, 2013). Hence, we disregard all of Turkey's FTAs in the EU expansion simulation.

Given the above information, in both simulations, we consider the bilateral elimination of import tariffs and the full removal of bilateral benchmarked NTBs from all sectors.[20] However, the scenarios in which Turkey becomes a member of either the EU or the GAFTA differs with regard to the change in the tariffs applied to imports from third countries. Turkey's import tariffs are unchanged in the case of the GAFTA membership. On the contrary, Turkey's import tariffs are adapted to the EU customs union's tariff level after becoming an EU member. Thereby, we account only for short-term effects of both trade agreements. Long-term effects of a deeper integration between the member countries are not taken into account. This is particularly important for Turkey's long-term EU membership, which might involve the effects of more policy changes such as the benefit of transfers within the first pillar of the common EU budget, the reform of environmental policies or the free movement of labor.

Simulation results

In this section, we discuss the results of the experiments that explore Turkey's inclusion into either the EU or GAFTA. In presenting the results, we focus on the welfare effects of the EU, GAFTA, and Turkey, which are assessed based on the equivalent variation (EV). Additionally, we discuss the change of the trade balance showing the change in trade pattern by agricultural product which is similarly reflected in the adjustment of domestic agricultural production. For this reason, we do not discuss the impact of domestic agricultural production here. The results are presented in millions of US$ for the year 2020. The simulations are performed using GEMPACK (Version 11.0) and RunGTAP (Harrison and Pearson, 1996). A fixed trade balance is adopted as a form of macroeconomic closure in the enlargement simulations.

Welfare effects

In the upper part of Table 8, we present the results of including Turkey in the EU, whereas the lower part considers the results of Turkey's membership in GAFTA. In both cases, we present the total EV in the first columns, whereas subsequent columns decompose the total EV according to the initiating shock. Thus, columns 2–6 show the effects of eliminating bilateral tariffs in the food and agricultural sector as well as the manufacturing sector in the EU, Turkey, and GAFTA. In the second part of Table 8 (Columns 7–15), we represent the effects of removing the NTBs for the food and agricultural, manufacturing, services, and extraction sectors for either the EU and Turkey or GAFTA and Turkey. In the experiments, the removal of import tariffs is considered in all sectors. Because the elimination of import tariffs in the services and extraction sectors induces very low or even no gains, the simulation results of removing import tariffs from these sectors are not included in Table 8.

The first column in the upper part of Table 8 shows that Turkey would unambiguously gain from EU membership. Turkey's total welfare gains amount to nearly 5 billion US$, whereas the EU's welfare gains of 2.26 billion US$ are more limited but remain considerable. These higher welfare gains for Turkey are in accordance with Acar et al. (2007), Lejour and Mooij (2004) and Zahariadis (2005). These results can primarily be traced back to the removal of NTBs in both regions. The overall effect from bilateral tariff elimination is equal to a 0.73 billion US$ gain for Turkey and 0.05 billion US$ loss for the EU and thus is much lower than the gains due to the removal of NTBs (3.42 billion US$ for Turkey and 2.55 billion US$ for the EU). This result is also consistent with Lejour et al. (2001), who show that the effects of NTBs are larger than the effects of the customs union if the EU is expanded to include Central and Eastern European countries. Due to the Customs Union Agreement between the EU and Turkey, considerable welfare effects of bilateral tariff elimination are only observed in the agro-food sector. The EU gains 0.37 billion US$ if Turkey eliminates the import tariffs in the protected food and agricultural sector (compare Section 'Overview of the Turkish trade structure and agreements' and Table 3). In addition to the welfare changes shown in Table 8, Turkey exhibits an additional gain caused by adopting a lower EU level for tariffs for imports from third-party countries after accession.

The removal of NTBs from the EU agro-food sector yields the highest gains both for Turkey (1.41 billion US$) and for the EU (1.87 billion US$). However, if the NTBs in the Turkish agro-food sector are abolished, the EU gains are more limited (0.18 billion US$) than those of Turkey (1.14 billion US$). Table 7 (Section 'Calculation of tariff equivalents') shows, that the AVEs of NTBs are estimated to be very high in the agro-food trade between Turkey and the EU. Accordingly, mutual welfare gains for Turkey and the EU are expected due to the abolition of high trade barriers between them.

Turkey's EU membership also creates welfare impacts on other economies. For instance, Asia experiences a welfare loss of 0.49 billion US$ and Latin America's welfare level decreases by 0.16 billion US$. These welfare losses stem from trade diversion. After Turkey's accession to the EU, the overall exports of Asia to Turkey and to the EU decrease. Particularly, EU's agro-food imports from

[19] Nearly all required import tariff reductions were initiated by 2005, but the implementation period lasted up until 2010.

[20] Due to our focus on food and agriculture, we assume the AVEs of NTBs in the non-food sectors to be 1%.

Table 8
Welfare results of enlargement experiments (million US$ relative to the baseline).

	Total EV	Bilateral tariff removal					Reduction of NTBs								
		EU		Turkey		Total	EU				Turkey				Total
		Food and Ag	Mnfc	Food and Ag	Mnfc		Food and Ag	Mnfc	Srvcs	Extrct	Food and Ag	Mnfc	Srvcs	Extrct	
Experiment 1: enlargement of the EU to include Turkey															
Turkey	4907	712	2	−49	68	733	1414	513	31	10	1143	234	74	8	3425
EU	2266	−480	−1	379	43	−58	1873	99	30	14	182	318	31	3	2550
GAFTA	−30	−51	0	6	−12	−58	−106	−26	−1	−5	3	−18	0	−3	−156
FSU	65	−37	0	−3	−5	−47	−79	−18	−1	−8	−10	−23	−3	−4	−146
Asia	−499	−90	0	35	−65	−120	−217	−132	−6	3	13	−59	1	1	−396
North Am.	80	−14	0	−12	−11	−38	−48	−21	−3	1	−33	0	−6	0	−110
Latin Am.	−167	−61	0	−25	−4	−90	−151	−6	0	−1	−18	−6	−1	0	−185
Oceania	−14	−11	0	−4	−2	−17	−20	−2	0	−1	−3	−4	−1	0	−30
SSA	−56	−39	0	−6	−2	−48	−46	−3	0	−2	−6	−14	−1	0	−72
ROW	−30	−10	0	−12	−8	−30	−14	−9	−1	−2	−12	−18	−1	0	−58
ROW	−86	−26	0	−5	−13	−44	−65	−19	−1	−4	−11	−25	−2	0	−127
Experiment 2: enlargement of GAFTA to include Turkey															
		GAFTA		Turkey		Total	GAFTA				Turkey				Total
Turkey	2486	89	942	261	−13	1259	250	107	7	2	715	29	6	107	1223
EU	−241	−6	−149	99	−33	−92	−14	−19	−2	0	26	−17	−1	24	−2
GAFTA	899	−34	−190	344	73	193	323	62	9	0	134	24	2	42	595
Iran–Israel	−17	−3	−21	15	−1	−12	−8	−3	0	0	4	1	0	1	−5
FSU	33	−10	−76	115	3	54	−25	−9	−1	−1	42	5	0	−85	−74
Asia	−405	−20	−280	187	−32	−129	−67	−33	−2	1	54	−12	0	−26	−84
North Am.	−48	−6	−48	47	−2	−6	−18	−5	−1	0	3	0	0	−2	−24
Latin Am.	−20	−7	−31	31	1	−8	−26	−4	0	0	7	2	0	−3	−23
Oceania	16	−3	−23	25	1	−1	−7	−3	0	0	10	2	0	0	3
SSA	−2	−2	−20	13	0	−11	−4	−3	0	0	5	1	0	−3	−3
ROW	−4	−6	−57	59	−2	−9	−16	−7	0	0	19	1	0	−3	−7

Note: our original mapping of ROW comprises Switzerland, Norway, Croatia, Rest of EFTA, Rest of Eastern Europe, Rest of Europe and Rest of the World (compare Table A1 in Appendix A). For reasons of simplification, we also aggregated Iran and Israel, Albania, Georgia and Chile to ROW to evaluate the results.
Source: authors' own calculation.

Asia are replaced by Turkish exports. Latin America also experiences a reduction in its food and agricultural trade to the EU.

In the lower part of Table 8, we illustrate the results of our second experiment, in which Turkey is treated as a GAFTA member. It is apparent that the overall welfare effect of this change is lower than in the simulation that evaluates Turkey's accession to the EU. Turkey's total welfare gains amount to 2.48 billion US$, whereas 0.89 billion US$ accrue to the GAFTA member countries. Unlike in our first experiment, we observe that Turkey's overall welfare gains from the removal of NTBs (1.22 billion US$) is nearly the same as its gains stemming from the elimination of import tariffs (1.25 billion US$). Conversely, for the GAFTA member countries, the effect of the removal of NTBs is greater (0.59 billion US$) than the effect of the elimination of import tariffs (0.19 billion US$). Duty free access to the manufacturing sector of the GAFTA member countries results in the highest welfare gains for Turkey at 0.94 billion US$. This gain for Turkey is resulting from its high share of manufacturing exports to GAFTA, which is also associated with high tariff rates (compare Section 'Overview of the Turkish trade structure and agreements' and Table 3). The tariffs imposed by Turkey on agro-food imports from GAFTA are higher than the tariffs imposed for the manufacturing sectors. Hence, for the GAFTA member countries, the improvement caused by the elimination of import tariffs from the Turkish agro-food sector is greater (0.34 billion US$) than the gain resulting from the removal of import tariffs from Turkish manufacturing sector (0.07 billion US$).

Abolishing the NTBs in the Turkish agro-food sector leads to a Turkish welfare gain of 0.71 billion US$, whereas this gain amounts to 0.13 billion US$ for the GAFTA member countries. In contrast, if the GAFTA member countries eliminate the NTBs in the same sector, the welfare gain increases to 0.32 billion US$ for the GAFTA member countries and decreases to 0.25 billion US$ for Turkey. Each region also experiences welfare increases if it removes its own NTBs in these sectors through efficiency gains.

Turkey's membership in GAFTA has also welfare impacts on other economies resulting from trade diversion. Similar to the EU-Turkey enlargement experiment, the largest decrease in welfare level is in the Turkey-GAFTA-FTA also observed for Asia. Asia experiences a welfare loss of 0.40 billion US$. Asia's welfare loss is caused by the decrease in its overall exports to GAFTA. However, in this case the decrease in exports is primarily observed in the manufacturing sector. Similar effects are also identified for the EU. The EU's welfare loss is predominantly caused by the decrease in its heavy manufacturing exports to GAFTA as well. GAFTA's imports of heavy manufacturing from the EU are replaced by the imports from Turkey.

In general, the effects of the removal of NTBs between GAFTA and Turkey yield smaller welfare gains than those caused by the removal of the NTBs between Turkey and the EU. The main reason for this result is the higher share and greater value of the agro-food trade between Turkey and the EU compared to the agro-food trade between Turkey and GAFTA. The EU enlargement to include Turkey increases the value of trade between Turkey and the EU by a value that is 2.3 times greater than the increase in the trade value resulting from the Turkey-GAFTA experiment. The next part therefore gives more insights into these changes in trade by focusing on the trade balance.

Trade balance effects

In Table 9, we present the impact on the trade balance caused by the two enlargement experiments disaggregated according to the 16 food and agricultural products. The first part of Table 9 shows the changes in the trade balance due to Turkey's membership to the EU; whereas the second part of the table demonstrates the changes in agro-food sector resulting from Turkey's joining the GAFTA. As mentioned in Section 'Welfare effects', Turkey is exhibiting higher welfare gains due to the EU membership. This result can be explained in more detail by the changes in trade balance of agro-food products.

The first part of Table 9 shows that Turkey's accession to the EU results in an increase of Turkey's agro-food trade balance by 3.16 billion US$. However, the EU's exports decrease relative to its imports by 1.95 billion US$. Turkey's relative sugar exports rise extensively (2.44 billion US$) as a result of its accession to the EU. The highest increase in the EU's agro-food trade balance is observed in dairy sector (1.24 billion US$), whereas Turkey's dairy imports decrease by 2.25 billion US$ more than its exports. All of these effects can be traced back to the pre-experiment high tariff rates and NTBs on the corresponding sectors (compare Section 'Overview of the Turkish trade structure and agreements' and Table 3 as well as Section 'Calculation of tariff equivalents' and Table 7). The removal of high trade barriers hence results in an increase of the trade volume.

Turkey's effect on the trade balance is particularly shown in the products that are highly traded between Turkey and the EU, namely, vegetables and fruits and other food products (compare Section 'Overview of the Turkish trade structure and agreements' and Table 3). The increase in Turkey's trade of vegetable and fruits (1.00 billion US$) and other food products (2.26 billion US$) is expected due to the removal of the NTBs from these sectors, which were estimated to be 77% and 177%, respectively (compare Section 'Calculation of tariff equivalents' and Table 7). This result is confirmed by Turkish exporters, 72% of whom indicate that they faced NTBs when exporting fresh vegetable and fruits to the EU in 2007 (Özdemir, 2008). The most frequent barriers are imposed for food safety reasons and are related to health and environmental labeling, pesticide use, genetically modified contents, quantity restrictions, and maximum residual limits for commodities. The aflatoxin level for hazelnuts, dried figs, pistachios, and commodities produced with these ingredients also creates barriers because the Turkish exports in these categories do not meet the relevant EU standards (Önen, 2008; Özdemir, 2008; Teknik Engel, 2013). Turkey ranked first in terms of aflatoxin hazard on fruits and vegetables products category. In 2012, 152 of 297 notices from the Rapid Alert System for Food and Feed[21] were for Turkish products exported to the EU due to high aflatoxin levels on hazelnuts, dried figs, and pistachios. In addition, Turkey was reported 60 times for high level of pesticide residues, primarily for fresh pepper exports (RASFF, 2013). Turkish beverage and tobacco exports also face high barriers, mostly due to a lack of appropriate labeling, which generates consumer concerns (Teknik Engel, 2013). Hence, we observe a slight increase in Turkey's beverages and tobacco exports to the EU due to the removal of the high NTBs on this sector (compare Section 'Calculation of tariff equivalents' and Table 7). The NTBs that the EU experiences in its exports to Turkey are generally related to meat and other livestock products as they have been put in place for public health reasons (European Commission, 2013b). Accordingly, the AVEs of NTBs on the EU's exports of cattle meat, other meat and other animal products to Turkey are estimated to be very high as 496%, 148% and 106%, respectively (compare Section 'Calculation of tariff equivalents' and Table 7). Hence, elimination of NTBs on these sectors results in a relative increase of EU's exports of meat and livestock products which increases the EU's trade balance in other animal products, cattle meat and other meat by 0.037 billion US$, 0.34 billion US$ and 0.027 billion US$, respectively. These findings are also in accordance with those of Oskam et al. (2004) who state that after Turkey's accession to the EU, Turkey remains to be a net exporter of vegetables and fruits, but imports of beef from the EU increase.

Turkey's membership to the EU also affects the trade balance of agro-food products in ROW. The agro-food trade balance of the ROW increases by 1.35 billion US$. Due to Turkey's adoption of a lower EU level for tariffs of imports from third countries after EU accession, relative food and agricultural imports from ROW to Turkey increase. These increases in agro-food trade balance are particularly observed in sugar and other food products sector (0.67 billion US$ and 0.83 billion US$, respectively).

In the second part of Table 9, we present the changes in the trade balance following the accession of Turkey to GAFTA. Turkey's membership to GAFTA results in a decrease of Turkey's agro-food trade balance by 2.69 billion US$. However, GAFTA's exports increase relative to its imports by 3.09 billion US$.

The largest decrease is given for the Turkish trade balance of dairy products (−3.12 billion). This is caused by the removal of high trade barriers on dairy imports from GAFTA to Turkey (compare Section 'Overview of the Turkish trade structure and agreements' and Table 3 as well as Section 'Calculation of tariff equivalents' and Table 7). Hence, after the removal of NTBs and the elimination of import tariffs on the dairy sector, Turkey's dairy imports substantially increase. Turkey also imports relatively more meat and livestock products due to the removal of trade distortions in this sector (compare Section 'Overview of the Turkish trade structure and agreements' and Table 3 as well as Section 'Calculation of tariff equivalents' and Table 7). Hence, following dairy products, GAFTA's trade balance of other meat increases the second highest by 0.26 billion US$.

Turkey's agro-food trade balance rises by 0.26 billion US$ and 0.22 billion US$, respectively for the vegetable oils and fats and other food products. These sectors include important export products from Turkey to GAFTA (compare Section 'Overview of the Turkish trade structure and agreements' and Table 3). After joining GAFTA, Turkey's relative exports of beverages and tobacco exports also rise (0.17 billion US$). Increasing relative exports of vegetable oils and fats, other food products and beverages and tobacco from Turkey to the GAFTA member countries are expected due to the removal of high trade barriers on these sectors as shown in Table 7 in Section 'Calculation of tariff equivalents'. In accordance, Turkish exporters also report that mostly NTBs for Turkish exports to GAFTA are related to plant-based food, owing to quality requirements regarding storage, labeling, transportation, sampling, and methods of testing. In particular, exports of tobacco products face high barriers resulting from labeling and consumer health protection concerns. Also, exports of alcoholic beverages are uncommon. Moreover, the NTBs for Turkey's meat and livestock products, vegetable oil and animal fats are a response to quality issues and the non-fulfillment of requirements for Halal accreditation (Teknik Engel, 2013). Turkey's accession to GAFTA also affects the trade balance of agro-food products in ROW. ROW's agro-food trade balance decreases by 1.42 billion US$ due to the relative decrease in imports of Turkey and GAFTA from third-party countries. These decreases in agro-food trade balance are particularly observed in vegetable oils and fats and other food products (−0.363 billion US$ and −0.37 billion US$, respectively).

Qualification of results

Empirical results always leave room for improvements and further research. The gravity approach employed here only allows the implicit estimation of trade costs of NTBs. We already discussed in Section 'Theoretical and empirical framework' that we control for many border-related factors in the trade cost func-

[21] The Rapid Alert System for Food and Feed is primarily a tool to exchange information between competent authorities on consignments of food and feed in cases where a risk to human health has been identified and measures have been taken.

Table 9
Changes of the trade balance of the enlargement experiments for disaggregated agro-food sectors (million US$).

	Experiment 1: enlargement of the EU to include Turkey		Experiment 2: enlargement of GAFTA to include Turkey	
	Turkey	EU	Turkey	GAFTA
Food and agricultural products	3164	−1950	−2692	3098
Wheat	−292	67	8	−32
Cereal grains	−98	63	17	−12
Vegetables and fruits	1001	−683	46	−12
Oil seeds	−58	27	19	−4
Plant-based fibers	−63	257	−27	109
Crops	−98	−99	1	108
Cattle	−4	9	−6	8
Other animal products	13	37	38	11
Vegetable oils and fats	761	−254	262	35
Dairy	−2251	1243	−3127	2564
Processed rice	−11	17	−27	28
Sugar	2442	−1500	−88	86
Other food products	2267	−1506	222	34
Beverages and tobacco	54	−1	174	−83
Cattle meat	−221	346	−9	8
Other meat	−280	27	−197	267

Source: authors' own calculation.

tion, but nevertheless the estimated AVEs do not include NTBs alone. Thus, using our estimated AVEs in GTAP model simulations might lead to the overestimation of our results. Additionally, the estimated AVEs might also include NTBs that are initiated for safety and health reasons. The elimination of those measures might not be desirable and might lead to biased welfare effects. With the help of benchmarking, we attempt to retain the NTBs of this type, although full control is impossible. A future improvement in the databases for NTBs might make it possible to estimate the effects of NTBs directly. In addition, we also need to emphasize that the EU and GAFTA benchmark settings are very ambitious. The trade relations between EU member countries and between GAFTA members have developed over a long period. Our estimates therefore indicate the potential long-term welfare effects of Turkey's integration to the EU or GAFTA. Also these welfare effects might be too high because we do not consider the WTO negotiation or tax replacement scenarios as well as political and social unrest in the Middle Eastern states. Further effects of Turkey's membership to the EU, such as financial and budgetary consequences on both parties as well as implications of potential labor movements between Turkey and the EU member countries can also be applied in future research.

In contrast, as also indicated by Winchester (2009), the results do not cover several welfare improving aspects; mainly traced back to the lack of dynamism of the CGE model. The standard GTAP model is static and does not include dynamic behavior. Hence, productivity improvements, foreign ownership of capital and changes in foreign and domestic wealth are not explicitly considered. If spillover effects were taken into account, we would expect Turkey to experience higher gains in terms of technology and knowledge transfer from the EU. As regards to Turkey's membership to GAFTA, we expect that these secondary effects of the FTA would be more limited for Turkey. Higher productivity improvements are expected to happen in GAFTA member countries, because knowledge and technology would be transferred from Turkey to the Middle East.

Another aspect that might lead to an overestimation of results is the so-called aggregation bias. Aggregation bias occurs in general equilibrium models due to the inability to implement tariffs at the six-digit level of the Harmonized System. The importance of the level of data disaggregation and the differences in results between models developed with aggregated and disaggregated databases are already emphasized by several authors (e.g., Charteris and Winchester, 2010; Grant et al., 2007; Narayanan et al., 2010a,b). These differences in results can be predominantly traced back to false competition (Narayanan et al., 2010a). False competition results from a situation in which competition does not initially exist between two exporting regions (e.g., in the EU and GAFTA) in a subsector (e.g., bananas). However, the trade data on this subsector may be available only in the form of an aggregated sector (e.g., vegetables and fruits) that also includes other competing sectors (e.g., tomatoes). Utilizing the aggregated sector in models causes false substitution effects caused by wrongly applied weights. False competition also applies to the situations that one of the subsectors aggregated in a sector may not face any NTBs whereas one of the other subsectors within the same aggregation can be subject to NTBs. Hence, false competition may result in the overestimation of trade effects when tariffs and/or NTBs are reduced or abolished and thereby may cause bias in the results.

Conclusion

This paper explores the economic implications of Turkey's membership in either the EU or GAFTA by considering both tariffs and NTBs. Particular emphasis is given to the food and agricultural sector. We use the GTAP database and the gravity approach to estimate the AVEs of border barriers that reflect the impacts of NTBs in 16 agro-food sectors. In general, the AVEs of the NTBs are comparable in magnitude with those reported in the results of recent studies on border effects for other countries.

According to the reports of Turkish and European exporters, we expected high NTBs on vegetables and fruits, other food products, other animal products and beverages and tobacco sector in the trade between Turkey and the EU. Those sectors are also strategically important for Turkey's trade flows with the EU and GAFTA as indicated by their high trade shares and protection structure. Turkish exporters report high barriers on other animal products, vegetable oils and fats, beverages and tobacco in the trade between Turkey and GAFTA. Our econometric estimates confirm that high AVEs of NTBs do indeed exist in these sectors. NTBs on Turkey's vegetables and fruits and other food products exported to the EU are, for example, equal to 77.06% and 177%, respectively. These barriers are much higher than the current barriers among the EU members (0% and 81.52%, respectively). Analogously, we find high AVEs of NTBs for other animal products, vegetable and oil and beverages and tobacco on Turkey's exports to GAFTA. Additionally, we also identified several sectors with high AVEs of NTBs which were initially not reported by exporters from either countries involved in the respective FTA. Those are cereal grains and processed rice in the case of the EU-Turkey enlargement and cereal grains, processed rice, and sugar in the case of the accession of Turkey to GAFTA.

We expect that sectors with particularly high AVEs of NTBs contribute the most to the gains resulting from the two FTA agreements compared in this paper. In a second step, we therefore use the GTAP framework to implement the AVEs in the general equilibrium model. In our analysis, we utilize the most recent version of the GTAP database, Version 8. Before using the AVEs, we extend the GTAP framework to the year 2020 by updating the political and economic environment. We also consider those of Turkey's FTAs that came into force after 2007 or that will be in force up until 2020. Thereafter, we run two enlargement experiments and compare the possible effects of Turkey's integration into the EU or GAFTA.

The results of our experiments indicate that higher overall welfare gains will accrue for Turkey through EU membership (4.90 billion US$) than through membership in GAFTA (2.48 billion US$). These gains result mainly from the higher share and greater value of the agro-food trade between Turkey and the EU compared to the

Table A1
Regional and sector aggregation.

	Regions		Sectors
1	Turkey	1	Paddy rice
2	European Union Austria, Belgium, Denmark, Finland, France, Germany, Ireland, United Kingdom, Greece, Italy, Luxembourg, Netherlands, Portugal, Spain, Sweden, Czech Republic, Hungary, Malta, Poland, Slovakia, Slovenia, Estonia, Latvia, Lithuania, Cyprus, Romania, Bulgaria	2	Wheat
3	Greater Arab Free Trade Area Bahrain, Kuwait, Oman, Qatar, Saudi Arabia, United Arab Emirates, Egypt, Morocco, Tunisia, Rest of North Africa, Rest of Western Asia	3	Cereal grains
4	Islamic Republic of Iran and Israel	4	Vegetables and fruits
5	Former Soviet Union Belarus, Romania, Russian Federation, Ukraine, Kazakhstan, Kyrgyzstan, Armenia, Azerbaijan, Rest of Former Soviet Union	5	Oil seeds
6	Asia China, Hong Kong, Japan, Korea, Mongolia, Taiwan, Cambodia, Indonesia, People's Democratic Republic of Lao, Malaysia, Philippines, Singapore, Thailand, Viet Nam, Bangladesh, India, Nepal, Pakistan, Sri Lanka, Rest of South Asia, Rest of Southeast Asia	6	Sugar cane, sugar beet
7	North America Canada, United States of America, Mexico, Rest of North America	7	Plant-based fibres
8	Latin America Argentina, Bolivia, Brazil, Chile, Colombia, Ecuador, Paraguay, Peru, Uruguay, Venezuela, Costa Rica, Guatemala, Honduras, Nicaragua, Panama, El Salvador, Caribbean, Rest of South America, Rest of Central America	8	Crops
9	Oceania Australia, New Zealand, Rest of Oceania	9	Cattle
10	Sub-Saharan Africa Cameroon, Cote d'Ivoire, Ghana, Nigeria, Senegal, Ethiopia, Kenya, Madagascar, Malawi, Mauritius, Mozambique, Tanzania, Uganda, Zambia, Zimbabwe, Botswana, Namibia, South Africa, Rest of African Customs Union, South Central Africa, Rest of Eastern Africa, Rest of Western Africa, Central Africa	10	Other animal products
11	Rest of the World Switzerland, Norway, Croatia, Rest of EFTA, Rest of Eastern Europe, Rest of Europe, Rest of the World	11	Raw milk
12	Albania	12	Wool
13	Georgia	13	Sugar
14	Chile	14	Processed rice
		15	Dairy
		16	Cattle meat
		17	Other meat
		18	Vegetable oils and fats
		19	Other food products
		20	Beverages and tobacco
		21	Extraction Forestry, fishing, coal, oil, gas, minerals not elsewhere specified (nec)
		22	Light Manufacturing Textiles, wearing apparel, leather products, wood products, paper products, publishing, metal products, motor vehicles and parts, transport equipment nec
		23	Heavy Manufacturing Petroleum, coal products, chemical, rubber, plastic products, mineral products nec, ferrous metals, metals nec., electronic equipment, machinery and equipment nec
		24	Services Electricity, gas manufacture, distribution, 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

Source: GTAP Database, Version 8, Base Year 2007.

trade between Turkey and GAFTA. As other authors have suggested, the new memberships will deliver higher gains for Turkey than for their partner economies; 2.26 billion US$ for the EU and 0.89 billion US$ for the GAFTA member countries. The removal of NTBs will predominantly result in greater economic effects rather than the elimination of import tariffs. These higher effects are more pronounced in the first simulation, in which we enlarge the EU to include Turkey. The abolition of trade costs of NTBs generates a welfare gain of 3.42 billion US$ for Turkey, whereas the welfare gain stemming from duty free access to the European market is only 0.73 billion US$. Similarly, the EU's and the GAFTA member countries' gains from NTB removal outweigh their gains due to the elimination of import tariffs in both experiments. This finding indicates the importance of NTBs in enlargement scenarios because eliminating NTBs contributes more to welfare increases than does tariff removal.

The changes in the trade balance show an increase of Turkey's trade balance for those products which are highly traded between Turkey and the EU and are often protected by tariffs and high AVEs of NTBs, namely, in vegetables and fruits and other food products sectors. After the enlargement to include Turkey, the EU imports relatively more vegetables and fruits, sugar and other food products, so that EU's trade balance of these sectors decreases. In contrast, the EU's trade balance of dairy products shows a substantial increase. The accession of Turkey to GAFTA leads to a decrease of Turkey's trade balance for dairy and meat and livestock products, while Turkey's trade balance increases for vegetable oils and fats and other food products, which are important export products of Turkey to GAFTA.

Policy makers might find our framework useful in their decision making process regarding Turkish foreign policy. Our experimental results verify the importance of the EU as a trade partner for Turkey and the narrow gains that will accrue from GAFTA membership. These gains will most likely be even lower due to the current political and military conflicts in the Middle Eastern states as well as the serious structural problems in the Arab economies. Turkey might obtain greater benefits if it strengthens its relations with the EU rather than with the GAFTA member countries.

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Appendix A

See Table A1.

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4 The Effect of Aggregation Bias: An NTB Modeling Analysis of Turkey's Agro-Food Trade with the EU

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Abstract

We explore how different data aggregation levels affect the gravity estimates of non-tariff barriers (NTBs) in the agro-food sector, and we examine their related impacts on policy simulations of an expansion to the European Union (EU) that would include Turkey. We calculate two sets of ad valorem equivalents (AVEs) of NTBs using the gravity approach to disaggregated and aggregated Central Product Classification data for 15 Global Trade Analysis Project (GTAP) agro-food sectors. We find that the AVEs of NTBs vary substantially across products and that using aggregated data primarily leads to an overestimation of the effects of NTBs. In a second step, we incorporate the AVEs of NTBs into the GTAP model to evaluate Turkey's EU membership and conclude that aggregation bias has considerable effects on both the estimation of NTBs and on the general equilibrium simulation results. Utilizing aggregated data leads to an overestimation of the trade costs of NTBs and, hence, to an overestimation of trade and welfare effects.

Keywords: aggregation bias; gravity estimates; non-tariff barriers; computable general equilibrium modeling; Global Trade Analysis Project

JEL classification: D58; F15; Q17

4.1 Introduction

Multilateral negotiations on trade liberalization and the increasing number of economic integration agreements have led to a low level of tariffs worldwide. Consequently, the number and importance of non-tariff barriers (NTBs) to trade has risen, and the plethora of different NTBs makes their regulation at the multilateral level almost impossible. Another potential framework to negotiate the reduction of NTBs might be bilateral and regional trade agreements (RTAs). Thus, a reduction in NTBs needs to be taken into account, particularly in the analysis of RTAs. Recent literature shows that NTB reduction has a greater impact on welfare results than reduced tariffs in most RTAs (e.g., Engelbert et al. 2014, Lejour and Mooij 2001).

RTAs are negotiated at a very detailed product level, whereas most empirical studies only consider the aggregated sector level. Against this background, this article analyzes the effects of different aggregation levels on econometric estimates of the trade costs of NTBs and their related impact on the policy simulations of Turkey's potential membership to the European Union (EU). In our analysis, we consider the importance of the food and agricultural trade between Turkey and the EU and the high NTBs imposed on this sector.

Aggregation bias is well-recognized and apparent in the gravity estimates used to quantify NTBs (e.g., Agostina et al. 2007; Anderson and van Wincoop 2004; Anderson 2009; Cipollina and Salvatici 2012; French 2012; Haveman and Thursby 1999; Haveman et al. 2003; Hillberry 2002; Hillberry and Hummels 2002). Authors argue that inferences about trade costs from the literature are limited and misleading due to highly aggregated data and the different effects of trade policies across products. These authors agree that the impacts of trade barriers can only be separated and compared at a sectoral level if disaggregated data are used. However, to the best of our knowledge, none of the existing studies offer gravity estimates at a very detailed agro-food product level, nor do existing studies offer a combination of econometric estimates of NTBs at different aggregation levels and their use in a CGE model.

We calculate two sets of ad valorem equivalents (AVEs) of NTBs using the gravity approach to disaggregated and aggregated Central Product Classification (CPC) data for 15 Global Trade Analysis Project (GTAP) agro-food sectors. We compare the disaggregated CPC pooled gravity results with the aggregated gravity results to reveal the impact of the level of data aggregation on the magnitude of trade costs caused by NTBs. Subsequently, we incorporate the AVEs of NTBs estimated at different aggregation levels into the GTAP model to simulate the EU's expansion to include Turkey. We run two experiments, which differ in terms of the NTBs resulting from the different gravity aggregation estimates, to show the impact of aggregation bias on the simulation results. Hence, our article contributes to the literature by revealing the impact of data aggregation on the estimation of NTBs and its related effect on policy simulation results.

Our analysis is divided into two parts. In the first part, we use the gravity approach to estimate the AVEs of NTBs using disaggregated and aggregated data. In the second part, we incorporate these AVEs, which are calculated at different aggregation levels, into the GTAP framework to expose the aggregation bias that is transferred from the gravity estimates to the CGE analysis. We focus on the extent of aggregation bias and the differences between the results of experiments that are either run using the AVEs of NTBs from the disaggregated gravity estimates or those from the aggregated gravity estimates.

4.2 Gravity Modeling

The measurement of the effects of NTBs at different levels of aggregation is based on an ex post study using the gravity approach. The gravity model has become a strong empirical tool for analyzing patterns of trade flows, regional agreements, and the effects of trade frictions. Due to its broad theoretical justification and strong explanatory power, it is also recognized as a useful tool for identifying and quantifying the trade costs of NTBs.[2] For our analysis, we adopt the gravity-like equation of Anderson and van Wincoop (2003, 2004). Their specification is based on the Armington model and takes into account the general equilibrium effects of trade barriers. In its basic formulation, imports depend on the output of the exporting country and the consumption of the importing country relative to world output. Bilateral trade is lowered by bilateral and multilateral trade barriers as governed by the elasticity of substitution. Multilateral trade barriers, also known as multilateral resistance terms, represent the average trade barriers (Anderson and van Wincoop 2003). The multilateral resistance terms are econometrically captured by country-specific dummies or by country-time-fixed effects in a panel data framework (Anderson and van Wincoop 2003; Feenstra 2004).[3] Bilateral trade barriers are unobservable, but they can be approximated by a trade cost function using observable trade cost proxies.

4.2.1 Identification Strategy and Data

To identify the effects of NTBs, we use an implicit measure that we integrate into our trade cost function. RTA variables serve as instruments to isolate the measures that aim to eliminate unnecessary and restrictive non-tariff measures, to reduce regulatory divergence and to harmonize standards or regulations within a region on average (Chen and Novy 2012). In the analysis of Turkey's potential accession to the EU, we apply a variable to the EU trade bloc to quantify the positive effects of regulatory convergence and the reduction in NTBs that occur in the integration process.[4] We compare existing trade levels under the European economic integration to a hypothesized, counterfactual trade level in the absence of the EU. We draw inferences about the trade costs of NTBs using the theoretical model structure based on the missing trade in the absence of the EU. Applying this approach allows us to calculate a consistently aggregated measure that identifies all NTB-induced trade costs at the sector or product level, which can be realistically eliminated within the EU integration process.

We use a panel data framework to obtain the most reliable estimate of the average expected effect of the European integration process (Baier and Bergstrand 2007; Magee 2008; Raimondi et al. 2012), but there are different specifications of the panel gravity equation (compare Baldwin and Taglioni 2006; Egger and Pfaffermayr 2003; Micco et al. 2003; Stack 2009; Sun and Reed 2010). For our analysis, we choose the panel structure with time-fixed and bilateral fixed effects because it is superior in controlling unobserved heterogeneity from different sources, RTA endogeneity and multilateral resistance (Gylfason et al. 2014). Accordingly, we use a panel data estimation strategy in which all time-invariant country-pair factors, such as distance, sharing a common border or common language, a colonial relationship, and other ties that are constant over

2 See Anderson (2011) and Head and Mayer (2014) for a thorough review on the theoretical and empirical developments of the gravity model.

3 Alternatively, multilateral trade barriers can be approximated using Baier and Bergstrand's (2009) method.

4 By using this identification strategy, we assume a wide-ranging notion of NTBs. We are not able to identify individual measures and so can only quantify the overall effects of the NTBs on trade.

time, are captured by the country-pair individual heterogeneity term. The intercept is also absorbed, so it has to be removed from the equation. Hence, only time-variant characteristics enter the fixed-effects model. As controls, we include several variables to capture changes in economic and political characteristics as well as trade policies. We use the Poisson fixed effects model to estimate the gravity equation (Palmgren 1981; Hausman et al. 1984). This estimation is accomplished through a multiplicative form incorporating trade flows in levels, and we thereby address the problem of zero bilateral trade flows. The evaluation of the parameters is based on the conditional quasi-maximum likelihood (Anderson 1970).[5] We infer from robust standard errors to properly account for heteroskedasticity which is typical of trade data (Santos Silva and Tenreyro 2006). The conditional fixed-effects Poisson regression technique is pursued to estimate the following empirical specification that differs according to the degree of data aggregation:

$$\begin{aligned} X_{ij,t}^{k} = exp\Big(&\alpha_{ij} + \alpha_{t} + \beta_{1} sGDP_{ij,t} + \beta_{2} dGDPpc_{ij,t} + \beta_{3} dPopDensity_{ij,t} \\ &+ \beta_{4} dPolicy_{ij,t} + \beta_{5}\, ln\, Tariff_{ij,t}^{k} + \beta_{6} EU_{ij,t} + \beta_{7} RTA_{ij,t}\Big) + \varepsilon_{ij,t}^{k} \end{aligned} \quad (1)$$

Here, the similarity in the terms for economic size ($sGDP_{ij,t}$) for each country pair is derived from the two countries' share of GDP,[6] and the difference in terms of relative factor endowments ($dGDPpc_{ij,t}$) for each country pair is derived from the absolute difference in the GDP per capita[7] (Helpman 1987; Stack 2009). In the same way, differences in population density ($dPopDensity_{ij,t}$) and political structure ($dPolicy_{ij,t}$) are obtained. The variable $Tariff_{ij,t}^{k}$ is equal to one plus the ad valorem tariff equivalent of country i on the exports of country j in year t and sector k. The variable $EU_{ij,t}$ is equal to one if countries i and j are both members of the EU and zero otherwise. The dummy variable $RTA_{ij,t}$ is set to unity if both countries belong to the same RTA and to zero otherwise. The EU and RTA dummies account for the regional non-tariff preferences. The corresponding regression parameters are denoted by β_1 to β_7, and the fixed effects control for time-invariant bilateral factors (α_{ij}) and time-specific macroeconomic shocks affecting global trade flows (α_t). Finally, $\varepsilon_{ij,t}^{k}$ is an error term.

To estimate Equation (1) and to compute the tariff cost equivalent of NTBs, we source annual data on bilateral trade flows for 157 CPC products[8] at the most disaggregated level from the United Nations Commodity Trade Statistics (UN COMTRADE) database.[9] Bilateral tariffs come from the UNCTAD TRAINS database using the World Integrated Trade Solution application software. Information on GDP and GDP per capita, population and land area is taken from the World Bank. The source of the political variable is the Polity IV project (CSP 2014). Finally, the binary RTA variable is taken from de Sousa (2014). Our panel set covers the period from 1988 to 2011. The most important parameters of our analysis are the ones for tariffs and EU membership, and we expect tariffs to have a negative effect on trade and EU membership to have a trade-

5 An alternative and equivalent method that would yield identical estimates would be to use a conventional Poisson regression by maximum likelihood including dummy variables for all country pairs and years to directly estimate the fixed effects. For convenience, we choose the conditional maximization of the likelihood.

6 The formula to compute the similarity between two countries in terms of economic size ($sGDP_{ij,t}$) is ln[1-$(GDP_{i,t}/(GDP_{i,t} + GDP_{j,t}))^2$-$(GDP_{j,t}/(GDP_{i,t}+GDP_{j,t}))^2$].

7 The formula to compute the difference between two countries in terms of factor endowments ($dGDPpc_{ij,t}$) is abs(log($GDPpc_{i,t}$) – log($GDPpc_{j,t}$)) where $GDPpc$ is the GDP per capita.

8 Table 2 shows the number of CPC sectors mapped to each food and agricultural GTAP sector. The complete and detailed listing of CPC sectors by GTAP sector is available at https://www.gtap.agecon.purdue.edu/databases/contribute/concordinfo.asp.

9 Trade flows that are recorded as missing, and countries that do not report any trade statistics are omitted from the dataset.

enhancing effect. In the regressions at the aggregated data level, we assume an upward bias over tariffs and EU membership that probably distorts the size of the estimates of tariff elasticity and economic integration compared to disaggregated data-level regressions. In the CPC product-level regressions, we anticipate high variation in the effects of tariffs and economic integration across products.

4.2.2 Empirical Results

We apply the two-way fixed effects Poisson model to the trade data of 157 CPC products for 15 GTAP agro-food sectors at the aggregated and pooled levels. In addition, we obtain estimates at each CPC product level to compare product line estimates to sector estimates and thus reveal the aggregation differences in the estimates. Table 4.1 shows the parameter estimates for the vegetables, fruits and nuts sector.[10] We only present and discuss the results of this sector in detail because it is important to the trade between the EU and Turkey and exhibits substantially relevant NTBs. Vegetables, fruits and nuts are highly affected by sanitary and phytosanitary measures and other food safety standards to which consumers are sensitive. Column 1 shows the estimates for the vegetables, fruits and nuts sector at the aggregated level, and column 2 shows the estimates from the disaggregated CPC pooled gravity regression. The subsequent columns display the gravity results for the corresponding individual disaggregated CPC products. Thereby, columns 3 to 6 represent vegetables, and columns 7 to 12 represent fruits.

Most control variables have the expected signs and are statistically significant. As expected, differences between countries in terms of factor endowments, population density and policies, as identified by the variables $dGDPpc_{ij,t}$, $dPopDensity_{ij,t}$ and $dPolicy_{ij,t}$, respectively, tend to decrease bilateral trade. Instead, the estimates of similarity in economic size, as captured by the variable $sGDP_{ij,t}$, are mixed in terms of having the correct sign. When the parameter shows the correct sign, it is not significant. In contrast, the effects of tariffs are consistent with our expectations and are highly significant. If the tariff increases by 1%, the trade of vegetables, fruits and nuts decreases by 3.1% in the aggregated version and by 2.3% in the disaggregated version. Considering the results from the product-level gravity approach, the tariff elasticity varies greatly from 0.8% to 4.8%.[11]

Economic integration agreements have a positive effect on trade. Trade between two countries that join the same RTA is expected to increase by 114.9% with the aggregated data and by 71.4% with the disaggregated data. In terms of the product-level results, trade is expected to increase somewhere between 23.4% (dried leguminous vegetables) and 103.2% (other vegetables, fresh or chilled).[12] As expected, deeper trade integration increases trade even more, and EU membership is expected to increase the trade of vegetables, fruits and nuts by 403.8% if considering the aggregated data and by 192.1% if considering the disaggregated data. In the product-level estimations, the positive trade effects of EU membership are greater for some products (e.g., dates, figs, bananas, coconuts, Brazil and cashew nuts, pineapples, and avocados (1,685%)) and lower

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10 Detailed regression results for the other sectors are available from the authors on request.

11 The interpretation of the parameters using log-transformed variables in the exponential function is identical to the interpretation using log-log equations; they are interpreted as elasticities.

12 The interpretation of the parameter associated with the economic integration dummy variables is standard for semi-logarithmic equations. For example, if we assume the coefficient estimated for the RTA in the aggregated version is $b_{RTA} = 0.765$, then two countries joining the same RTA will trade an extra $(\exp(b_{RTA})-1)*100 = (\exp(0.765)-1)*100 = 114.9\%$ relative to the amount traded between two non-RTA countries.

for others (e.g., potatoes (80.6%)). In two sectors (shelled, dried leguminous vegetables and edible roots and tubers with high starch or inulin content), EU membership does not have a significant effect on trade.

In terms of aggregation bias, the effect of EU membership is significantly lower using disaggregated data compared to the result using aggregated data. This notion is not applicable to all regressions and trade policy variables because there is an overlap between the confidence intervals of the disaggregated gravity and aggregated gravity results. Nonetheless, we can conclude that for some sectors (vegetables, fruits, and nuts, crops; dairy; other food products; beverages and tobacco), there is a significant overestimation of trade policy effects using aggregated data. This result is in accordance with those of other authors using aggregated data in gravity modeling (e.g., French 2012; Hillberry 2002).

Table 4.1: Poisson Estimation Results for the Vegetables, Fruits and Nuts Sector (Dependent Variable: Imports)

	Sector Level		Product Level									
	(1) Vegetables, fruits, nuts agg	(2) Vegetables, fruits, nuts disagg	(3) Potatoes	(4) Dried leguminous vegetables	(5) Other vegetables, fresh or chilled	(6) Edible roots and tubers	(7) Dates, figs, bananas, coconuts, etc.	(8) Citrus fruit, fresh or dried	(9) Grapes, fresh or dried	(10) Other fruit, fresh	(11) Other fruit, dried	(12) Other nuts
lnTariff	-3.091***	-2.279**	-0.811***	-0.954***	-4.490***	-4.620*	-3.705***	-4.823***	-1.941***	-4.064***	-3.573***	-4.073**
	(1.168)	(1.045)	(0.163)	(0.192)	(0.788)	(2.413)	(0.637)	(1.632)	(0.593)	(1.064)	(1.041)	(1.681)
EU	1.617***	1.072***	0.591*	-0.178	1.570***	0.629	2.882***	0.790***	1.304***	1.309***	1.161***	0.824***
	(0.135)	(0.120)	(0.321)	(0.357)	(0.168)	(0.738)	(0.279)	(0.191)	(0.161)	(0.179)	(0.312)	(0.241)
RTA	0.765***	0.539***	0.381**	0.215*	0.709***	0.489*	0.447***	0.311**	0.635***	0.661***	0.417***	0.0732
	(0.0751)	(0.0666)	(0.183)	(0.125)	(0.113)	(0.271)	(0.0834)	(0.142)	(0.0960)	(0.0763)	(0.122)	(0.227)
sGDP	0.135	-0.127	-0.140	-0.320	0.221	-1.099***	0.242	0.239	-0.490**	-0.193	-0.126	0.121
	(0.124)	(0.128)	(0.333)	(0.224)	(0.166)	(0.335)	(0.198)	(0.248)	(0.235)	(0.162)	(0.159)	(0.232)
dGDPpc	-0.599***	-0.660***	-0.660**	-0.705***	-0.567***	-1.245***	-0.139	-0.331*	-0.870***	-0.751***	-0.901***	-0.630**
	(0.104)	(0.107)	(0.321)	(0.172)	(0.126)	(0.233)	(0.193)	(0.184)	(0.192)	(0.128)	(0.176)	(0.288)
dPopDensity	-0.459	-0.598*	-0.580	-0.714	-1.329**	-7.831***	-0.452	0.957	0.979	-0.762	-0.885	0.683
	(0.374)	(0.332)	(1.090)	(0.776)	(0.590)	(2.715)	(0.437)	(0.762)	(0.850)	(0.540)	(0.737)	(0.895)
dPolicy	-0.0539***	-0.0322***	-0.0299	-0.0252**	-0.0334**	-0.0193	-0.0433***	-0.0282	-0.0635***	-0.0167	0.00408	-0.0155
	(0.0120)	(0.0107)	(0.0316)	(0.0117)	(0.0156)	(0.0155)	(0.0116)	(0.0286)	(0.0207)	(0.0186)	(0.0101)	(0.0173)
Obs.	91094	251572	11686	27812	36525	10213	38078	20785	19229	34708	21059	22310
AVEs of NTBs (%)	68.73	60.06	107.24	25.28	41.86	11.16	117.68	17.8	95.78	38.0	38.39	22.42

Note: Standard errors are reported in parentheses. Asterisks (*), (**) and (***) denote significance at the 10%, 5% and 1% levels, respectively.

Source: Authors' calculation.

Following the structure of the theoretical gravity model, the parameters of the economic integration variables are interpreted as $\beta_6 = (\sigma - 1) ln b_{EU}$ and $\beta_7 = (\sigma - 1) ln b_{RTA}$, where σ is the elasticity of substitution between goods[13] and b_{EU} -1 and b_{RTA} - 1 are the tariff cost equivalents of the EU NTBs and a typical RTA.[14] Accordingly, the last row of Table 4.1 displays the tariff cost equivalents of NTBs. In terms of the aggregated gravity result, EU membership leads to a reduction in NTBs or regulatory divergence in vegetables, fruits and nuts equivalent to a 68.7% tariff for both countries. Considering the CPC-pooled regression results, the

13 The substitution elasticity is equal to the absolute tariff coefficient resulting from sectoral or product estimations plus 1. When the tariff elasticity estimate is not significant, we take the GTAP elasticity of substitution for the sector-level calculations or the average tariff elasticity from the remaining significant estimates in the GTAP sector group for the product-level calculations.

14 Whenever the EU dummy coefficient is not significant, we consider the typical RTA quantity effect to calculate the trade costs of NTBs. In that way, we assume that the effect of EU membership does not differ from a typical RTA effect. However, there are also some cases in which both economic integration variables are not significant or have the incorrect sign. In these cases, we assume that Turkey's EU membership will not have any effects on the reduction of NTBs in the respective sectors.

trade-enhancing effect for the vegetables, fruits and nuts sector that results from Turkey's membership in the EU amounts to only 60.06%. This reflects the overestimation effect of using highly aggregated data to estimate the effects of NTBs.

The results of the CPC product-level gravity approach reveals that the most regulatory convergence occurs in the dates, figs, bananas, coconuts, Brazil and cashew nuts, pineapples, and avocados sector (117.7%). The least regulatory compliance occurs in the edible roots and tubers with high starch or inulin content sector (11.2%). The results on AVEs of NTBs are very sensitive to the elasticity of substitution (e.g., Obstfeld and Rogoff 2001; Raimondi and Olper 2011). In general, the lower the elasticity of substitution, the greater the AVEs of NTBs will be. Thus, even low levels of non-tariff protection can have large trade-hindering effects if the substitution elasticity is sufficiently low. This issue also applies to our estimates of tariff elasticity and explains the high AVEs of NTBs for some disaggregated CPC-level products.

To compare the CPC product-level results to the sector-level results, we aggregate the results of the product-level gravity approach on AVEs to the sector level and weight them by their relative importance using trade quantities as weights.[15] Specifically, we utilize the weights according to the bilateral trade structure of the EU and Turkey for each sector. This approach leads to asymmetric AVEs of NTBs for the EU and Turkey.

Table 4.2 exhibits aggregated, disaggregated and re-aggregated AVEs of NTBs that the EU and Turkey are expected to decrease during the process of Turkey's integration into the EU. In addition, we present the number of CPC sectors mapped to each GTAP-level sector and the variation coefficient of AVEs of NTBs from the CPC product-level gravity regressions. In the wheat and processed rice sectors, there is only one corresponding CPC sector leading to equal AVEs of NTBs for all gravity versions. Consequently, there is also no variation at the CPC level across products. In line with other studies (e.g., Anderson and van Wincoop 2004), there is high variation across products. We observe high variation coefficients in the sectors of other meat, other animal products and plant-based fibers with variation coefficients of 188%, 130% and 122%, respectively. The lowest variation is found in the oil seeds (22%), sugar (50%), and vegetable oils and fats (64%) sectors. Turning to the results of the aggregated gravity approach to estimate the AVEs of NTBs, the trade of plant-based fibers is expected to face relatively low non-tariff compliance. The very high trade costs caused by NTBs are expected to decrease in beverages and tobacco, wheat, and cereal grains. The order is similar when considering the pooled CPC-disaggregated gravity regression results on AVEs of NTBs, although the magnitude is much lower. The EU and Turkey are assumed to only marginally reduce trade costs in the crop and sugar sectors. Instead, the two parties are expected to achieve the most regulatory compliance in the wheat, beverages and tobacco, other food products and cereal grains sectors. With one exception, namely, other food products, all gravity results on the AVEs of NTBs using aggregated data are higher than those obtained using disaggregated data. This result again confirms our previous assumption that estimates from aggregated data regressions will overestimate the effect of EU membership.

According to the trade-weighted results, the EU and Turkey show the greatest deviation in terms of reduced NTBs in the beverages and tobacco, dairy and sugar sectors, in which Turkey is expected to reduce NTBs

15 Applying trade weights to the aggregation method is atheoretic and might considerably bias the measurement of trade restrictiveness due to NTBs. Anderson and Neary (1996, 2003) propose theoretic aggregation by using the idea of uniform tariff equivalents. However, this theory-based aggregation method requires large and mostly unavailable quantities of data, so we rely on the standard procedure. We are aware that most restrictive NTBs enter into the overall average with relatively low weights and vice versa (Lard and Yeats 1988).

more strongly than the EU. Additionally, in the cattle meat, other animal products, cereal grains and crops sectors, there are large deviations. Here, the EU is willing to reduce NTBs to a higher degree than Turkey.

Not shown in Table 4.2 but important nonetheless, is the average AVE of NTBs across all 15 sectors, which decreases greatly from the aggregated version (131.7%) to the disaggregated version (83.1%) and even more in the re-aggregated version (72.9% for the EU and 76.3% for Turkey). Hence, the overestimation effect ranges between 60 and 80 percentage points. Considering the sectoral differences between the aggregated and disaggregated gravity estimation results, there is a bias of between 11 and 635 percentage points. In the same way, the variation in the average AVEs of NTBs across sectors decreases substantially.

Table 4.2: Aggregated, Disaggregated and Re-aggregated AVEs of NTBs (%)

Sector	CPC sectors (No.)	Variation coefficient (%)	Aggregated AVEs EU/TUR	Disaggregated AVEs EU/TUR	Re-aggregated AVEs TUR→EU	Re-aggregated AVEs EU→TUR
Wheat	1	-	315.17	315.17	315.17	315.17
Cereal grain	4	76.75	291.89	140.94	98.08	86.15
Vegetables, fruits and nuts	10	77.01	68.73	60.06	47.07	47.75
Oil seeds	5	22.32	40.86	26.64	17.75	19.42
Plant-based fibers	3	122.45	8.52	0.00	0.00	0.03
Crops	14	113.51	101.77	13.86	43.34	32.75
Other animal products	10	130.14	122.28	78.38	13.45	1.41
Cattle meat	9	91.41	88.62	35.02	127.25	48.01
Other meat	9	188.00	116.95	104.62	21.39	19.52
Vegetables oils and fats	11	64.08	52.66	29.95	30.62	29.35
Dairy	11	113.91	84.14	56.98	102.70	137.30
Processed rice	1	-	50.14	50.14	50.14	50.14
Sugar	4	49.58	42.52	28.96	125.00	135.73
Other food products	52	95.19	49.26	148.99	41.49	37.52
Beverages and tobacco	13	113.15	541.97	156.00	60.56	183.96

Source: Authors' calculation.

4.3 Simulations with the Global Trade Analysis Project (GTAP) Framework

We analyze the effects of the aggregation bias of the gravity estimates on the policy simulation results with the help of the GTAP model, which is a comparative, static, multi-region general equilibrium model. The standard GTAP model provides a detailed representation of the economy, including the linkages between the farming, agribusiness, industrial and service sectors. The use of the non-homothetic, constant difference of elasticity to handle private household preferences, the explicit treatment of international trade and transport margins and the inclusion of the global banking sector are innovative features of the GTAP model. Trade is represented by bilateral matrices based on the Armington assumption. Additional features of the standard GTAP model are in perfect competition in all markets and the profit- and utility-maximizing behavior of producers and consumers. All policy interventions are represented by price wedges. The framework of the standard GTAP model is well-documented in Hertel (1997) and is available on the Internet.[16]

4.3.1 Incorporation of NTBs into the GTAP Model

NTBs are not considered in the standard GTAP model. However, they can be modeled using several methods, namely, as export taxes or import tariffs or as efficiency losses depending on the policies with which they are related. In the cases in which trade barriers generate rents, they can be implemented into the CGE model as import tariffs or export taxes. When NTBs only cause efficiency losses and thus increase the cost of production, an efficiency approach can be used (compare Francois 1999, 2001). Several authors employ a combination of both NTB-modeling approaches to account for the different effects of trade barriers (Adriamananjara et al. 2003, 2004; CEPR 2013; Fox et al. 2003; Fugazza and Maur 2008; Walkenhorst and Yasui 2005). With the efficiency approach, the removal of trade costs is reflected as an increase in technology by introducing an additional effective import price that is a function of the observed import price and an exogenous unobserved technical coefficient (Francois 1999, 2001; Hertel et al. 2001, p. 13). The efficiency approach to modeling NTBs is also referred to as the "sand in the wheels" of trade or the "iceberg cost approach." Alternatively, rent-creating NTBs are incorporated into the GTAP model using the import-tariff or export-tax approach. Hence, a change in import tariffs or export taxes is simulated to account for the protection effect of NTBs. The "Altertax" program in the GTAP model enables users to implement NTBs as additional duties to the initial GTAP duties. Therefore, the partial or complete removal of import tariffs and/or export taxes reflects the effects of trade costs (Adriamananjara et al. 2003; Fox et al. 2003; Walkenhorst and Yasui 2005).

4.3.2 Experimental Design

In this article, we employ version 8 of the GTAP database. We combine the original 134 countries and regions and the original 57 sectors into a 23-sector, 10-region aggregation. We keep food and agricultural sectors separate and group non-food sectors into extraction, manufacturing and services. In the regional mapping, we single out the main country groups. Our sector and region aggregations are highlighted in Table 4.A1 in the Appendix.

The base year in version 8 of the GTAP database is 2007. We move the GTAP framework to 2020 because we assume that Turkey's membership in the EU will be concluded by then. Croatia's membership in the EU is established after 2007. With the help of a pre-experiment, we model the enlargement of the EU to include Croatia, and we include exogenous projections of GDP, population, technical progress and growth in factor endowments to incorporate economic developments until 2020. We source the data for the corresponding shocks from the Centre d'Études Prospectives et d'Informations Internationales, the UN and the World Bank. We disregard Turkey's free trade agreements (FTAs) after 2007 since Turkey would have to withdraw from any FTAs with third-party nations on its membership in the EU (European Commission 2014a; Turkish Undersecretariat of Foreign Trade 2014).

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[16] See https://www.gtap.org.

We then run two experiments using the AVEs of NTBs, which are calculated at different aggregation levels, namely, by using the AVEs of NTBs from the aggregated gravity approach (EXP1) and those from the disaggregated gravity approach (EXP2).[17] We consider the bilateral import tariffs and export subsidies between Turkey and the EU and Turkey's adaptation of the EU Customs Union's tariff level after becoming an EU member. In modeling the NTBs, we take the predominance of technical NTBs in the food and agricultural sectors into account by assuming that 75% of NTBs to the agro-food trade are technical NTBs. Hence, we model them using the efficiency approach.[18] The remaining 25% are assumed to be rent-creating NTBs, so they are implemented in the GTAP model by employing the import tariff modeling technique.[19] We also assume 1% of trade facilitation in non-food sectors due to our focus on the agro-food sector (Engelbert et al. 2014; Francois 2007).

4.3.3 Simulation Results: Welfare and Trade Effects

This section discusses the results of two experiments, EXP1 and EXP2, and we focus on the welfare and trade balance effects. We use the NTBs estimated with the gravity approach based either on aggregated data or disaggregated data to reveal the effect of different data aggregation levels on the policy simulation results. We present our results in millions of 2007 US$. GEMPACK (Version 11.0) and RunGTAP (Harrison and Pearson 1996) are used to perform the simulations. We adopt a fixed trade balance as macroeconomic closure in the enlargement simulations.

In Table 4.3, we present the welfare results of Turkey's potential membership in the EU. The simulation results in the first part of the table are based on the experiment using the aggregated data in the gravity estimation, whereas the second part of Table 4.3 displays the simulation results using the disaggregated data in the gravity estimation. The welfare results are also differentiated according to the gains that result from the reduction of NTBs or the removal of tariffs. We consider our first experiment, EXP1, as our reference situation. In the third part of the table, we therefore present the absolute and percentage deviations of EXP2 from EXP1. The percentage deviations are denoted in parentheses.

As expected, Turkey's inclusion in the EU results in unambiguous gains for both Turkey and the EU in both experiments. Turkey's total welfare gain amounts to 6.55 billion US$ in the first experiment whereas 5.87 billion US$ accrue to the EU. In EXP2, in which NTBs from the disaggregated gravity estimates are used, the welfare gains for Turkey and the EU are more limited but remain considerable (5.20 billion US$ and 5.49 billion US$, respectively). In EXP1, 0.89 billion US$ of welfare gain accrue to Turkey due to the bilateral removal of import tariffs between Turkey and the EU, and Turkey's adaptation of the EU Customs Union's

[17] We do not consider the re-aggregated AVEs of NTBs in our policy CGE experiment because of the additional aggregation bias we incorporate through the atheoretic trade weighting.

[18] An inspection of NTBs to trade between Turkey and the EU show that especially in the food and agriculture sector, the most frequent trade barriers are technical. They are imposed for food safety reasons, such as labeling, maximum residual limits, pesticide use, and genetically modified content. The remaining frequent NTBs are rent-creating and include quantitative restrictions as well as non-automatic and import licenses (European Commission 2014b; RASFF 2013; Önen 2008; Özdemir 2008; Teknikengel 2014). The predominance of technical NTBs, especially in the agro-food sector, is also common in the literature (Adriamananjara et al. 2003; Fugazza and Maur 2008).

[19] We only use efficiency and import tariff modeling of NTBs. We disregard export tax modeling since NTBs that are related to export prices, such as quantitative export restrictions, are not common in trade between Turkey and the EU except for the export restrictions on copper scrap (European Commission 2014c).

tariff level after becoming an EU member. The remaining 5.66 billion US$ stem from the reduction in NTBs. The greater welfare effects through the elimination of NTBs, as opposed to the abolition of tariffs, also applies to the EU (5.25 billion US$ vs. 0.62 billion US$). Similar welfare effects are observed in EXP2, in which the gains stemming from NTB reduction outweigh the gains resulting from bilateral tariff removal. Hence, the welfare effect of the removal of NTBs amounts to 4.30 billion US$ for Turkey and 5.00 billion US$ for the EU. Including Turkey in the EU also has welfare impacts on other countries. Asia in EXP1 and Latin America in EXP2 experience welfare losses due to the decrease in their agro-food imports to the EU. In both experiments, the overall welfare level of the Middle East and North Africa (MENA) and the Rest of the World (ROW) increase considerably. In both cases, those welfare gains can be predominantly traced to Turkey's adaptation of the EU Customs Union's tariff level.

Table 4.3: Welfare Results of the Enlargement Experiments (million US$)

	Turkey	EU	MENA	Asia	NorthAm	LatinAm	Oceania	SSA	ROW
EXP1									
NTBs from aggregated gravity estimates									
Total	6548	5867	629	-329	-468	-247	8	306	502
Tariffs	893	622	705	-422	179	358	36	187	749
NTBs	5655	5245	-262	247	-255	-356	-46	-27	-349
EXP2									
NTBs from pooled gravity estimates									
Total	5200	5485	452	-117	-221	-44	28	210	442
Tariffs	898	484	630	-33	255	200	53	157	755
NTBs	4302	5001	-359	249	-86	-292	-53	-63	-404
EXP1 - EXP2									
Total	1348	382	177	-212	-247	-203	-20	96	60
	(21)	(7)	(28)	(64)	(53)	(82)	(-250)	(31)	(12)
Tariffs	-5	138	75	-389	-76	158	-17	30	-6
	(-1)	(22)	(11)	(92)	(-42)	(44)	(-47)	(16)	(-1)
NTBs	1353	244	97	-2	-169	-64	7	36	55
	(24)	(5)	(-37)	-(1)	(66)	(18)	(-15)	(-133)	(-16)

* The numbers in brackets are the percentage deviations of EXP1 from EXP2. For instance, the percentage change in Turkey's total welfare level between EXP1 and EXP2 is equal to 21%.

Source: Authors' calculation.

As presented in Table 4.3, the transfer of aggregation bias from the econometric estimations to the GTAP level simulations creates differences between the welfare results of the two experiments. Using gravity estimates based on aggregated data results in higher welfare gains for both Turkey and the EU. However, especially for Turkey, deviations across experiments are higher (6.55 billion US$ vs. 5.20 billion US$ for Turkey and 5.87 billion US$ vs. 5.49 billion US$ for the EU). Higher differences between EXP1 and EXP2 for Turkey can be traced back to the predominance of the higher AVEs of NTBs in the gravity estimates using aggregated data (compare Table 4.1 and Table 4.2). Using EXP1 as our reference situation, total welfare effects deviate by 21% for Turkey and by 7% for the EU. For Turkey, the deviation across experiments that resulted from the reduction in NTBs (24%) is higher than the deviation due to the removal of tariffs (-1%). In contrast, the difference in welfare gains between EXP1 and EXP2 caused by NTB reduction for the EU is not highly pronounced (5%).

In Table 4.4, we present the impact of Turkey's membership in the EU focusing on the trade balance of the total agro-food sector and the 16 individual food and agricultural products. The first part of the table shows changes in the trade balance when NTBs stem from gravity estimates using aggregated data (EXP1). The second part demonstrates the effects of tariff and NTB reduction between Turkey and the EU when NTBs from the disaggregated gravity estimates are used (EXP2). The third part exhibits the absolute and percentage changes of EXP2 from the reference situation, EXP1.

Table 4.4: Trade Balance Results of Enlargement Experiments (million US$)

	EXP1 NTBs from aggregated gravity estimates			EXP2 NTBs from disaggregated gravity estimates			EXP1 - EXP2		
	Turkey	EU	ROW	Turkey	EU	ROW	Turkey	EU	ROW
Food and agricultural products	1598	-2350	-911	-162	-1856	897	1760	-494	-1808
							(110)	(21)	(198)
Wheat	-596	308	249	-559	277	245	-37	31	4
							(6)	(10)	(2)
Cereal grain	-478	306	136	-481	260	186	3	46	-50
							(-1)	(15)	(-37)
Paddy rice	-1	-10	10	-1	-10	11	0	0	-1
							(0)	(0)	(-10)
Vegetables, fruit and nuts	2412	-2621	-188	1838	-1808	-287	574	-813	99
							(24)	(31)	(-53)
Oil seeds	-44	438	-408	-45	324	-293	1	114	-115
							(-2)	(26)	(28)
Plant-based fibers	119	-8	-105	45	8	-54	74	-16	-51
							(62)	(200)	(49)
Crops	-32	45	-71	-578	-104	572	546	149	-643
							(-1706)	(331)	(906)
Other animal products	-272	332	-87	-195	254	-80	-77	78	-7
							(28)	(23)	(8)
Vegetable oils and fats	117	-444	229	-55	-466	412	172	22	-183
							(147)	(-5)	(-80)
Dairy	-2354	1617	593	-1526	963	465	-828	654	128
							(35)	(40)	(22)
Processed rice	-140	144	-21	-131	131	-17	-9	13	-4
							(6)	(9)	(19)
Sugar	1712	-1085	-669	1505	-894	-659	207	-191	-10
							(12)	(18)	(1)
Other food products	2156	-2180	-688	1358	-1389	-257	798	-791	-431
							(37)	(36)	(63)
Beverages and tobacco	-553	545	-68	-377	390	-70	-176	155	2
							(32)	(28)	(-3)
Cattle meat	-287	103	185	-864	120	720	577	-17	-535
							(-201)	(-17)	(-289)
Other meat	-161	160	-8	-96	88	3	-65	72	-11
							(40)	(45)	(138)

* The numbers in brackets are the percentage deviations of EXP1 from EXP2. For instance, the percentage change difference in Turkey's agro-food trade balance between EXP1 and EXP2 is equal to 110%.

** Originally, we differentiated between Switzerland, Norway, Croatia, Rest of EFTA, Rest of Eastern Europe, Rest of Europe, Belarus, Russian Federation, Ukraine, Kazakhstan, Kyrgyzstan, Armenia, Azerbaijan, Rest of Former Soviet Union, and Rest of the World (compare Table 4.A1 in the Appendix). To simplify, we aggregated all regions other than Turkey and the EU to ROW to present the results.

Source: Authors' calculation.

The aggregation level used to estimate NTBs with the gravity approach has different trade balance effects on Turkey, the EU, and the ROW. For instance, the results of EXP1 indicate that Turkey's membership in the EU causes an increase in Turkey's agro-food trade balance by 1.60 billion US$ when the aggregated gravity estimates are used to estimate the AVEs of NTBs. However, Turkey's agro-food trade balance decreases by 0.16 billion US$ according to the results of EXP2. Hence, the deviation between EXP1 and EXP2 amounts to 110%. The same effect of aggregation bias, and thus a deviation of 21%, is also observed for the EU agro-food trade balance. EU agro-food imports relative to exports decrease by 2.35 billion US$ in EXP1, whereas this decrease is smaller and is equal to 1.86 billion US$ in EXP2. As expected, Turkey's inclusion in the EU also has effects on other economies, but the direction and magnitude of the effect again differ according to the aggregation level that is used to estimate the AVEs of NTBs. For example, Turkey's membership to the EU has a negative effect on the ROW agro-food trade balance when NTBs from aggregated gravity estimates are used. However, the ROW trade balance in the food and agricultural sector increases when NTBs from gravity estimates using disaggregated data are input in the GTAP model. Here, the deviation amounts to 198%.

At the product level, the greatest changes to Turkey's and EU's agro-food trade balance are observed in the vegetables, fruits and nuts, dairy and other food products sectors in both experiments.
The changes in the trade balance of the separate food and agricultural sectors also drive the results for the total trade of food and agricultural products. This is particularly true for vegetables, fruits and nuts as well as other food products, which are highly exported from Turkey to the EU (GTAP database, version 8); NTBs are most frequently imposed in these sectors (European Commission 2014b; RASFF 2013, Önen 2008; Özdemir 2008; Teknikengel 2014). Following Turkey's membership in the EU, the imports of dairy products from the EU to Turkey increase and result in a rise in the EU dairy trade balance.

For EXP1, the largest increase, 2.41 billion US$, in Turkey's agro-food trade balance occurs in the vegetables, fruits and nuts sector. Remarkably, the increase in other food exports from Turkey is relative to its imports by 2.16 billion US$. In accordance with the relative increase in Turkey's exports of vegetables, fruits and nuts as well as other food products in EXP1, the EU trade balance in these sectors decreases by 2.62 billion US$ and 2.18 billion US$, respectively. For the EU, the highest increase in the agro-food trade balance occurs in dairy products (1.16 billion US$) accompanied by a decrease in Turkey's trade balance (2.35 billion US$). However, using the NTBs from the disaggregated gravity estimates leads to lower changes in the trade balances of Turkey and the EU for the vegetables, fruits and nuts, dairy and other food products sectors. In EXP2, Turkey's trade balance of the vegetables, fruits and nuts sector increases by only 1.83 billion US$, which corresponds to a deviation of 24% from the results of EXP1. The increase in the trade balance in other food products amounts to 1.36 billion US$ for Turkey in EXP2, so the deviation between EXP1 and EXP2 equals 37%. For dairy products, we calculate the EU trade balance changes in EXP2 to be equal to 0.96 billion US$, resulting in a deviation of 40% between EXP1 and EXP2. These differences clearly reveal the effects of aggregation bias, which stems from the econometric estimates of trade costs at different data aggregation levels and is particularly prominent in those two sectors. For instance, the AVE of NTBs for dairy products is estimated to be 84.14% with the aggregated gravity estimates, whereas the number equals 56.98% when disaggregated gravity estimates are used (compare Table 4.2). We also observe similar differences in the AVEs of NTBs for the vegetables, fruits and nuts sector (68.73% in EXP1 vs. 60.06% in EXP2). The only exception occurs in the other food products sector, in which the estimated AVE of NTBs is lower in the gravity estimates using aggregated data, but the reduction of the NTBs in this sector results in higher changes in the trade balance in EXP2.

The predominant assumption of aggregation bias in the CGE analysis is that a higher degree of sector disaggregation results in larger trade and welfare effects in the simulations performed with CGE models (e.g., Brockmeier and Bektasoglu 2014; Charteris and Winchester 2010; Grant et al. 2007, 2008; Narayanan et al. 2010a, 2010b). However, in previous studies, NTBs are not considered, and the AVEs of NTBs that are calculated at different aggregation levels are not compared. In our analysis, the overestimation of the CGE model traces back to the aggregation bias occurring in the estimates of AVEs of NTBs. As demonstrated by several authors, it is common to observe the overestimation effects of gravity estimates on trade costs using aggregated data (e.g., French 2012; Hillberry 2002; Hillberry and Hummels 2002). Because we use the exact same structure of the GTAP database in both experiments and only change the implemented AVEs of NTBs between our experiments, we observe the pure effects of aggregation bias from the gravity estimates in our results. Hence, our analysis is not comparable to existing studies analyzing the effect of data aggregation levels in CGE models.

4.4 Concluding Remarks

In this article, we focus on the importance of NTBs in the analysis of RTAs and the effect of aggregation bias on the estimation of the AVEs of NTBs. We explore the impact of different data aggregation levels on the estimation of the trade costs of NTBs. In addition, we reveal how the aggregation bias from the econometric estimates is transferred to the GTAP framework and thus affects the results of policy simulations analyzing Turkey's membership to the EU. In our analysis, we focus on food and agriculture. First, we infer the trade costs of NTBs for 15 aggregated GTAP sectors using the gravity approach and state-of-the-art econometrics. We apply the gravity model to aggregated and disaggregated data. We choose a model specification in which we capture all policy measures that reduce regulatory divergence and eliminate unnecessary restrictive NTBs in the European integration using a binary variable. We convert the missing trade in the absence of EU membership into a tariff equivalent using the theoretical model structure.

Our results show that AVEs of NTBs vary substantially across sectors, particularly when using disaggregated data. In addition, the AVEs of NTBs are significantly higher for some sectors when using aggregated data, indicating the overestimation effect of applying trade policies at the aggregated level. Considering average values, the AVEs of NTBs resulting from aggregated gravity estimations are approximately 60 percentage points higher than the AVEs of NTBs resulting from disaggregated gravity estimations. In terms of sectoral differences, the overestimation ranges from 11 to 635 percentage points.

Secondly, we incorporate the estimated AVEs of NTBs into the GTAP framework by using the efficiency and import tariff modeling approaches. In our experiments, we use both the disaggregated and the aggregated gravity estimates to reveal the extent to which the policy simulation results differ when different aggregation levels are used to estimate the AVEs of NTBs. The results of our two experiments show that Turkey's membership in the EU results in unambiguous welfare gains for both Turkey and the EU in both experiments. However, there are considerable differences between the experiments using NTBs from either aggregated gravity estimates (EXP1) or from disaggregated gravity estimates (EXP2). The deviations of EXP2 from EXP1 amount to 21% and 7% for Turkey's and the EU's welfare gains, respectively. Similar effects of aggregation bias are also observed in the trade balance results. The deviations between experiments for the agro-food trade balance of Turkey and the EU are equal to 110% and 21%, respectively. At the product level, the greatest differences between the results of the two experiments are observed in the trade balance of the vegetables, fruits and nuts, dairy and other food products sectors. This effect of aggregation bias clearly results from the predominance of higher levels of AVEs of NTBs obtained using aggregated data to the gravity approach. Therefore, using highly aggregated data to estimate the effects of NTBs predominantly results in an overestimation of trade costs. The effect of aggregation bias that already occurs in gravity estimations is then transferred to CGE simulations. Hence, we also obtain deviating results in the policy simulation conducted with the GTAP framework, which is especially observed at the sector level when different data aggregation levels are used to estimate the AVEs of NTBs.

In this article, we are able to confirm the importance of NTBs in the analysis of RTAs. Our results show that the welfare gains from the reduction of NTBs outweigh the gains from the elimination of import tariffs and export subsidies. Hence, the consideration of NTBs in trade policy analysis should not be disregarded. Second, we conclude that the aggregation level of the data influences the outcome of the estimation of the AVEs of NTBs considerably. The implementation of different values of estimated trade costs into the GTAP model directly affects policy simulation results. Consequently, researchers and policy makers should be aware of aggregation bias in the in-depth analysis of trade policies and be cautious when finding a compromise between spending resources to gather disaggregated data and inaccurate results.

4.5 Appendix

Table 4.A1: Regional and Sector Aggregation

	Regions		Sectors
1	Turkey	1	Paddy rice
2	European Union Austria, Belgium, Denmark, Finland, France, Germany, Ireland, United Kingdom, Greece, Italy, Luxembourg, Netherlands, Portugal, Spain, Sweden, Czech Republic, Hungary, Malta, Poland, Slovakia, Slovenia, Estonia, Latvia, Lithuania, Cyprus, Romania, Bulgaria	2	Wheat
3	Croatia	3	Cereal grains
4	Middle East and North Africa Bahrain, Kuwait, Oman, Qatar, Saudi Arabia, United Arab Emirates, Egypt, Morocco, Tunisia, Islamic Republic of Iran, Israel, Rest of North Africa, Rest of Western Asia	4	Vegetables and fruits
5	Asia China, Hong Kong, Japan, Korea, Mongolia, Taiwan, Cambodia, Indonesia, People's Democratic Republic of Lao, Malaysia, Philippines, Singapore, Thailand, Viet Nam, Bangladesh, India, Nepal, Pakistan, Sri Lanka, Rest of South Asia, Rest of Southeast Asia	5	Oil seeds
6	North America Canada, United States of America, Mexico, Rest of North America	6	Sugar cane, sugar beet
7	Latin America Argentina, Bolivia, Brazil, Chile, Colombia, Ecuador, Paraguay, Peru, Uruguay, Venezuela, Costa Rica, Guatemala, Honduras, Nicaragua, Panama, El Salvador, Caribbean, Rest of South America, Rest of Central America	7	Plant-based fibres
8	Oceania Australia, New Zealand, Rest of Oceania	8	Crops
9	Sub-Saharan Africa Cameroon, Cote d'Ivoire, Ghana, Nigeria, Senegal, Ethiopia, Kenya, Madagascar, Malawi, Mauritius, Mozambique, Tanzania, Uganda, Zambia, Zimbabwe, Botswana, Namibia, South Africa, Rest of African Customs Union, South Central Africa, Rest of Eastern Africa, Rest of Western Africa, Central Africa	9	Cattle
10	Rest of the World Switzerland, Norway, Croatia, Rest of EFTA, Rest of Eastern Europe, Rest of Europe, Belarus, Russian Federation, Ukraine, Kazakhstan, Kyrgyzstan, Armenia, Azerbaijan, Rest of Former Soviet Union, Rest of the World	10	Other animal products
		11	Raw milk
		12	Wool
		13	Sugar
		14	Processed rice
		15	Dairy
		16	Cattle meat
		17	Other meat
		18	Vegetable oils and fats
		19	Other food products
		20	Beverages and tobacco
		21	Extraction Forestry, fishing, coal, oil, gas, minerals not elsewhere specified (nec)
		22	Manufacturing Textiles, wearing apparel, leather products, wood products, paper products, publishing, metal products, motor vehicles and parts, transport equipment nec, petroleum, coal products, chemical, rubber, plastic products, mineral products nec, ferrous metals, metals nec., electronic equipment, machinery and equipment nec
		23	Services Electricity, gas manufacture, distribution, 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

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5 Keep Calm and Disaggregate: The Importance of Agro-Food Sector Disaggregation in CGE Analysis of TTIP

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Abstract

We explore the potential effects of the Transatlantic Trade and Investment Partnership (TTIP) between the European Union (EU) and the United States (US). We focus on non-tariff barriers (NTBs) in the agro-food sector and analyze the effect of different data aggregation levels using five different agro-food sector aggregation versions of the Global Trade Analysis Project (GTAP) database. Our policy simulation results show that a higher disaggregation level in computable general equilibrium (CGE) modeling predominantly results in higher trade and welfare effects. The deviations across experiments can be traced back to estimations of trade costs of NTBs at different levels of data aggregation, tariff averaging, and false competition. Our results indicate that the aggregation of tariffs is more important than applying the estimated ad valorem equivalents (AVEs) of NTBs at different data aggregation levels in explaining the biases found in the TTIP results. Thereby, tariff averaging appears to be more important than false competition in explaining the biases arising from tariff aggregation.

Keywords: TTIP; NTBs; CGE; GTAP; false competition; tariff averaging

JEL classification: D58; F15; Q17

5.1 Introduction

Over the last five decades, the multilateral trade negotiations of the General Agreement on Tariffs and Trade and of the World Trade Organization have led to a considerable reduction of tariffs. Accordingly, other trade measures, particularly non-tariff barriers (NTBs), have become a focus of researchers and policy makers. NTBs include a diverse range of instruments that directly or indirectly restrict trade. Because of their complex designs and lack of strict rules, negotiations in which NTBs are addressed on a multilateral level are both a tedious and resource-intensive process. Countries are more optimistic about the potential to overcome trade restriction in the form of NTBs if they are considered within free trade agreements (FTAs). In fact, NTBs are one of the most important points in FTA treaties because future trade and welfare gains are expected through the reduction of restrictive NTBs and the harmonization of regulatory systems.

The number of FTAs has increased dramatically in recent decades. However, the scope and depth of topics and trade aspects involving NTBs has also increased. One of the most prominent and ambitious FTAs is the currently negotiated Transatlantic Trade and Investment Partnership (TTIP) between the European Union (EU) and the United States (US). NTBs in food and agricultural products play an especially important role in the TTIP because European and American consumers appear to have rather different, and at times seemingly opposing, positions toward the production and consumption of food. Most studies on the potential effects of the TTIP using a computational general equilibrium (CGE) model consider only an aggregated food and agricultural sector, although it is well known that trade barriers in the agro-food sector are highly relevant for the overall impact of an FTA. How would the outcome of the TTIP policy simulation change if different disaggregated agro-food sectors were used? Which factors explain the aggregation bias? Is one of these factors more important than the other factors?

The importance of the data disaggregation level in CGE models and the effect of aggregation bias on the simulation results have been emphasized by several authors (e.g., Alexeeva-Talebi et al., 2012; Brockmeier and Bektasoglu, 2014; Charteris and Winchester, 2010; Grant, Hertel and Rutherford, 2007, 2008). Narayanan, Hertel and Horridge (2010a, 2010b) also compare the results of a partial equilibrium (PE) model constructed using disaggregated data with the results of a general equilibrium (GE) model developed using aggregated data and an integrated model that links these PE and GE models. Nielsen (1999) compares six models aggregated at varying sector levels with different closures. However, these approaches do not allow the effects of sectoral breakdown to be isolated. To the best of our knowledge, only Alexeeva-Talebi et al. (2012) and Brockmeier and Bektasoglu (2014) use two different versions of the same CGE model that are aggregated at different sector levels to reveal aggregation bias.

However, the effect of different sector aggregation levels by simultaneously considering NTBs, import tariffs and export subsidies in an FTA policy simulation is not found in the literature. Against this backdrop, we create five differently aggregated versions of the Global Trade Analysis Project (GTAP) database that differ according to the number of agro-food sectors and use them as a foundation for our two-step analysis. First, we calculate the ad valorem equivalents (AVEs) of NTBs using the gravity approach for all sectors according to the five versions of the GTAP database. In the second step, we implement the NTBs in the GTAP model and perform the policy experiments with the GTAP model by simultaneously reducing bilateral tariffs and NTBs between the EU and the US in all simulations using the differently aggregated versions of the GTAP database. With this approach, we are not only able to quantify the aggregation bias, but we also identify the factors that contribute most to the deviation of the simulation results.

This paper is organized as follows. Section 5.2 is divided into two subsections. The first subsection provides an overview of the estimation of NTBs with the gravity model, and the second subsection introduces the modeling of NTBs in the GTAP model. In Section 5.3, we present our results by focusing on welfare and trade effects, and we consider the reasons for aggregation bias. Section 5.4 concludes and summarizes our findings.

5.2 Methodological Framework

The analysis in this paper uses the GTAP modeling framework. The GTAP model is a comparative static multi-region general equilibrium model that is well documented in Hertel (1997) and is available on the Internet [20]. The GTAP database is aggregated into five versions that cover different levels of the agro-food sector. In the first step of the empirical analysis, we use estimates from gravity modeling to compute the AVEs of NTBs that are implemented in the second step, which involves the CGE simulations of a deep FTA between the EU and US based on the five differently aggregated versions of the GTAP database. In the FTA policy scenarios, we consider the simultaneous reduction of tariff and non-tariff trade barriers. With this two-step analysis, we attempt to capture the FTA negotiations using model versions based on different database aggregations. To reveal aggregation bias, we compare the performance of estimates and simulations at different aggregation levels.

Version 9 of the GTAP database (March, 2014) covers 57 sectors in 140 regions. The five differently aggregated versions of the GTAP database are created by focusing on the food and agricultural sectors to quantify the effect of aggregation level on the CGE analysis. The versions differ according to the level of agro-food sectors but employ identical sector aggregation in terms of non-food sectors, i.e., manufacturing, extraction and services. Table 5.1 exhibits the sector aggregation of the food and agricultural sector of the differently aggregated versions of the GTAP database. The first version of the GTAP database, version AGG, is highly aggregated and covers a single agro-food sector in which 20 food and agricultural sectors are combined. The DIS1 version of the GTAP database covers two food and agricultural sectors by combining raw agriculture and processed food. The DIS2 version covers four agro-food sectors, i.e., crops, grains, livestock and meat products, and processed food. The third version of the GTAP database, version DIS3, is more disaggregated and is mapped to 10 food and agricultural sectors. The DIS4 version has the highest disaggregation level and separately covers 20 food and agricultural sectors of the GTAP database. In all differently aggregated versions of the GTAP database, the regions are grouped into the EU, the US, Canada, Japan, Korea, the high-income countries, China, India, Brazil, Mexico, Turkey, Central America, Eastern Europe, North Africa, the Association of Southeast Asian Nations, Mercosur, Bangladesh, Mozambique, the least developed countries, and the rest of the world (ROW) .

[20] See https://www.gtap.org

Table 5.1: Aggregation of Food and Agricultural Sectors in Differently Aaggregated Versions of the GTAP Database.

Version name	Sectors in the version	Number of agro-food sectors	Subsectors in the aggregation
AGG	Agro-food	1	Paddy rice, wheat, cereal and grains, vegetables, fruit and nuts, oil seeds, sugar beet and cane, plant-based fibers, other crops, cattle, pork and poultry, beverages and tobacco, other animal products, raw milk, wool, other food, sugar, processed rice, dairy products, vegetable oils and fat, other meat, beef
DIS1	Raw agriculture	2	Paddy rice, wheat, cereal and grains, vegetables, fruitand nuts, oil seeds, sugar beet and cane, plant-based fibers, other crops, cattle, raw milk, wool
	Processed food		Pork and poultry, beverages and tobacco, other food, sugar, processed rice, dairy products, vegetable oils and fats, other meat, beef
DIS2	Crops	4	Paddy rice, vegetable, fruit and nuts, oil seeds, sugar beet and cane, plant-based fibers, other crops
	Grains		Wheat, cereal and grains
	Meat and other livestock		Cattle, pork and poultry, raw milk, wool, other meat, beef
	Processed food		Other food, sugar, dairy products, vegetable oils and fats, beverages and tobacco, processed rice
DIS3	Sugar	10	Sugar beet and cane, sugar
	Rice		Paddy rice, processed rice
	Cattle and beef		Cattle, beef
	Other meat		Pork and poultry, other meat
	Dairy		Dairy products, raw milk
	Vegetable oils		Oil seeds, vegetable oils and fats
	Fruits and crops		Vegetables, fruit and nuts, other crops
	Grains		Wheat, cereal and grains
	Other food and beverages		Other food, beverages and tobacco
	Textile fibers		Plant based fibers, wool
DIS4	Paddy rice	20	
	Wheat		
	Cereal and grains		
	Vegetables, fruit and nuts		
	Oil seeds		
	Sugar beet and cane		
	Plant-based fibers		
	Other crops		
	Cattle		
	Pork and poultry		
	Raw milk		
	Wool		
	Beverages and tobacco		
	Other food		
	Sugar		
	Processed rice		
	Dairy products		
	Vegetable oils and fat		
	Other meat		
	Beef		

Source: Authors' illustration.

5.2.1 Estimation of NTBs Using the Gravity Model

We estimate the trade effects of NTBs by applying the theory-consistent gravity model. The gravity model has become a strong tool for empirical analysis of the patterns of trade and the effects of trade agreements and barriers.[21] For our analysis, we implement the structural gravity-like equation developed by Anderson

[21] See Anderson (2011) and Head and Mayer (2013) for a thorough review of the theoretical and empirical developments of the gravity model.

and van Wincoop (2003, 2004), which accounts for general equilibrium effects of trade barriers. This basic model explains bilateral trade according to the exporter's production and importer's consumption relative to global output. Trade is restricted by bilateral trade barriers and by average trade barriers. Both types of barriers are governed by the elasticity of substitution. The average trade barriers are also known as multilateral resistance terms.

Empirically, the average trade barriers can be fully controlled by time-varying country-specific effects. Because bilateral trade frictions are not observable, they are defined as a function of the observed trade cost factors. Generally, a set of geographical, political and cultural adjacency variables are included in the cost function. To identify the trade costs of NTBs that are reasonable for reduction in a potential FTA between the EU and the US, we consider an indirect approach. An FTA variable aids in capturing the positive trade effects resulting from the elimination or reduction of NTBs within FTAs on average (Chen and Novy, 2010). In addition to the FTA dummy variable, we include two interaction terms between the FTA dummy variable and the EU and US importer dummy variables to identify asymmetric trade creation effects of EU and US trade agreements. The final empirical specification in multiplicative form reads as follows:

$$\begin{aligned} Imports_{ijt} = exp\Big(& \alpha_{it} + \alpha_{jt} + \beta_1 \ln Dist_{ij} + \beta_2 Landlocked_{ij} + \beta_3 Island_{ij} + \beta_4 Contig_{ij} \\ & + \beta_5 Language_{ij} + \beta_6 Colony_{ij} + \beta_7 Colonizer_{ij} + \beta_8 EU_{ij} + \beta_9 NAFTA_{ij} \\ & + \beta_{10} \ln Tariff_{ijt} + \delta_1 FTA_{ijt} + \delta_2 FTA_{i,EU,t} + \delta_3 FTA_{i,USA,t} \Big) \end{aligned} \qquad (2)$$

where $Imports_{ijt}$ is the value of trade from country i to country j in year t, α_{it} is the fixed effect of the exporting country in year t and α_{jt} is the fixed effect of the importing country in year t accounting appropriately for general equilibrium effects. Because country-time specific effects are controlled for, only country-pair effects enter the model. Geographical adjacency is captured by the population-weighted distance in km between the two countries in logarithmic form ($lnDist_{ij}$) and by three dummy variables that take on the value of one if at least one country is landlocked (*Landlocked*) or is an island (*Island*) or if the two countries share a common land border (*Contig*). The dummy variables *Language*, *Colony* and *Colonizer* take on the value of one if a common language is spoken by at least 9% of the population in both countries, for pairs of countries that have ever been in colonial relationship and for a common colonizer after 1945, respectively. To capture trade policy effects, we include the bilateral tariff in logarithmic form ($lnTariffi_{jt}$) and an *EU* dummy variable that takes on the value of one if both countries are EU members. The *NAFTA* dummy variable takes on the value of one if both countries are NAFTA members. Furthermore, β_1 through β_{10} are the coefficients of the explanatory variables. The binary variable *FTA* takes on the value of one if both countries are in the same FTA. The interaction terms FTA_{iEUt} and FTA_{iUSt} are equal to one if the importers in the FTA are the EU and US, respectively, and zero otherwise. The coefficient δ_1 represents the average effect of a typical FTA, whereas δ_2 and δ_3 indicate EU and US behavioral deviations from the average FTA effect, respectively.

We interpret the average FTA effect as δ_1=(σ-1)ln(1+AVE_{FTA}), where σ=(β_{10}+1) is the elasticity of substitution and AVE_{FTA} is the trade cost equivalent of a typical FTA. We apply the gravity equation to the sectors for each version of the GTAP database presented in Table 5.1. The most important parameters for our analysis are the coefficients of the FTA variable, the interaction terms and the tariff elasticity. We apply the Poisson Pseudo Maximum Likelihood (PPML) estimator proposed by Santos Silva and Tenreyro (2006, 2011) to address the problems of zero trade flows and heteroskedasticity in trade data.

We source data on bilateral imports according to the sectors of the differently aggregated versions of the GTAP database from the United Nations Commodity Trade Statistics (UN COMTRADE) database and the applied tariff rates from the United Nations Conference on Trade and Development (UNCTAD) Trade Analysis and Information System (TRAINS) database for 2010, 2011 and 2012. The information on distance, landlocked status, island, contiguity, common language and colonial relationships is sourced from the Centre D'Etudes Prospectives et D'Informations Internationales (CEPII). Finally, the FTA variable is taken from de Sousa (2014). Data unavailability leads to an unbalanced panel setting analysis, but subsequent regressions with a balanced panel setting revealed no significant differences.

5.2.2 Modeling of NTBs in the GTAP Model and Experimental Design

In analyzing the TTIP, we implement the reduction of trade costs of NTBs in the GTAP framework using the iceberg cost approach first developed by Francois (1999, 2001) and subsequently extended by Hertel, Walmsely and Itakura (2001a, 2001b). The iceberg cost approach is predominantly preferred in modeling of technical NTBs (e.g., Fugazza and Maur, 2008; Adriamananjara, Ferrantino and Tsigas, 2003). Chang and Hayakawa (2010); Engelbert, Bektasoglu and Brockmeier (2014); Philippidis and Carrington (2005); Philippidis and Sanjuán (2006, 2007); and Winchester (2009) have also applied the iceberg cost approach to include the estimated AVEs of NTBs in CGE models.[22] In this approach, NTBs are modeled as unobserved trade costs that are not explicitly covered by the GTAP database. The removal of trade costs is reflected as progress in technical change by introducing an additional effective import price that is a function of the observed import price and an exogenous unobserved technical coefficient. Hence, the removal of trade costs mirrors a reduction in the effective import price induced by technical change. Accordingly, a decrease in the effective import price leads to an increase in the effective imported quantity. In other words, using import-augmenting technology shocks, the real resource cost-increase effect of NTBs is abolished (Hertel, Walmsley and Itakura, 2001a, p. 13). The iceberg cost approach is also known as the "efficiency approach" because NTBs are treated as efficiency losses that hinder trade.

Simulations are based on the same versions of the GTAP database that were used in the econometric component of our analysis. Accordingly, we use version 9 of the GTAP database with base year 2011. To simulate the TTIP between the EU and the US, we apply the GTAP model to move the GTAP database to 2030. We assume that the negotiations on the TTIP will be concluded and the agreement will be in force by that time. Croatia's membership in the EU has been established since 2013. Hence, with the aid of a pre-experiment, we model the enlargement of the EU to include Croatia. Moreover, to consider the economic developments up to 2030, we include exogenous projections of GDP, population, and technical progress as well as growth in factor endowments. We source the data for the corresponding shocks from CEPII, the UN and the World Bank. In all versions of the GTAP database, we consider the simultaneous bilateral removal of import tariffs and export subsidies as well as the reduction of NTBs between the EU and the US. Due to our focus on the food and agricultural sector, we apply a general approach for the non-food sector. In this work, we follow

[22] It is also possible to model NTBs using import tariff and export-tax modeling approaches. However, these methods are mostly preferred for rent-creating NTBs rather than technical NTBs. Due to our focus on the agro-food sector and the frequency of technical NTBs in this sector, we prefer to use the iceberg cost approach in our analysis. Some studies have used a combination of iceberg cost, import tariff and export tax methods to account for the diverse impacts of NTBs (e.g., Adriamananjara, Ferrantino and Tsigas, 2003; Adriamananjara et al., 2004; Fox, Francois and Londono-Kent, 2003; CEPR 2013, Fugazza and Maur, 2008; Walkenhorst and Yasui, 2005).

Francois (2007) and Engelbert, Bektasoglu and Brockmeier (2014) and assume a 1% trade facilitation in non-food sectors.

5.3 Results

This section first discusses the results of the estimates of NTBs and second covers the simulation results using the previously discussed versions AGG, DIS1, DIS2, DIS3 and DIS4 by focusing on the welfare and trade balance effects. We present our simulation results in millions of US$ for the year 2011. GEMPACK (Version 11.0) and RunGTAP (Harrison and Pearson, 1996) are used to perform the simulations. We adopt a fixed trade balance as macroeconomic closure in the enlargement simulations.

5.3.1 Estimates of NTBs

In Table 5.2, we display the estimated elasticity of substitution and the AVEs of NTBs that the EU and the US are expected to reduce within the TTIP accompanied by the mean values and coefficients of variation.[23] With respect to the existing heterogeneity of the EU and the US in their attitudes concerning preference arrangements and trade liberalization within FTAs, we take into account the cumulative effect by combining the typical FTA effect and the importer-specific FTA effect given the joint significance of the two parameters. If the estimates are only individually significant, we take either the typical FTA quantity effect and conclude that EU and US agreements are not different compared with a typical FTA or we take only the importer-specific FTA quantity effects and conclude that the EU and US agreements have an effect that is not observed in a typical FTA.[24] If the final quantity effect is negative, we assume no effect of the FTA for the EU and US in terms of NTB reduction or harmonization of standards and regulations.[25] This situation is more often the case for the US (19 times) than for the EU (7 times), revealing that the US is more restrictive in reducing NTBs or harmonizing regulations and standards. In general, the high number of agro-food sectors excluded from the full liberalization schedule is typical, particularly for the more disaggregated sectors considered in our analysis. The high rate of sector exclusion also fits with the differentiated special treatment in the agriculture agreements across countries (Pasadilla, 2009; Shearer, Almeida and Gutierrez, 2009). Specifically, this result reflects the behavior of the EU and US in past FTA negotiations in which such sensitive sectors as sugar, rice and dairy were not or were only partially liberalized primarily as result of historical factors and political sensitivity (European Commission, 2014a; ICTSD, 2009; USTR, 2014). In addition, sectors that are minimally traded, such as cattle, sugar cane and beet and paddy rice, exhibit zero or notably low AVEs of NTBs.

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23 Detailed panel PPML gravity estimates are available upon request from the authors.

24 If both the cumulative and the individual effects are not significant, we consider the average quantity effect from the agro-food sector regression of version AGG. We proceed in the same manner if the tariff elasticity is not significant.

25 It is important to note that the presented estimates on AVEs of NTBs do not illustrate the actual level of non-tariff protection. These values represent trade costs, which are expected to decrease in the FTA between the EU and US. It is not possible to conclude whether the EU and US have a high level of NTBs.

Table 5.2: Estimation Results for the Easticity of Substitution and AVEs of NTBs

Version name	Sectors in the version	Elasticity of substitution			EU			US		
		Value	Mean value	Variation coefficient	AVEs of NTBs	Mean value	Variation coefficient	AVEs of NTBs	Mean value	Variation coefficient
AGG	Agro-food	7.40	7.40	-	3.62	3.62	-	2.61	2.61	-
DIS1	Raw agriculture	4.91	6.26	0.31	7.56	4.78	0.82	16.17	8.09	1.41
	Processed food	7.61			2.00			0.00		
DIS2	Crops	5.37			5.34			16.46		
	Grains	7.40	5.62	0.41	4.11	10.65	1.41	30.25	34.01	1.14
	Meat and other livestock	2.50			32.86			89.34		
	Processed food	7.23			0.27			0.00		
DIS3	Sugar	7.40			10.41			0.00		
	Rice	8.96			2.90			0.00		
	Cattle and beef	3.62			9.06			66.96		
	Other meat	2.41			33.25			12.40		
	Dairy	6.27	7.11	0.49	0.00	7.46	1.33	0.00	12.32	1.76
	Vegetable oils	6.34			0.00			0.00		
	Fruits and crops	4.93			1.88			13.58		
	Grains	7.40			3.62			30.25		
	Other food and beverages	8.60			3.07			0.00		
	Textile fibers	15.12			10.45			0.00		
DIS4	Paddy rice	15.04			1.63			1.18		
	Wheat	7.40			33.92			35.99		
	Cereal and grains	7.40			3.62			34.15		
	Vegetables, fruit and fruits	6.64			2.04			14.18		
	Oil seeds	7.40			0.00			20.73		
	Sugar beet and cane	0.00			0.00			0.00		
	Plant-based fibers	7.40			31.46			0.00		
	Other crops	7.40			2.84			2.15		
	Cattle	7.40			3.62			0.00		
	Pork and poultry	2.53	6.29	0.53	44.83	9.45	1.40	0.00	10.87	1.82
	Raw milk	0.00			0.00			0.00		
	Wool	7.40			15.27			14.54		
	Beverages and tobacco	7.13			1.16			0.00		
	Other food	8.23			3.23			0.00		
	Sugar	7.40			10.29			0.00		
	Processed rice	7.75			3.43			0.00		
	Dairy products	6.27			0.00			0.00		
	Vegetable oils and fat	7.40			0.00			0.00		
	Other meat	2.14			22.12			15.61		
	Beef	3.50			9.51			78.81		

Source: Authors' calculation.

In computing FTA negotiations on NTBs at different data aggregation levels, we observe an interesting pattern in the results. If the AVEs of NTBs of higher-level sectors are estimated as zero, then the estimated AVEs of NTBs of the corresponding lower-level sectors are mostly zero. An example would be the aggregated processed food sector in version DIS1. According to our results, the US would not give any concessions on NTBs in the processed food sector (DIS1). In compliance, the respective disaggregated sectors would not be issued in the FTA from a US point of view. Our estimation results indicate that the US would exclude many sectors from negotiations. Nevertheless, we find that the average AVEs of NTBs for reduction are higher for the US than for the EU in each version of the GTAP database. One exception is given for the AGG version, in which the EU AVEs of NTBs are one percentage point higher.

5.3.2 Welfare Effects

In Table 5.3, we present the welfare effects induced by the formation of the TTIP. We present results for the EU, the US and ROW for five versions. In the first row, the results are based on the most aggregated version of the GTAP database, i.e., AGG, as exhibited in Table 5.1. The level of sector disaggregation increases from top to bottom. Hence, in the last row, we present the welfare results of DIS4, in which the highest agro-food sector disaggregation level is used. Correspondingly, we also select DIS4 as our reference situation because it has the highest sector disaggregation. We also differentiate the results according to the effects stemming from the removal of import tariffs and the reduction of NTBs on agro-food and on non-food sectors. The numbers in brackets in Table 5.3 indicate the percentage deviations of results from the reference situation DIS4 based on simulations with differently aggregated versions of the GTAP database.

The results of the TTIP simulations are as expected and indicate welfare gains for both the EU and the US for all versions of the GTAP database. The welfare gain accruing to the EU ranges from 7.46 billion US$ (AGG) to 9.19 billion US$ (DIS4), whereas the US welfare gain due to the FTA is higher (12.37 billion US$ in AGG and 13.59 billion US$ in DIS4). In all experiments, the welfare gains resulting from the removal of agro-food NTBs outweigh the gains due to the reduction of import tariffs for the EU. However, for the US, the bilateral elimination of import tariffs on the food and agricultural sector leads to higher welfare gains than the reduction of NTBs. This effect of the elimination of import tariffs results from the high initial tariffs on US agro-food imports from the EU. In all experiments, the high share of non-food trade between the EU and the US (European Commission, 2014b) results in considerable welfare gains when NTBs and tariffs are eliminated between the TTIP partners. The TTIP has a negative effect on the welfare level of the Rest of the World (ROW) due to trade diversion.[26]

[26] Trade diversion effects of the TTIP on third countries can be lower if spillover effects of the TTIP are considered in the simulations (CEPR, 2013).

Table 5.3: Welfare Effects Resulting from TTIP Simulations Based on Differently Aggregated GTAP Databases (million US$)

	EU					US					ROW				
	Total	NTB		Tariff		Total	NTB		Tariff		Total	NTB		Tariff	
		agro_food	non_food	agro_food	non_food		agro_food	non_food	agro_food	non_food		agro_food	non_food	agro_food	non_food
AGG	7461	996	7111	-769	123	12369	1100	6738	2433	2098	-7254	-188	-3863	-873	-2330
	(19)	(38)	(0)	(288)	(-16)	(9)	(-3)	(0)	(33)	(3)	(4)	(11)	(-3)	(37)	(-6)
DIS1	7443	952	7093	-725	123	12892	937	6711	3132	2112	-7426	-34	-3805	-1424	-2163
	(19)	(40)	(0)	(277)	(-16)	(5)	(12)	(0)	(14)	(3)	(1)	(84)	(-1)	(-3)	(1)
DIS2	8626	1639	7138	-298	147	11955	839	6782	2148	2186	-6918	186	-3852	-947	-2305
	(6)	(-3)	(-1)	(173)	(-39)	(12)	(21)	(-1)	(41)	(-1)	(8)	(188)	(-3)	(31)	(-5)
DIS3	8552	1411	7123	-70	88	13454	1118	6780	3373	2183	-7448	-136	-3795	-1310	-2207
	(7)	(12)	(-1)	(117)	(17)	(1)	(-5)	(-1)	(7)	(-1)	(1)	(36)	(-1)	(5)	(-1)
DIS4	9194	1597	7082	410	106	13593	1063	6724	3637	2169	-7534	-212	-3752	-1381	-2189
	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–

Notes: The numbers in parentheses are the percentage deviations of results based on simulations with differently aggregated versions of the GTAP database from the reference situation, i.e., version DIS4. For instance, the percentage deviation in the EU welfare level between AGG and DIS4 is equal to 19%. For reasons of simplification in evaluating the results, we aggregated all regions other than the EU and the US to ROW. For the original mapping of ROW, please compare Table 5.A1 in the appendix.

Source: Authors' calculation.

Due to aggregation bias, we are able to clearly identify deviations among the welfare results of the experiments. For instance, when the agro-food sector is treated as a single sector (AGG), the welfare gain accruing to the EU amounts to 7.46 billion US$. However, as the level of disaggregation increases, the total welfare gain of the EU increases as well. Hence, in the DIS4 version of the GTAP database, in which 20 agro-food sectors are separately covered, 9.19 billion US$ accrues to the EU. Referring to DIS4 as our reference situation, version AGG deviates by 19% in terms of welfare effects of TTIP on the EU. The welfare effects stemming from the reduction of agro-food NTBs also show high deviations across experiments, and in particular, the deviations of versions AGG and DIS1 from DIS4 amount to 38% and 40%, respectively. Similar effects due to different data aggregation levels are observed once tariffs on the food and agricultural sector are removed between the EU and the US. The bilateral elimination of all import tariffs results in a decrease in EU welfare level by 0.77 billion US$ if simulations are based on the highly aggregated version of the GTAP database (AGG). However, using the most disaggregated version of the GTAP database (DIS4) results in a welfare gain of 0.41 billion US$ for the EU. In this work, the deviation of version AGG from version DIS4 is equal to 288%.

For the US, the percentage deviation in welfare changes of version AGG from version DIS4 is lower than that observed for the EU across simulations but remains considerable at 9% (12.37 billion US$ vs. 13.59 billion US$). As noted above, for the US, the welfare gains resulting from the removal of bilateral import tariffs on the agro-food sector are higher than the gains stemming from the reduction of NTBs on the agro-food sector. Hence, substantial differences exist across experiments in terms of welfare gains, which can be traced back to the bilateral tariff elimination in the agro-food sector. Here, the deviations of AGG and DIS2 from DIS4 are 33% and 41%, respectively. The differences in welfare effects stemming from the reduction of agro-food NTBs are most pronounced between DIS2 and DIS4 and result in a deviation of 21%. We do not note considerable deviations across experiments for the non-food sector, both for the US and for the EU, because we use the same level of sector disaggregation of non-food sectors in all versions of the GTAP database.

Moreover, the total welfare effect of the TTIP on third countries shows high divergences across simulations for the agro-food sector, for which the highest difference of 37% is observed between AGG and DIS4 when the bilateral tariffs on the agro-food sector between the EU and the US are removed. In contrast, the reduction of non-food tariffs and elimination of NTBs do not result in extensive differences for ROW across differently aggregated versions of the GTAP database.

5.3.3 Trade Effects

Table 5.4 reports the changes in the trade balance of the aggregated agro-food sector for the selected regions across different simulations. Again, we select DIS4 as our reference situation in the discussion of our results. Hence, Table 5.4 also indicates the absolute and percentage deviations (given in parentheses) of versions AGG, DIS1, DIS2 and DIS3 from the reference situation DIS4. To be able to compare the results across differently aggregated versions of the GTAP database, we add the results based on different data aggregation levels to the single agro-food sector, which is given in the AGG version.

In general, the TTIP between the EU and the US results in a decrease in the EU agro-food trade balance, whereas the US experiences an increase in its agro-food trade balance. The decrease in EU food and agricultural exports relative to its imports range from 10.97 billion US$ (AGG) to 12.81 billion US$ (DIS4). For the US, the increase in the agro-food trade balance amounts to 8.26 billion US$ in the AGG version, but it is equal to 11.47 billion US$ in simulations based on the version DIS4 of the GTAP database. The TTIP also has effects on third countries. However, the direction of the effect in the agro-food trade balance of third countries shows a mixed picture according to the different versions. In general, Turkey and the Eastern European (EEU) countries experience decreases in their agro-food trade balance in all versions of the GTAP database, whereas in Canada, China, Mexico, and ROW, the trade balance of agro-food products always increases.

The use of different data aggregation levels has considerable effects on the agro-food trade balances of the EU and the US. Predominantly, the changes in trade balance are greater as the level of disaggregation increases. However, the highest absolute and percentage change difference across experiments is observed between versions DIS2 and DIS4 for both the EU and the US. Moreover, the trade effects that occur in DIS2 are considerably higher than the trade effects estimated with DIS3. As noted above, the magnitude of the effects of trade balances of the TTIP on third countries differs according to the aggregation level used.

Aggregation bias also has diversion impacts on different countries. For instance, the deviation between the most aggregated and most disaggregated versions of the GTAP database is the highest for Japan, ROW, and China, with values of -918%, -225% and -173%, respectively. The following sections shed light on the reasons behind these deviations.

Table 5.4: Changes in the Agro-Food Trade Balance Resulting from TTIP Simulations Based on Differently Aggregated GTAP Databases (million US$)

	EU	US	Canada	Japan	Korea	China	India	Mexico	Turkey	EEU	ROW
AGG	-10966	8261	300	290	-45	796	-88	366	-105	-122	905
DIS4 - AGG	-1846	3210	0	-262	-58	-504	-19	-183	-4	-21	-626
%	(14)	(28)	(0)	(-918)	(56)	(-173)	(18)	(-101)	(3)	(14)	(-225)
DIS1	-10571	9135	230	146	-87	444	-140	194	-92	-134	356
DIS4 - DIS1	-2242	2335	69	-118	-16	-153	33	-12	-16	-8	-78
%	(17)	(20)	(23)	(-414)	(16)	(-52)	(-30)	(-7)	(15)	(6)	(-28)
DIS2	-6440	5616	102	57	-52	290	-128	93	-77	-109	140
DIS4 - DIS2	-6373	5854	197	-29	-51	1	20	89	-32	-34	139
%	(50)	(51)	(66)	(-100)	(50)	(0)	(-19)	(49)	(29)	(24)	(50)
DIS3	-13027	11508	234	61	-100	337	-110	175	-90	-123	408
DIS4 - DIS3	215	-38	65	-33	-3	-46	3	7	-18	-19	-130
%	(-2)	(0)	(22)	(-116)	(3)	(-16)	(-3)	(4)	(17)	(13)	(-47)
DIS4	-12812	11470	299	28	-103	291	-108	182	-108	-142	278
	–	–	–	–	–	–	–	–	–	–	–
	–	–	–	–	–	–	–	–	–	–	–

Notes: The numbers in parentheses are the percentage deviations of results based on simulations with differently aggregated versions of the GTAP database from the reference situation of version DIS4. Our original regional mapping covers 21 countries and regions (compare Table 5.A1 in the appendix). However, for reasons of simplification, we only select countries that experience the highest changes in agro-food trade balance.

Source: Authors' calculation.

5.4 Reasons for Aggregation Bias in the Simulation Results

The simulations conducted with different versions of the GTAP database, which differ according to the data aggregation level in the agro-food sector, indicate a considerable impact of the aggregation level on the simulation results of the TTIP. Table 5.5 is included to reveal the extent to which NTB reduction and tariff elimination contribute to the deviation of welfare results. This table reports the welfare changes for the EU, US, ROW and the world induced by the TTIP for the five versions of the GTAP database. The welfare effects are differentiated according to the effects resulting from the reduction of NTBs and the elimination of import tariffs. Moreover, the absolute and percentage deviations of versions AGG, DIS1, DIS2, and DIS3 from version DIS4 are included. The contributions of NTB reduction and tariff removal to the deviation of results across versions are also given separately. Table 5.5 demonstrates that the contribution of tariffs to the deviation of results across experiments with differently aggregated GTAP databases is always higher for the EU, US, and the world. For instance, the deviation of version AGG from our reference situation, i.e., version DIS4, initiated by tariff elimination is equal to 67% for the EU, whereas the change in NTBs contributes only 23%. For versions DIS2 and DIS3, the contributions of tariffs to deviation of results amount to 117% and 78%, respectively, and again, the change in NTBs is less important. For the US and the world, similar effects of tariff elimination are observed. Hence, in general, the aggregation of tariffs is more important than application of the AVEs of NTBs that are estimated at different data aggregation levels for the biases that occur in the TTIP simulations.

Table 5.5: Contribution of NTB Reduction and Tariff Elimination to the Deviation of Welfare Results in Simulations with Differently Aggregated GTAP Databases (million US$)

	World Total	NTBs	Tariffs	EU Total	NTBs	Tariffs	US Total	NTBs	Tariffs	ROW Total	NTBs	Tariffs
AGG	12576	11894	682	7461	8107	-646	12369	7838	4531	-7254	-4051	-3203
DIS4 - AGG	2678	608	2070	1734	572	1162	1224	-51	1275	-280	87	-367
%		(23)	(77)		(33)	(67)		(-4)	(104)		(-31)	(131)
DIS1	12909	11854	1055	7443	8045	-602	12892	7648	5244	-7426	-3839	-3587
DIS4 - DIS1	2344	648	1697	1751	634	1118	701	139	562	-108	-125	17
%		(28)	(72)		(36)	(64)		(20)	(80)		(116)	(-16)
DIS2	13663	12732	931	8626	8777	-151	11955	7621	4334	-6918	-3666	-3252
DIS4 - DIS2	1591	-230	1821	569	-98	667	1638	166	1472	-616	-298	-318
%		(-14)	(114)		(-17)	(117)		(10)	(90)		(48)	(52)
DIS3	14558	12501	2057	8552	8534	18	13454	7898	5556	-7448	-3931	-3517
DIS4 - DIS3	696	1	695	642	145	498	139	-111	250	-86	-33	-53
%		(0)	(100)		(23)	(78)		(-80)	(179)		(38)	(62)
DIS4	15253	12502	2752	9194	8679	516	13593	7787	5806	-7534	-3964	-3570

Notes: The numbers in parentheses are the percentage deviations of results based on simulations with differently aggregated versions of the GTAP database from the reference situation, i.e., version DIS4.

Source: Authors' calculation.

As presented in Table 5.2 in Section 5.3.1, the average AVEs of NTBs for reduction are commonly higher for the US than for the EU. This result is explained by the higher variation of AVEs of NTBs in the case of the US. We calculate a more homogenous structure of NTBs for the EU throughout different aggregation levels, which leads to a variation coefficient of between 0.82 (DIS1) and 1.41 (DIS2). In contrast, our results for the US exhibit sectors with notably high AVEs of NTBs and notably low NTBs. In this work, the variation coefficient ranges from 1.14 (DIS2) to 1.82 (DIS4). In the EU results, we observe the highest dispersion of AVEs in DIS2, followed by DIS4. According to our results for the US, we identify the highest variation coefficient in DIS4, followed by DIS3. The lowest variation is observed in version DIS1 in the case of the EU and in DIS2 in the case of the US. Hence, only a rough pattern of a positive relationship is observed between the disaggregation of sectors and the variation of AVEs of NTBs. A clear pattern is only determined for the elasticity of substitution. In this work, the variation coefficient increases with disaggregation level from 0.31 (DIS1) to 0.53 (DIS4).

Relating the variation coefficient of AVEs of NTBs to the aggregation bias in simulation results, we observe a positive relationship between the variation coefficient with respect to NTBs and the performance of simulation results. A higher variation coefficient is associated with a higher contribution of NTBs to welfare results if separately analyzing this pattern for the EU and US. The correlation coefficient is quite high and is calculated as 0.91 for the EU and 0.93 for the US. To further support the relationship, we run simple regressions that explain the contribution of NTBs to aggregation bias in the simulation results by the variation coefficients of AVEs of NTBs for the EU and US, respectively. The results reveal that the variation coefficient with respect to NTBs explains 90% (EU) and 80% (US) of the variation in the contribution of NTBs to the deviation in the simulation results. Because the variation of AVEs of NTBs predominantly increases with disaggregation, the NTBs estimated at higher data aggregation levels primarily lead to an underestimation of the contribution of NTBs to the simulation results. Although the variation coefficient for the US is higher in all versions except DIS2, the contribution of NTBs to welfare results is greater for the EU. This result can be explained by the high rate of excluded sectors in the case of the US (see Table 5.2).

The differences resulting from tariff aggregation can be traced back to "averaging of tariffs" and "false competition." Although tariff averaging leads to larger trade and welfare effects due to the use of a higher disaggregation level (Brockmeier and Bektasoglu, 2014; Bureau and Salvatici, 2003; Narayanan, Hertel and Horridge, 2010a, 2010b), Brockmeier and Bektasoglu (2014) and Narayanan, Hertel and Horridge (2010a, 2010b) trace the overestimation effect of the aggregation of sectors to false competition. However, in our TTIP simulations, tariff averaging appears to be more important than false competition for the biases that arise from tariff aggregation due to higher welfare and trade effects obtained with the increasing data aggregation level.

Anderson and Neary (1994, 1996) demonstrate that an atheoretic method of trade-weighted tariff aggregation creates a bias in the welfare and trade effects that leads to underestimation. Hence, the authors develop theoretically consistent aggregation methods, namely, the Trade Restrictiveness Index (TRI) and the Mercantilist Trade Restrictiveness Index (MTRI). Following Anderson and Neary (1994, 2003), Brockmeier and Bektasoglu (2014) and Pelikan and Brockmeier (2008), we also calculate the bilateral MTRI between the EU and the US for the aggregated agro-food sector for versions DIS1, DIS2, DIS3 and DIS4. We compare this value with the trade-weighted average tariff rate given in the AGG version of the GTAP database. The calculated MTRI and the trade-weighted average tariff rate for the agro-food sector are presented in Table 5.6. The bilateral MTRIs calculated for DIS1, DIS2, DIS3 and DIS4 are always higher than the trade-weighted average tariff rates for agro-food in AGG. For food and agricultural imports of the EU from the US, the trade-weighted average tariff rate is given as 8.2% in the GTAP database, whereas we calculate the corresponding MTRI as 14.6% for DIS4. For the agro-food exports of the EU to the US, the tariff rate is 2.4%, but the MTRI reaches 3.1% in the most disaggregated version of the GTAP database. Larger differences between the trade-weighted average tariff rate and the MTRI on the US agro-food exports to the EU result in a higher deviation of welfare effects both for the EU and the US when the tariffs are removed. As shown in Table 5.3, the US welfare gains stemming from the removal of tariffs on the agro-food sector is 2.43 billion US$ in AGG but is 3.63 billion US$ in DIS4.

Cases also exist in which the calculated MTRI in a more aggregated version is higher than that in a more disaggregated version. For instance, the MTRI for agro-food imports of the US to the EU in DIS2 (11.3%) is smaller than the value calculated for version DIS1 (12.2%).[27] This lower MTRI can explain the larger trade and welfare effects of the simulations performed with aggregated versions of the GTAP database. As demonstrated in Table 5.4, the decrease in EU agro-food trade balance amounts to 10.57 billion US$ in version DIS1, whereas in version DIS2, the decrease is smaller, at 6.44 billion US$.

[27] A likely reason for the lower MTRI in DIS2 compared with that in DIS1 is the selection of sectors in our aggregation, possibly due to meat and other livestock products. Meat and other livestock products are given as an individual sector in DIS2, but the sectors grouped under this aggregation (i.e., cattle, pork and poultry, raw milk, wool, other meat, and beef) are both aggregated in raw and processed agriculture in DIS1. Due to highly varying tariffs in subsectors of meat and other livestock products, we obtain unexpected calculations of MTRIs.

Table 5.6: Bilateral Trade-Weighted Average Tariffs and MTRIs on the Agro-Food Sector and Welfare Effects of Using Different Tariff Calculation Methods

		AGG	DIS1	DIS2	DIS3	DIS4
Percentage, %	Tariff (trade weighted)					
	(agro-food, US, EU)	8.2	–	–	–	–
	(agro-food, EU, US)	2.4	–	–	–	–
	MTRI					
	(agro-food, US, EU)	–	12.2	11.3	13.7	14.6
	(agro-food, EU, US)	–	2.8	2.9	2.7	3.1
Million US$	EV1 (based on separate sectors)					
	EU	7461	7443	8626	8552	9194
	US	12369	12892	11955	13454	13593
	World	12577	12910	13663	14556	15254
	EV2 (based on MTRI)					
	EU	–	7411	7437	7402	7491
	US	–	14289	13790	15137	15558
	World	–	13785	13488	14330	14706
Million US$	EV1 - EV2					
	EU	–	-32	-1189	-1150	-1703
	US	–	1397	1835	1683	1965
	World	–	875	-175	-226	-548

Source: Authors' calculation.

To isolate the effect of tariff averaging from the other effects that result in aggregation bias (i.e., applying AVEs of NTBs estimated at different data aggregation levels and false competition), we substitute the bilateral trade-weighted tariff of the agro-food sector in the AGG version of the GTAP database with the calculated MTRIs using the Altertax program [28]. Thereafter, we run four additional TTIP simulations based on the AGG version of the GTAP database, which only differ according to the bilateral tariff of the agro-food sector of the TTIP partners. The resulting welfare effects are documented in Table 5.6. To facilitate interpretation, we also repeat the welfare results of simulations using the initial tariff rates in the GTAP database from Table 5.3. In the bottom section of the table, we also include the differences in welfare results stemming from the use of tariffs based on MTRI or based on separate sectors.

After substituting MTRIs with the initial tariff rates in the four versions of the GTAP database, we observe that the EU welfare effects of TTIP simulations are not only lower for the most disaggregated version DIS4, but the differences across versions are also less significant. The welfare effects based on MTRI do not show divergence across versions for the EU and are thus always calculated at approximately 7.4 billion US$. Hence, it appears that the use of a theoretically consistent aggregation methods helps to dampen the aggregation bias for the EU. However, this effect is not entirely consistent for the US. As indicated in the bottom section of Table 5.6, differences between the welfare effects due to the use of MTRI or tariffs based on separate sectors are higher for the US than they are for the EU for all versions of the GTAP database but especially for DIS1 (-0.032 billion US$ for the EU vs. 1.40 billion US$ for the US). Hence, the effect of tariff averaging is considerably higher for the US. The US welfare gains still show variations across versions when the calculated bilateral MTRIs are implemented into the GTAP database to run the TTIP simulations (compare

[28] Altertax is an available option in RunGTAP.

Table 5.6). These deviations across versions of the GTAP database can now be traced back to the AVEs of NTBs estimated at different data aggregation levels and/or false competition.

Brockmeier and Bektasoglu (2014) and Narayanan, Hertel and Horridge (2010a) explain false competition as a situation in which competition does not initially exist between two exporting countries for a subsector. However, this subsector can be aggregated with other subsectors in which competition does exist. The aggregation of the respective sectors can lead to wrongly applied weights, which also causes false substitution effects and leads to the overestimation of trade and welfare effects. The authors explicitly calculate the value share of source-specific imports of a sector in aggregated imports across sources and the corresponding own-price elasticity of source-wise imports with respect to their corresponding prices to explain the reasons for false competition. These authors conclude that varying elasticities as well as grouping sub-sectors with varying value shares of source-specific imports in aggregated imports across sources cause false competition and lead to a bias in results by overestimating the trade and welfare effects. Following Brockmeier and Bektasoglu (2014) and Narayanan, Hertel and Horridge (2010a), we calculate the value share of source-specific imports in aggregated imports (θ) and the corresponding own-price elasticity of source-wise imports with respect to their corresponding prices (ε) by dividing the percentage change in imports of a sector to the percentage change in the domestic price of the pertinent sector. Table 5.7 demonstrates our results for the EU, for which we observe a higher false competition effect than for the US. [29]

Table 5.7 also exhibits the trade balance changes for the EU at the disaggregated sector level for all versions of the GTAP database due to TTIP. For instance, the larger change in the EU agro-food trade balance in DIS1 (10.57 billion US$) compared with the change in DIS2 (6.44 billion US$) arises from false competition due to aggregation. DIS2 consists of sectors in which the source-specific value shares in aggregated imports vary greatly; for example, grains and crops, which represent 5% of aggregated imports across sources (θ(i, EU,US)), are combined with the processed food sector, which has a higher share of 22%. In other words, the processed food sector, which is considerably imported from the EU to the US, is aggregated with the sectors in which the EU is not an important importer (i.e., grains and crops). It is also interesting to note that the DIS2 version of the GTAP database yields an elasticity of -13 (ε(i, EU,US)). However, for the DIS1 version, we calculate a much higher own-price elasticity of source-wise agro-food imports at -18. We also observe similar cases of varying value shares of source-specific imports in aggregated imports, diverse own-price elasticities, and different trade balance effects of the TTIP on different sectors for the other versions of the GTAP database.

[29] As demonstrated in Table 6, we detect a higher tariff-averaging effect for the US than for the EU. Moreover, when the effect of tariff averaging, which is calculated in Table 6, is deducted from the total effect of tariff aggregation given in Table 5, we observe the false competition effect. Hence, we observe a higher false competition effect for the EU (i.e., -0.032 billion US$ - 1.12 billion US$ = -1.2 billion US$) than for the US (i.e., 1.40 billion US$ - 0.56 billion US$ = 0.84 billion US$) for the deviations between DIS1 and DIS4.

Table 5.7: Changes in Trade Balance of the EU, Value Shares and Own-Price Elasticities

		Trade Balance, EU (million US $)	θ(i, EU,US)	ε(i,EU,US)
AGG	**Agro-food**	-10966	0.167	-22
DIS1	**Agro-food**	-10571	0.153	-18
	Raw agriculture	529	0.057	-31
	Processed food	-11100	0.202	-16
DIS2	**Agro-food**	-6440	0.156	-13
	Crops	485	0.048	-35
	Grains	-198	0.045	-316
	Meat and other livestock	-2156	0.097	-83
	Processed food	-4571	0.215	-10
DIS3	**Agro-food**	-13027	0.171	-16
	Sugar	-250	0.004	-5
	Rice	-113	0.015	-13
	Cattle and beef	-2303	0.050	-57
	Other meat	-847	0.131	17
	Dairy	-3084	0.501	-11
	Vegetable oils	205	0.072	-17
	Fruits and crops	759	0.048	-26
	Grains	-118	0.045	-327
	Other food and beverages	-7230	0.257	-15
	Textile fibers	-48	0.051	-29
DIS4	**Agro-food**	-12812	0.171	-15
	Paddy rice	-25	0.010	-42
	Wheat	-1027	0.059	-227
	Cereal grains	119	0.029	-368
	Vegetables, fruit and nuts	428	0.026	-62
	Oil seeds	223	0.014	247
	Sugar beet and cane	1	0.006	-11
	Plant-based fibers	-85	0.076	-16
	Other crops	557	0.097	-16
	Cattle	106	0.149	-15
	Pork and poultry	-72	0.068	-6
	Raw milk	5	0.070	-23
	Wool	-1	0.000	-129
	Beverages and tobacco	495	0.560	-15
	Other food	-6761	0.122	-14
	Sugar	-226	0.004	-5
	Processed rice	-97	0.014	-11
	Dairy products	-3075	0.472	-11
	Vegetable oils and fats	216	0.047	-11
	Other meat	-567	0.144	17
	Beef	-3026	0.012	-164

Source: Authors' calculation.

5.5 Conclusion and Policy Implications

In this article, we explore the potential effects of the TTIP between the EU and US. Although tariffs in the trade between EU and US are already low, most gains are expected via the reduction of restrictive NTBs and the harmonization of regulatory systems. Hence, in our policy simulations, we allow for the simultaneous reduction of NTBs and the removal of import tariffs as well as export subsidies between the EU and the US. We include all sectors of the economy but focus on the agro-food sector for two reasons. First, NTBs are predominantly imposed on food and agricultural products, and second, most previous studies neglect the agro-food sector or take only a highly aggregated sector into account. We investigate how the effects of the TTIP vary by considering different aggregations of the agro-food sector in the CGE simulations. We quantify the bias resulting from data aggregation by creating five different versions of the GTAP database, which differ in the number of food and agricultural sectors. Our most aggregated version consists of a single agro-food sector, whereas the subsequent versions contain two, four, 10 and 20 agro-food sectors.

The estimation of the effects of NTBs for each version of the GTAP database is performed using the gravity model in an advanced econometric setting. To cover all relevant NTBs that are potentially reducible in the TTIP, we rely on the historical behavior of the EU and US in free trade negotiations. We implement the estimated NTBs in the GTAP model and use the extended model to conduct policy experiments in which we simultaneously reduce bilateral tariffs and NTBs between the EU and the US. The GTAP simulations are conducted using differently aggregated versions of the GTAP database.

The outcomes of the EU-US FTA simulations result in welfare gains both for the EU and the US for all versions of the GTAP database. However, there are clear deviations across results based on simulations with differently aggregated versions of the GTAP database. Primarily, the changes in welfare and trade balance are greater as the level of aggregation increases, but there are also cases in which a higher level of aggregation results in larger trade and welfare effects. By selecting the most disaggregated version, DIS4, as our reference situation, we show that EU welfare gain in the version AGG deviates by 19% from that of version DIS4. In terms of trade effects, the percentage change deviation in the US agro-food trade balance between AGG and DIS4 amounts to 28%.

In explaining the aggregation bias found in the simulation results of the TTIP, we differentiate between two factors, i.e., tariff aggregation and the application of NTBs, that are estimated at different data aggregation levels. Estimating the AVEs of NTBs at higher data aggregation levels principally smoothes out peaks in the AVEs and reduces the variation across products. Hence, applying the AVEs of NTBs that are estimated at higher data aggregation levels in CGE simulations leads to an underestimation of the effects of NTBs on trade and welfare results. In terms of tariff aggregation, it is possible to separate two factors that cause aggregation bias: tariff averaging and false competition. A theoretic method of trade-weighted tariff aggregation creates a bias in the welfare and trade effects that leads to underestimation. Hence, as our simulation results indicate, the use of consistent aggregation methods (such as MTRI) results in higher tariffs than the trade-weighted average tariff rates. In contrast, false competition has an overestimation effect on simulation results. A high level of data aggregation causes artificial competition, which leads to greater trade and welfare effects. For the US, we observe a considerably higher effect of false competition, whereas for the EU, the impact of tariff averaging is more pronounced. Based on our results, we find that the aggregation of tariffs is more important than NTBs because the contribution of tariffs to the deviation of results across versions is commonly higher. Due to predominantly higher trade and welfare results obtained with increasing data aggregation levels, tariff averaging appears to be more important than false competition for the biases arising from tariff aggregation.

With our experimental setting, we are thus able to confirm the direct relation between data aggregation level and the extent of aggregation bias. By also considering NTBs, we confirm the importance of sectoral breakdown on simulation results. For a thorough analysis of FTAs, the highest level of data disaggregation level should always be preferred. Hence, policy makers should be cautious in the selection of data aggregation level and be aware of the considerable impact that sectoral breakdowns can have on the policy analysis of trade agreements.

5.6 Appendix

Table 5.A1: Regional Aggregation

	Regions
1	European Union Austria, Belgium, Denmark, Finland, France, Germany, Ireland, United Kingdom, Greece, Italy, Luxembourg, Netherlands, Portugal, Spain, Sweden, Czech Republic, Hungary, Malta, Poland, Slovakia, Slovenia, Estonia, Latvia, Lithuania, Cyprus, Romania, Bulgaria, Croatia
2	United States of America
3	Canada
4	Japan
5	Korea
6	High Income Countries Austalia, New Zealand, Hong Kong, Taiwan, Singapore, Switzerland, Norway, Rest of EFTA
7	China
8	India
9	Brazil
10	Mexico
11	Turkey
12	Central America Costa Rica, Guatemala, Honduras, Nicaragua, Panama, El Salvador, Rest of Central America, Dominican Republic, Jamaica, Puerto Rico, Trinidad and Tobago, Caribbean
13	East Europe Albania, Belarus, Ukraine, Rest of Eastern Europe, Rest of Europe
14	North Africa Israel, Rest of Western Asia, Egypt, Morocco, Tunisia, Rest of North Africa
15	Association of Southeast Asian Nations Indonesia, Malaysia, Philippines, Thailand, Viet Nam
16	Mercosur Argentina, Paraguay, Uruguay
17	Bangladesh
18	Mozambique
19	Least Developed Countries Rest of East Asia, Brunei Darassala, Camboida, Lao People's Democratic Republic, Rest of Southeast Asia, Nepal, Rest of South Asia, Benin, Burkina Faso, Guinea, Senegal, Togo, Rest of Western Africa, Central Africa, South Central Africa, Ethiopia, Madagascar, Malawi, Rwanda, Tanzania, Uganda, Rest of Eastern Africa
20	Rest of the World Rest of Oceania, Mongolia, Pakistan, Sri Lanka, Rest of North America, Bolivia, Chile, Colombia, Ecuador, Peru, Venezuela, Rest of South America, Russian Federation, Kazakhstan, Kyrgyzstan, Rest of Former Soviet Union, Armenia, Azerbaijan, Georgia, Bahrain, Islamic Republic of Iran, Jordan, Kuwait, Oman, Qatar, Saudi Arabia, United Arab Emirates, Cameroon, Cote d'Ivoire, Ghana, Nigeria, Kenya, Mauritius, Zambia, Zimbabwe, Botswana, Namibia, South Africa, Rest of South African Customs Union, Rest of the World

Source: GTAP database, version 9, base year 2011.

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6 Conclusion

CGE models are widely used to conduct policy analysis because they provide economy-wide results while considering the linkages and interactions between industries, regions and economic variables. At present, there are various CGE models aggregated at different data levels and focusing on different regions. However, in this dissertation we utilize the GTAP model for our simulations. We focus on two critical issues in trade policy analysis of CGE modeling: the aggregation bias and extent of its impact on simulation results and evaluation of NTBs in RTAs through gravity estimates. In our further analysis, we offer a combination of the two. We expound the effect of data aggregation in the gravity estimates of NTBs using the GTAP or other more disaggregated databases, and the impact of reduction of pertinent trade costs on policy simulation results.

The use of higher data disaggregation in CGE models usually results in greater welfare and trade effects, although in some cases simulations utilizing disaggregated databases can lead to smaller changes in simulation results (compare Alexeeva-Talebi et al., 2012; Charteris and Winchester, 2010; Grant et al., 2008; Narayanan et al., 2010a, 2010b). The overestimation effects of aggregation bias are generally explained by "tariff averaging"; whereas, "false competition" results in underestimation of trade and welfare effects (Bureau and Salvatici, 2003; Narayanan et al., 2010a, 2010b). With our simulations in the first and last article, we confirm that the use of different aggregation levels can drive the aggregation bias up or down. A higher disaggregation level primarily results in greater trade and welfare effects, but the difference between the simulation results of the aggregated version and the disaggregated version is also seldom positive.

As demonstrated by Anderson and Neary (1994, 1996), the atheoretic method of trade-weighted tariff aggregation is the trigger of lower trade and welfare effects. Following Anderson and Neary (1994, 2003) and Pelikan and Brockmeier (2008), in our articles we calculate the Mercantalistic Trade Restrictiveness Index (MTRI), which is a theoretically consistent aggregation method. Comparing the MTRIs with the initial trade-weighted tariffs in the GTAP database, we observe that the calculated MTRIs are commonly much higher than the trade-weighted tariffs. Similar to the findings of Anderson and Neary (1994, 2003), Bureau and Salvatici (2003), and Narayanan et al. (2010a, 2010b), with our simulations in our first and last article, we are able to confirm that greater trade and welfare effects generally result from tariff averaging. The calculated MTRIs verify the underestimation effect of trade-weighted tariffs in the GTAP database. For instance, in our last article, "*Keep Calm and Disaggregate: The Importance of Agro-Food Sector Disaggregation in CGE Analysis of TTIP*", we obtain five different versions of the GTAP database, and reveal that in the most aggregated version (one agro-food sector), the initial GTAP tariff rates are the lowest, and in the version with the highest data disaggregation (20 agro-food sectors) the calculated MTRIs are the highest among five versions of the GTAP database.

However, as mentioned earlier, in some cases higher levels of data aggregation can lead to greater changes in results. This overestimation effect of data aggregation can be explained by "false competition". Such a situation arises when competition for a particular subsector does not initially exist between two exporting countries, but this subsector can be aggregated with others in which competition actually exists. For instance, as demonstrated in our first article, "*Model Structure or Data Aggregation Level: Which Leads to Greater Bias of Results*?", Sub-Saharan Africa (SSA) is the largest sugar exporter to the EU, but not an exporter of beverages, tobacco, or dairy products. However, these sectors are grouped into one (processed food) in our GTAP aggregation. This leads to artificial or false competition. Wrongly applied weights result in false substitution effects, which cause overestimation of results. Therefore, in the aggregated version of the GTAP database

SSA's trade balance change in the processed food sector is substantially greater than the one calculated with the disaggregated version. We have also observed the same effects of false competition in our last article.

The second focal point of this dissertation is the evaluation of NTBs on agro-food sector in RTAs. Due to their complexity, NTBs are harder to be addressed in trade agreements, but their direct or indirect effect on restricting trade is not negligible. In our articles, we are able to confirm the importance of NTBs in the analysis of RTAs. Our results indicate that the welfare gains stemming from the reduction of NTBs outweigh the gains due to the elimination of import tariffs. Therefore, NTBs are one of the most important points in FTA treaties, and their consideration in trade agreements is vital for thorough analysis of trade policies.

NTBs are not considered in the standard GTAP framework. Hence to account for trade costs of NTBs in our analysis, we first estimate the AVEs of NTBs through gravity estimations, and then we incorporate them into the GTAP model. NTBs can be implemented into the GTAP model in several ways. The main approaches utilized to model NTBs are the efficiency, import-tariff and export-tax modeling. While the efficiency approach is primarily used to account for technical NTBs, import-tariff and export-tax modeling approaches are employed to model rent-creating trade costs. Since our focus is food and agricultural sector in our articles, we mainly consider NTBs on this sector as efficiency loses. We utilize the efficiency approach to model the trade costs because of the predominance of technical NTBs on the agro-food sector. However, in our third article, "*The Effect of Aggregation Bias: An NTB-Modeling Analysis of Turkey's Agro-Food Trade with the EU*", we provide a combination of import-tariff modeling and efficiency modeling of NTBs. Nevertheless, the welfare effects of removing NTBs are greater when the efficiency modeling of trade costs is employed than the ones when the import-tariff approach is used. This result is expected because in the efficiency approach the reduction of NTBs is modeled as technological improvement; whereas, in the import-tariff modeling, AVEs of NTBs are added to the initial tariffs in the GTAP database, and then removed.

In this dissertation, we also combine the effect of aggregation bias and the estimation of NTBs. Hence, in our third article, we calculate the trade costs of NTBs between Turkey and the EU using disaggregated CPC level data that is pooled and also aggregated over GTAP sectors. We find that the AVEs of NTBs estimated with aggregated data are mainly higher than those estimated with disaggregated data. Hence, the incorporation of NTBs from either aggregated gravity estimates or from disaggregated gravity estimates lead to considerable differences in simulation results. The transfer of aggregation bias coming from the estimation of trade costs of NTBs to the GTAP model directly affects simulation results and leads to overestimation. Although in CGE modeling higher disaggregation levels generally result in greater changes in simulation results, this is not the case in this article since the overestimation effect of data aggregation clearly stems from the predominance of higher levels of AVEs of NTBs obtained using aggregated data in the gravity approach.

In our last article, we are able to explain the aggregation bias found in the simulation results by differentiating between two factors, namely, tariff aggregation and the application of NTBs, which are estimated at different data aggregation levels. The estimation of AVEs of NTBs at higher data aggregation levels reduces the variation across sectors, and hence, commonly leads to higher trade and welfare results. In terms of tariff aggregation, averaging of tariffs and false competition create an aggregation bias in simulation results. However, the contribution of tariffs to the deviation of results across versions is commonly higher than the contribution of NTBs. Hence, based on our simulation results, we demonstrate that aggregation of tariffs is more important than the NTBs. Thereby; tariff averaging appears to have more impact on the aggregation bias arising from tariff aggregation due to the primarily higher trade and welfare results obtained with increasing data disaggregation level.

However, with our current experimental settings in our articles it is not entirely possible to isolate the reasons of aggregation bias (i.e., tariff averaging, false competition and applying AVEs of NTBs estimated at different data aggregation levels) from each other. A possible way to single out the effect of tariff averaging would be to calculate bilateral MTRIs for all sectors and regions, and to substitute the bilateral trade-weighted tariffs in the GTAP database with the calculated MTRIs. In our last article, we alternate the initial GTAP tariff rates of the agro-food sector with the calculated MTRIs for different versions of the GTAP database. Our results demonstrate that the deviations across versions commonly decrease when the theoretically consistent aggregation methods are used to calculate the bilateral tariffs. With respect to the impact of applying trade costs of NTBs at different data aggregation levels on the aggregation bias, the development of an index for the AVEs of NTBs to provide a measure, which compares the effect of trade costs calculated at different aggregation levels (i.e., MTRI for tariffs) would also help explain the differences in results occurring from the reduction of NTBs more systematically.

Neither the impact of aggregation bias nor the importance of NTBs in the evaluation of RTAs on trade policy analysis is negligible. There are considerable differences across simulation results depending on the data aggregation level used. The differences in results occur both in the estimation of trade costs of NTBs and also in the policy simulation results on the GTAP level. Hence, the selection of data aggregation level can be critical for thorough analysis of trade agreements, especially for the detailed examination of policy changes at the product level. Aggregation bias cannot be entirely overcome in econometric estimates or in CGE analysis; however, the extent of its possible effect can be born in mind. Depending on the aim of the policy analysis, the appropriate level of data disaggregation should be chosen.

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