Institute of Agricultural Economics in the Tropics and Subtropics
University of Hohenheim
International Agricultural Trade and Food Security
Prof. Dr. Martina Brockmeier

International Agricultural Price Transmission and Its Implications for Domestic Markets

A cumulative dissertation
Submitted in fulfilment of the requirements for the degree “Doktor der Agrarwissenschaften”
(Dr.sc.agr. / Ph.D. in Agricultural Sciences)
to the
Faculty of Agricultural Sciences

Presented by
Fan Yang

Place of birth: Shanxi, China
Stuttgart-Hohenheim, 2016

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I assure that all quotations and statements have been inferred literally or in a general manner from published or unpublished writing are marked as such.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, January 2016

Fan Yang

This thesis was accepted as a doctoral dissertation in fulfillment of the requirements for the degree ‘Doktor der Agrarwissenschaften’ (Dr. sc. Agr. / Ph.D.) by the faculty of Agricultural Sciences at the University of Hohenheim on June 03, 2016.

Date of oral examination: June 22, 2016

Examination committee

Supervisor and reviewer: Prof. Dr. Martina Brockmeier

Co-reviewer: Prof. Dr. Thomas Heckelei

Additional examiner: Prof. Dr. Christian Lippert

Head of the committee: Prof. Dr. Markus Rodehutscord

Acknowledgements

I am grateful to the many people for their constant support and trust in me. It is my privilege to have shared this important journey of my life with them.

My deepest thanks go to my Doktormutter Prof. Dr. Martina Brockmeier. She has always been an inspiring supervisor, generously sharing her knowledge with me and directing me towards excellence. Being an enthusiastic mentor, she has encouraged me to overcome challenges, offered me many opportunities and guidance in every aspect of my life.

My gratitude also goes to Porf. Dr. Thomas Heckelei, for his readiness to review my thesis and his enlightening speech on “Publishing as an Agricultural Economist” that instructed me; and to Prof. Dr. Regina Birner, for being in the examination committee, her encouragement during my PhD and her organisation of the joyful activities in the institute.

The dedicated work of Prof. Dr. Joseph Francois and Dr. Eddy Bekkers is indispensable in the accomplishment of my thesis. I learnt a great deal from their in-depth expertise, structural thinking, and analytical rigor.

I am pleased to acknowledge the support from the German Ministry of Science, Research and Arts Baden - Wuerttemberg and the China Scholarship Council for funding this work.

I am lucky to be surrounded by the extraordinary colleagues in 490b. Kirsten Urban, a resourceful scientist and a great co-author in my final paper, kindly offered me suggestions to improve my thesis. Dr. Beyhan Bektasoglu, my former officemate, always brought me positive energy with her sincere friendship and delighted company. Many thanks also go to Tanja Engelbert, Vladimir Korovin, Mira Frommknecht, Ryan Gorman for providing me fruitful discussions and proofreading of my thesis, and Clara Sifi for her endless help.

I am extremely grateful to my loving friends who accompanied me with their care and patience through this challenging project and all else.

The boundless love and support of my family has been the foundation of my life. My gratitude to my parents for their understanding and motivations during my PhD is beyond words. Finally, I want to thank Jan Lukas Weigl for being my amazing partner, closest friend and wise advisor, supporting me every step of the way.

Brief Contents

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List of acronyms

ADF	Augmented Dickey Fuller
AMS	Aggregated Measurement Support
AR	Autoregressive
AR1	Autoregressive model of order 1
ASEAN	Association of Southeast Asian Nation
CAP	Common Agricultural Policy
CD	Cobb Douglas
CDE	Constant Difference of Elasticity
CES	Constant Elasticity of Substitution
CGE	Computable General Equilibrium
CPI	Consumer Price Index
EFTA	European Free Trade Association
FAO	Food and Agriculture Organisation of the United Nations
FTAs	Free Trade Agreements
GDP	Gross Domestic Product
GTAP	Global Trade Analysis Project
Hinc	High-income
IDR	Import Dependency Ratio
ILO	International Labour Organisation
IMF	International Monetary Fund
IMFIFS	International Monetary Fund International Financial Statistics
LRPT	Long Run Pass-Through
MENA	Middle East and North America
MFN	Most Favourite Nation

MOA	Ministry of Agriculture of the People's Republic of China
MOFCOM	Ministry of Commerce of the People's Republic of China
NGO	Non-Governmental Organisation
NPS	Non-Product Specific
NRA	National Rate of Assistance
OECD	Organisation for Economic Co-operation and Development
PC	Per Capita
PPP	Purchasing Power Parity
PS	Product Specific
PSE	Agricultural Producer Support Estimate
ROW	Rest of the World
SEAsia	South East Asia
SSA	Sub-Saharan Africa
TPP	Trans-Pacific Partnership
TRI	Trade Restrictiveness Index
VEC	Vector Error Correction
WFPI	World Food Price Index
WTO	World Trade Organisation

Summary

International agricultural price surges in 2007/08 and 2010/11 appeared to undermine the global food system from diverse sources. Soaring agricultural prices may exacerbate food availability for net food buyers in low-income countries. In response, governments in these countries implemented either border or domestic policies in order to stabilise domestic food prices. The contentious impact of these policies on the international agricultural price transmission is often assessed in the literature by applying CGE (Computable General Equilibrium) models. Among the various comparative static general equilibrium models, the GTAP (Global Trade Analysis Project) model is extensively used in policy analyses given its broad data coverage and firm economic assumptions. However, the setup of the standard GTAP model does not fully account for the variations in international agricultural price transmission, causing the simulation results to deviate from the empirical findings derived from econometric analyses. Therefore, the primary focus of this thesis is to enhance the realism of the CGE framework in analysing the international agricultural price transmission and its implications for domestic markets by associating econometric analyses with the standard GTAP model.

Against this background, the thesis includes three articles either published or submitted to peer-reviewed journals in addressing the following objectives: (1) to identify the determinants of food price transmission from the international agricultural market to domestic markets; (2) to exploit the impact of border restrictions on food price transmission, accounting for variations in domestic margin services in different countries and regions; and (3) to investigate the impact of increasing agricultural domestic support on China's domestic market, given the imperfect food price transmission caused by border policy adjustments.

Applying econometric time series analyses, our first article identifies and evaluates the determinants causing variations in food price transmission, i.e., a country's income level and its market integration indicators. The result underscores an inverse relationship between income levels and the price transmission elasticities from international agricultural commodities to domestic food products. The major reason is that a large part of consumed food consists of a high share of domestic margin services e.g., transport, food processing services and retailing. Their share in consumed food is greater in high-income countries,

implying a lower price transmission of price shocks to final consumers in these countries than in low-income countries.

Following the theoretical development in the first article, our second article extends the standard GTAP model by quantifying the value of domestic margin services in the private household consumption. Thereby, the extended model is able to reflect the price insulating impact by domestic margin services, leading to a weakened magnitude of price transmission from international to domestic markets. The impact is more pronounced in high-income countries, consistent with our previous findings. Furthermore, we demonstrate how the model extension improves the simulation results in analysing impacts of trade restrictions on food price transmission. Our results show that export restrictions implemented by major grain exporters enable these countries to insulate domestic consumers from the surge in international agricultural prices. These policies further increase the volatility of international prices, worsening the net food buyers' situation in countries where no policies are applied. However, the negative impact of shocks to international agricultural prices on consumer food prices tends to be overestimated particularly in high-income countries, when domestic margin services are not taken into account.

After improving the model's ability to assess the effectiveness of agricultural border policies, our last article addresses the impact of increasing agricultural domestic support on food price transmission. We introduce two extensions to the standard GTAP framework, i.e., a better representation of incomplete price transmission based on econometric analyses, and an updated agricultural domestic support structure according to China's current domestic policy. Simulation results show that under the assumption of incomplete food price transmission, net importing countries such as China experience less volatility than in the standard GTAP framework. Lowered price increases benefit domestic consumers but insulate producers from receiving higher selling prices. This result is consistent with the observations given during the price surge period from 2007 to 2011. When agricultural domestic support is assumed to increase to its *de minimis* threshold level, domestic producers have access to higher prices than in the previous simulation, and are thus incentivised to reach higher agricultural production. As a result, consumers potentially benefit from the further reduced price surges. China also exerts less demand pressure on the international agricultural market.

In conclusion, this thesis raises the question of how variations in international agricultural price transmission affect domestic markets, especially under the interventions of border and domestic policies. In answering this question, we introduce several extensions to the standard GTAP framework in order to enhance the realism of the model in analysing food price transmission, so that the simulation results are more in line with empirical findings based on our econometric estimations. Our analyses contribute to the current literature with regard to three aspects. First, we extend the scope of current literature in explaining variations in food price transmission by applying a global sample of countries. Second, we evaluate the impact of border restrictions on food price transmission more accurately by accounting for domestic margin services explicitly in the GTAP model. Third, we improve the GTAP framework's ability to evaluate the development of China's agricultural domestic support by a detailed representation of incomplete price transmission and domestic structure in the model. We also call for better reconciliations of econometric estimations and CGE modelling through enhanced data availability, and further analyses of other less-distorting policies in stabilising agricultural domestic markets.

Zusammenfassung

Der Anstieg der Nahrungsmittelpreise auf den internationalen Märkten in den Jahren 2007/08 und 2010/11 schien das globale Nahrungsmittelsystem auf unterschiedliche Art und Weise zu schwächen. Stark ansteigende Preise für Agrarprodukte könnten die Nahrungsmittelverfügbarkeit für die Verbraucher in Niedrigeinkommensländern verringern. Um dem entgegenzuwirken und somit die inländischen Nahrungsmittelpreise zu stabilisieren, haben die Regierungen der betroffenen Länder entweder inländische Agrarpolitikmaßnahmen oder Handelsbeschränkungen eingeführt. In der wissenschaftlichen Literatur wird der umstrittene Einfluss dieser Maßnahmen auf die internationale Preistransmission oft durch den Einsatz von CGE-Modellen (Allgemeine Numerische Gleichgewichtsmodelle) bewertet. Unter der großen Anzahl allgemeiner komparativ-statischer Gleichgewichtsmodelle wird das GTAP (Global Trade Analysis Project) Modell häufig zur Politikanalyse eingesetzt, da es eine breite Datenbasis und fundierte ökonomische Annahmen enthält. Die Aufstellung des GTAP-Standardmodells ermöglicht es jedoch nicht die Schwankungen der internationalen Agrarpreistransmission vollständig zu erklären. Aufgrund dessen weichen die Ergebnisse der Modellsimulationen von empirischen Befunden aus ökonometrischen Analysen ab. Der Fokus dieser Arbeit liegt daher darin, CGE-Modelle dahingehend realistischer zu gestalten, so dass die internationale Preistransmission und deren Implikationen für inländische Märkte besser analysiert werden können, indem ökonometrische Analysen mit dem CGE Modellen, hier dem GTAP-Standardmodell, verbunden werden.

Vor diesem Hintergrund enthält diese Arbeit drei Artikel, die entweder bei wissenschaftlichen Fachzeitschriften eingereicht oder in diesen bereits veröffentlicht wurden und die nachfolgenden Zielsetzungen verfolgen: (1) Identifikation der Determinanten der Nahrungsmittelpreistransmission von internationalen auf inländische Agrarmärkte; (2) Bestimmung oder Quantifizierung der Auswirkung von Handelsbeschränkungen bezüglich der Nahrungsmittelpreistransmission unter Beachtung der Schwankungen inländischer Dienstleistungen in unterschiedlichen Ländern und Regionen; (3) Analyse der Auswirkungen eines Anstiegs der inländischen Agrarmarktstützung auf den Binnenmarkt Chinas, unter der Annahme, dass die unzureichende Nahrungsmittelpreistransmission durch eine Veränderung der Handelsbeschränkungen hervorgerufen wird.

Unter der Verwendung ökonometrischer Zeitreihenanalysen identifiziert und beurteilt der erste Artikel die Faktoren, welche die Schwankungen der Nahrungsmittelpreistransmission verursachen. Diese sind unter anderem das Einkommensniveau auf Länderebene und dessen Marktintegrationsindikatoren. Das Ergebnis bestätigt die inverse Abhängigkeit der Einkommenslevel und der Preistransmissionselastizität von internationalen Agrarrohstoffen hin zu inländischen Nahrungsmitteln. Der dafür wesentliche Einflussfaktor ergibt sich daraus, dass ein Großteil der konsumierten Nahrungsmittel mit einem hohen Anteil inländischer Dienstleistungen verbunden ist, wie z.B. Transport, Lebensmittelverarbeitung und Einzelhandelsaktivitäten. Diese Rate ist in Hocheinkommensländern größer und impliziert daher, dass in diesen die Preistransmission an den Verbraucher im Falle von starken Nahrungsmittelpreisschwankungen geringer ausfällt als in Niedrigeinkommensländern.

Auf Basis der theoretischen Herleitung im ersten Artikel, wird im zweiten Artikel das GTAP-Standardmodell erweitert, indem der Wert der inländischen Dienstleistungen anhand der privaten Haushaltsnachfrage quantifiziert wird. Das auf diese Weise erweiterte Modell ist nun in der Lage, die Auswirkung einer Preisisolierung durch inländische Dienstleistungen zu berücksichtigen. Dies führt dazu, dass das Ausmaß der Preistransmission von den internationalen auf die nationalen Märkte abgeschwächt wird. Dieser Effekt ist in Hocheinkommensländern stärker ausgeprägt und bestätigt daher die Ergebnisse des ersten Artikels. Zusätzlich wird gezeigt, wie die Modellerweiterung die Simulationsergebnisse verbessert, indem die Auswirkungen von Handelsbeschränkungen auf die Nahrungsmittelpreistransmission analysiert werden. Die Ergebnisse bestätigen, dass die von großen Getreide exportierenden Ländern eingeführten Exportbeschränkungen es diesen ermöglichen, die inländischen Verbraucher von einem Anstieg der internationalen Agrarrohstoffpreisen zu isolieren. Diese Maßnahmen erhöhen die Volatilität der internationalen Preise und führen dazu, dass sich die Situation der Endverbraucher der Länder verschlechtert, die keine Handelsbeschränkungen umgesetzt haben. Es ist jedoch anzunehmen, dass die negativen Auswirkungen starker Veränderungen der internationalen Agrarrohstoffpreise auf die Verbraucher insbesondere in Hocheinkommensländern gerade dann überschätzt werden, wenn die inländischen Dienstleistungen nicht berücksichtigt werden.

Nachdem das Modell so verbessert werden konnte, dass auch die Wirksamkeit landwirtschaftlicher Handelspolitiken bewertbar ist, befasst sich der letzte Artikel mit dem Einfluss der Subventionen im Agrarsektor auf die Nahrungsmittelpreistransmission. Es werden zwei Erweiterungen des GTAP-Standardmodells eingeführt, zum einen eine verbesserte Darstellung der unvollständigen Preistransmission auf Basis ökonometrischer Analysen und zum anderen eine detailliertere Berücksichtigung der inländischen Subventionen im Agrarsektor auf Grundlage der aktuellen Agrarpolitik Chinas. Die sich daraus ergebenden Simulationsergebnisse zeigen, dass - unter der Annahme unvollständiger Nahrungsmittelpreistransmission – Nettoimportländer wie China eine geringere Volatilität aufweisen als unter Verwendung des GTAP-Standardmodells. Die inländischen Verbraucher profitieren von geringeren Preiserhöhungen, welche gleichzeitig verhindern, dass die Produzenten höhere Preise erzielen können. Dieses Ergebnis entspricht den Beobachtungen während der Nahrungsmittelpreiskrise von 2007 bis 2011. Sofern angenommen wird, dass inländische Agrarsubventionen auf das WTO *de minimis* Niveau angehoben werden, könnten Produzenten höhere Preise erzielen als in der vorherigen Simulation und erhalten dadurch einen Anreiz, mehr landwirtschaftliche Güter herzustellen. Daraus ergibt sich zudem ein weiterer Vorteil für die Verbraucher, da dieser Anstieg der Produktion zu einem weiteren Absinken der Preise führt. Gleichzeitig verringert sich dadurch der Nachfragedruck Chinas auf die internationalen Agrarmärkte.

Diese Arbeit diskutiert letztlich die Frage, wie die Veränderungen auf der Ebene einer internationalen Nahrungsmittelpreistransmission die Binnenmärkte beeinflussen, unter der besonderen Beachtung des Einflusses von Handelsbeschränkungen- und inländischer Agrarpolitikinstrumente. Zur Beantwortung werden mehrere Erweiterungen des GTAP-Standardmodells vorgestellt, um ein möglichst realistisches Modell zur Analyse der Nahrungsmittelpreistransmission zu erhalten, damit dessen Simulationsergebnisse mit den empirischen Ergebnissen auf Basis der ökonometrischen Schätzungen besser übereinstimmen. Diese Vorgehensweise erweitert den bestehenden wissenschaftlichen Fundus um drei Aspekte. Erstens wird der Anwendungsbereich wissenschaftlicher Literatur dadurch ergänzt, dass Schwankungen der Nahrungsmittelpreistransmission mittels einer globalen Stichprobe verschiedener Länder erklärt werden können. Zweitens wird der Einfluss handelspolitischer Beschränkungen auf die Nahrungsmittelpreistransmission insofern genauer bestimmbar, da explizit die inländischen Dienstleistungen in das GTAP-Modell aufgenommen werden. Drittens wird die Anwendungseignung des GTAP-Modells in Bezug auf die Effekte und Bewertung von Entwicklungen der inländischen Agrarpolitik Chinas durch eine detailliertere Darstellung der unvollständigen Preistransmission und der Binnenstruktur der inländischen Agrarpolitikinstrumente verbessert. Es besteht weiterer Forschungsaufwand darin, die ökonometrischen Schätzungen und CGE-Modelle durch eine verbesserte Datenverfügbarkeit besser zu vereinbaren, und weitere Analysen bezüglich der Auswirkung weniger verzerrender Maßnahmen auf eine Stabilisierung der Agrarbinnenmärkte.

1 Introduction

1.1 Background and motivation

International agricultural price surges in 2007/08 and 2010/11 appeared to underscore the vulnerability of the global food system (Headey and Fan, 2008; Piesse and Thirtle, 2009; Gilbert, 2010; Swinnen, 2011; Ivanic, *et al.*, 2012; Serra and Gil, 2013). High prices were triggered by a combination of different factors, e.g., historical low grain stock, shortfall of agricultural harvest in major grain exporting countries, increasing demand of meat products in emerging economies, and unrest in energy and financial markets (Timmer, 2008; Trostle, 2010, Abbott *et al.*, 2011; Wright, 2011; Tadesse *et al.*, 2014). Surges in international agricultural prices generated controversial impacts on domestic food markets in low-income countries (Ivanic and Martin, 2008; Dorward, 2012; Bellemare; 2015). In spite of the sustained low food prices through decades prohibiting agricultural producers from receiving high selling prices, the recent focus shifted to the negative impact of food price surges on food consumers (Swinnen and Squiccinarini, 2012). In fact, a majority of households in low-income countries is found to be net food buyers and spend a large share of their disposable income on food (Maggio *et al.*, 2015). The Food and Agricultural Organisation of the United Nations (FAO) estimated that the outbreak of the 2007/08 international agricultural price surge increased the population facing undernourishment to greater than one billion people globally (FAO, 2009).

However, FAO (2012) lowered its estimation on the prevalence of undernourishment caused by the surge in agricultural prices in 2007/08. Mainly due to the economic and political divergences in different countries and regions, surges in international agricultural prices transmit to domestic prices at different degrees, and thus generate various impacts on domestic markets. The earlier measure in 2009 overestimated the size of the population affected by high international agricultural prices (FAO, 2012). [1] This fact highlights the focus of this thesis, which is to analyse the international agricultural price transmission and its implications for domestic markets.

[1] According to the FAO (2012), first, the short-term impact of price spikes is ambiguous on the prevalence of undernourishment, which is related to habitual consumption of dietary energy and is chronic. Second, the surge in international agricultural prices transmitted differently to domestic markets, causing major differences in the impact on undernourishment.

International agricultural price transmission means the extent to which domestic food prices change, given a one percent change in international agricultural prices.[2] If an agricultural domestic market is perfectly integrated into the international market, the price movements in both markets should align (Fackler and Goodwin, 2001). However, variations in price transmission persist stemming from the following factors. First, the existence of marketing margins in the final consumed goods could mitigate the international agricultural price volatility transmitted to domestic markets (Dawe and Maltsoglou, 2014; Minot and Dewina, 2015). Second, goods that are imported from international market are not identical to domestically produced goods. The imperfect substitutability of these two goods are summarised by the Armington assumption, which could cause imperfect price transmission (Armington, 1969). Third, fluctuations in exchange rates could weaken the impact of an increase in international prices denominated with $US when domestic currencies appreciate *vis-à-vis* the $US (Abbott and de Battisti, 2011; Baquedano and Liefert, 2014). Lastly, the shift in agricultural and food policies may have mixed impacts on the price transmission. As a response to the international agricultural price crises in 2007/08 and 2010/2011, governments in many developing countries adjusted their border and/or domestic measures to stabilise agricultural domestic prices and thus to protect domestic net food buyers. Among these measures, trade restrictions such as export bans and taxes increased the domestic availability of certain agricultural commodities, in order to moderate domestic price changes. However, when a country is a major agricultural exporter, this action may cause a supply shortage in the international market, intensifying the international price volatility and exacerbating the situation of poor food buyers in low-income countries (Anderson, *et al.*, 2013). Reducing import tariffs by net agricultural importers could have a similar impact. With regard to domestic policies, releasing grain stocks, reducing grain taxes and scaling up agricultural support were also pursued by governments to ensure a sufficient domestic grain supply (Wodon and Zaman, 2009).

In assessing how different factors affect international agricultural price transmission, two types of methodologies, i.e., econometric analyses and Computable General Equilibrium (CGE) models are widely applied in the literature. On one hand, econometric analyses aim to

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[2] Empirical evidence show that price transmission from the international market to domestic market is asymmetric, i.e. food price spike is transmitted to domestic market more quickly and noticeable whereas price decreases merely transmit to domestic market (Peeters and Albers, 2013; Ianchovichina *et al.*, 2014). In this thesis, we focus on the impact of price increases.

reveal whether the movement in domestic prices follows international prices through time. Most findings indicate that price transmission of major grain commodities from international market to developing countries is incomplete and limited in recent years (Baquedano and Liefert, 2014; Ianchovichina, *et al.*, 2014; Minot, 2014).[3] On the other hand, CGE analyses enable modellers to quantify the impact of agricultural and trade policies on international agricultural price transmission (e.g., Arndt *et al.*, 2008; Breisinger *et al*., 2008). Among the various comparative static general equilibrium models, the GTAP (Global Trade Analysis Project) model has been used extensively in economy-wide policy analyses in a regional/global context (e.g. Rutten, *et al.*, 2013; Yu and Jensen, 2014).

The standard GTAP model is a multi-regional CGE model that captures world and regional economic activity in 57 different industries of 140 regions (Version 9.1 of the database with base year 2011). It assumes perfect competition and constant returns to scale, whereas bilateral trade is managed via the Armington assumption (Hertel and Tsigas, 1997).[4] Despite its broad data coverage and firm economic assumptions, the setup of the standard GTAP model does not directly reflect the empirically estimated food price transmission elasticities from econometric analyses. Instead, the model determines the price transmission by a range of model parameterisations, such as the calibration of Armington elasticities (Armington, 1969) in order to reach a certain price transmission level. Warr (2008) studies the relationship between price transmission elasticities and Armington elasticities and clarifies the range of Armington parameters within applied general equilibrium models. However, the Armington parameters do not capture other factors, e.g., variations in margin services, as noted above that cause incomplete price transmission. Siddig and Grethe (2014) indicate that econometric studies use historical data in estimating food prices transmission elasticities. The estimation results may provide a basis for validation and calibration in CGE models. The authors use a single-country CGE model of Israel to identify various channels of how the price transmission in the model may be reconciled with estimated pass-through of prices. However, the literature that formally associating econometric analysis with CGE models in analysing international agricultural price transmission is rather scarce. Only Valenzuela *et al.*

[3] Price transmission elasticities are found to be on average around 0.25 for major grain commodities in developing countries according to Baquedano and Liefert (2014), and around 0.30 for Arab countries according to Ianchovichina, *et al.* (2014).
[4] The framework of the standard GTAP model is well documented in Hertel and Tsigas (1997) and available on the Internet (see www.gtap.org).

(2007) applies the econometric estimates in a CGE framework to study price volatility. The authors show that incorporating the tariff equivalent price transmission elasticities into the standard GTAP model greatly enhances the validation results of the model in assessing grain price volatility.

Therefore, the simulations results in analysing agricultural and food policies by applying the standard GTAP model may deviate from the empirical findings derived from the econometric analyses due to the model's lack of fully considering incomplete price transmission. A research gap persists in utilising the standard GTAP model to assess the impact of international agricultural price transmission on domestic markets.

1.2 Overall objective

In this context, the overall objective of this cumulative thesis is to enhance the realism of the CGE framework in analysing the international agricultural price transmission and its implications for domestic markets by associating econometric analyses with the standard GTAP model. This objective is addressed from different aspects by three articles included in this thesis:

The first article identifies the determinants of food price transmission from international agricultural market to domestic market.

The second article exploits the impact of border restrictions on food price transmission, accounting for variations in domestic margin services in different countries and regions.

The third article investigates the impact of increasing agricultural domestic support on China's domestic market, given the imperfect food price transmission caused by border policy adjustments.

1.3 Research articles

Table 1.1 outlines the title, authors and publication status of the three articles included in this cumulative thesis. These articles are either published in or submitted to peer-reviewed journals.

Table 1.1 Published and submitted articles included in the thesis

Chapter	Title	Authors	Journal
2	Food Security and Transmission of Food Prices	Bekkers, E., Brockmeier, M., Francois, J., & Yang,F.	Submitted (2015) to *World Development*
3	Food Price Pass-Through and the Role of Domestic Margin Services	Yang, F., Bekkers, E., Brockmeier, M., & Francois, J.	Published in *Journal of Agricultural Economics* (2015), 66 (3), 796-811
4	Impact of Increasing Agricultural Domestic Support on Food Price Transmission	Yang, F., Urban, K., Brockmeier, M., Bekkers, E., & Francois, J.	Submitted (2015) to *China Agricultural Economic Review*

***Source*:** Own illustration.

In the first article titled with "Food Security and Transmission of Food Prices" submitted to the *World Development*, we examine the determinants of variations in food price transmission from the international agricultural to domestic food market. The article extends the scope of the current literature in studying food price transmission by a worldwide sample of 147 countries. A two-stage analysis is included. First, we estimate the price transmission in a country-by-country regression of local consumer food price indices on an international agricultural price index. Second, we relate the estimated transmission elasticities to income levels and various indicators of market integrations, i.e., geography and infrastructure related trade cost measures, and policy related trade cost measures and trade outcome measures. In so doing, we are able to quantify to what extent different determinants affect food price transmission. Our analyses imply an inverse relationship between income levels and the degree of price transmission. High-income countries have a lower degree of transmission of the international agricultural price to the local food price index, because their cost share of primary food in consumed food is lower. On the contrary, consumers in low-income countries purchasing most of their food directly after they are imported, and thus are subject to higher volatility from the international market. The different cost structures of food consumption are mainly attributed to the variation in the share of domestic margin services. A higher share of margin services in the final consumption shields domestic consumers from the turbulence of international agricultural prices.

Despite the importance of domestic margin services in affecting food price transmission, CGE models often treat these services as a separate sector, and thus ignore their price insulating impact. Therefore, our second paper "Food Price Pass-Through and the Role of Domestic Margin Services", published in the *Journal of Agricultural Economics*, addresses this issue directly. We present an extended version of the GTAP model in which the value of margin services delivered in form of transport, food processing and retailing is attached to the value of goods directly purchased by final consumers. Therefore, we are able to observe the role of domestic margin services in affecting consumer food prices with the surge in international agricultural prices, in particular, when countries implement border restrictions to insulate domestic consumers from the international market. The simulation results underline that domestic margin services weaken the international agricultural price transmission. The impact is more pronounced in high-income countries. To validate the results, we compare the simulation results to the econometrically estimated price transmission elasticities based on the theoretical framework developed in our first article. We also describe the feasibility and limitation of fitting econometric estimations in the standard GTAP model. Furthermore, we extensively discuss how the consideration of domestic margin services enhances the model's ability in analysing the impact of border restrictions on international agricultural price transmission.

After examining the implications of border policies for domestic agricultural markets, our third article "Impact of Increasing Agricultural Domestic Support on Food Price Transmission", submitted to the *China Agricultural Economic Review* extends the scope of this thesis by analysing agricultural domestic support in affecting food price transmission. China is selected as a focus given its noticeable development in agricultural support in recent years. We introduce two extensions to the standard GTAP model. First, we include a better representation of incomplete price transmission based on econometric analyses. Second, we update the agricultural domestic support structure according to China's current domestic policy. Based on these extensions, we are able to demonstrate the impact of increasing agricultural domestic support on the domestic market while innovatively accounting for incomplete food price transmission caused by border measure adjustments. Two sets of simulations are designed. In the first set of simulations, we compare two scenarios with and without the consideration of incomplete price transmission caused by border policy adjustments in response to the surge in international prices. In the second simulation, we assume that China increases its agricultural output subsidy substantially to the *de minimis* level limited by the World Trade Organization (WTO). Our results underscore the importance of the interdependencies of different agricultural policies in affecting international agricultural price transmission and its implications for domestic markets. We demonstrate that an increase in the agricultural output subsidy in China could compensate the negative impact due to incomplete price transmission caused by border measures adjustments on the domestic market.

Table 1.2 provides an overview of the three articles and their inter-linkages in terms of the objectives, methodologies and contributions to the current literature. As shown in the table, these articles address international agricultural price transmission and its implications for domestic markets from different perspectives. By quantifying the impact of domestic margin services in a global context, the first and second articles underline the importance of differentiating price transmission according to a country's income level in the GTAP model. The third article uses China as an example and emphasises the importance of addressing interdependencies in political measures in studying food price transmission. In terms of methodologies, the first article applies econometric analysis and presents a theoretical foundation for this thesis. The second article utilises the econometric estimations to validate the simulation results derived from the extended GTAP model, whereas the third article incorporates price transmission elasticities directly into the GTAP model and enhances the realism of the model in policy analyses. This thesis contributes to the current literature with regard to three aspects. First, we extend the scope of current literature in explaining variations in food price transmission by applying a global sample of countries. Second, we evaluate the impact of border restrictions on food price transmission more accurately by accounting for domestic margin services explicitly in the GTAP model. Third, we improve the GTAP framework's ability to evaluate the development of China's agricultural domestic support by a detailed representation of incomplete price transmission and domestic support structure in the model.

1.4 Structure of the thesis

The thesis is divided into five chapters. The first chapter includes a general introduction. The second, third, and fourth chapters consist of the three published or submitted journal articles (Table 1.2). The final chapter summarises the major findings of the thesis, discusses the methodology advancements and policy implications, and points out directions for future research.

Table 1.2 Overview of three articles

<table>
<tr><th rowspan="2">Chapter</th><th rowspan="2">Objective</th><th colspan="4">Methodology</th><th rowspan="2">Contribution</th></tr>
<tr><th>Econometric analyses</th><th colspan="3">CGE analyses</th></tr>
<tr><td>2</td><td>To identify the determinants of food price transmission from the international agricultural market to domestic markets</td><td>Price transmission elasticities for aggregated food commodities across countries; Significance of different determinants in affecting price transmission elasticities</td><td colspan="3"></td><td>Extending the scope of current literature in explaining variations in food price transmission by applying a global sample of countries</td></tr>
<tr><td rowspan="4">3</td><td rowspan="4">To exploit the impact of border restrictions on food price transmission, accounting for variations in domestic margin services</td><td rowspan="4">Price transmission elasticities for aggregated food commodities in three different regions grouped per income
↳ Validation</td><td>GTAP database: V. 8.1, 2007</td><td colspan="2">Base Year: 2007</td><td rowspan="4">Evaluating the impact of border restrictions on food price transmission more accurately by accounting for domestic margin services explicitly in the GTAP model</td></tr>
<tr><td colspan="3">Model Extension: Quantified domestic margin services</td></tr>
<tr><td colspan="3">Simulations</td></tr>
<tr><td>International Agricultural Price Surges</td><td colspan="2">Border policy adjustments</td></tr>
<tr><td rowspan="4">4</td><td rowspan="4">To investigate the impact of increasing agricultural domestic support on the China's domestic market, given the imperfect food price transmission caused by border measure adjustments</td><td rowspan="4">Price transmission elasticities for single agricultural or food commodity across countries with a focus on China
↳ Parameterisation</td><td>GTAP database: V. 9.1, 2011</td><td colspan="2">Base year: Updated 2020</td><td rowspan="4">Improving the GTAP framework's ability to evaluate the development of China's agricultural domestic support by a detailed representation of incomplete price transmission and domestic support structure in the model</td></tr>
<tr><td colspan="3">Model extensions: (1) Incomplete price transmission
(2) Updated domestic support structure</td></tr>
<tr><td colspan="3">Simulations</td></tr>
<tr><td>International Agricultural Price Surges</td><td>Border policy adjustments</td><td>Domestic support increases</td></tr>
</table>

Source: Own illustration.

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2 Food Security and Transmission of Food Prices

Authors: Bekkers, E., Brockmeier, M., Francois, J., Yang, F.

Submitted (2015) to: *World Development*

Abstract

World food prices spiked in the periods 2007-2008 and 2010-2011. The impact of these spikes in world food prices on local food prices and thus on food security of local consumers is determined by the food price pass-through. Pass-through is defined as the extent to which changes in world food prices lead to changes in local food prices. We examine the determinants of variation in food price pass-through from global to local consumer prices in a global sample of 147 countries, using FAO data on world food prices and ILO data on food prices for consumers. While market integration matters, our study finds that income per capita is the dominant factor explaining cross-country variation in pass-through of food prices. We estimate an elasticity of about -0.3 of pass-through with respect to income per capita. This means far greater price transmission of food price shocks at the commodity level to final consumers in low-income countries than in high-income countries. The implication is that future swings in world food prices will in particular jeopardise food security in poor countries. Trade policy measures of market integration also affect the pass-through significantly, whereas infrastructure and geography measures play a more limited role.

Keywords: Food price pass-through, Food security, Primary food shares

JEL codes: Q02, Q11, Q17, Q18

2.1 Introduction

World food prices spiked in the periods 2007-2008 and 2010-2011. Various reasons have been spelled out for these price spikes, ranging from extreme weather events to increased use of food stocks as biofuel input, rising energy prices, larger meat demand in emerging countries, exchange rate movements and low stock level expectations (see for example Abbott and de Battisti (2011), Diouf (2008) and Timmer (2008)). Ray *el al.* (2015) attribute one-third of crop yield variations to climate variation, while Asseng *et al.* (2015) find that warming trends are driving down global wheat yields. On the socio-economic front, Dessus *et al.* (2008), Ivanic and Martin (2008), and Ivanic *et al.* (2012) conclude that recent episodes of spikes in food prices raised poverty considerably, especially in urban areas of food importing countries. Soaring prices can also contribute to political unrest, and the most recent episodes generated protectionist measures in many countries. Anderson *et al.* (2013) have pointed out that these policy measures actually magnified price shocks, while Swinnen and Squicciarini (2012) have argued that calls for protectionist measures by Non-governmental Organisations (NGOs) are inconsistent with their earlier calls for abolition of food production subsidies in rich countries to help farmers in poor countries. There were consistent demands for changes in food policy in the Organisation for Economic Cooperation and Development (OECD) Member countries over the last two decades. In particular a mandate was negotiated for elimination of subsidies and income support to farmers. Changes in these policies led predictably to food price increases. These increases have themselves been criticised by the same combination of NGOs and developing countries thereafter. In addition, India is now invoking food security to justify departure from (World Trade Organisation) WTO obligations and introduction of the same support schemes developing countries lobbied heavily against when the WTO was established. See Swinnen and Squicciarini (2012) for further discussion.

The transmission of global food price shocks to high- and low-income consumers alike is linked closely to the food security debate, weaving patterns of price transmission together with poverty, politics, and trade policy. A large transmission of global food price shocks jeopardises food security for poor consumers in case of soaring world food prices. The impact of an increase in world food prices on the local cost of living (and hence on local household consumption and the general affordability of food) is determined by the food price pass-through, the extent to which changes in world food prices lead to changes in local food prices. The standard explanation for variations in food price pass-through relies on variations in the degree of market integration. The degree of market integration is a function of the size of trade costs, often heavily affected by government policy. Baffes and Gardner (2003) study how policy reform affected pass-through, rejecting the hypothesis that pass-through increased as a result of liberalisation. Myers and Jayne (2012) show that price transmission of South African maize prices to Zambian prices varies with the amount of imports, whereas Ferrucci *et al.* (2012) emphasise the importance of the Common Agricultural Policy (CAP) for pass-through in the EU. Figure 2.1 suggests that something more fundamental is also at play: the level of income. Local consumer prices for food in a rich country like Sweden are far less responsive to world food prices than local consumer prices for food in poor countries like Gabon and China.[1]

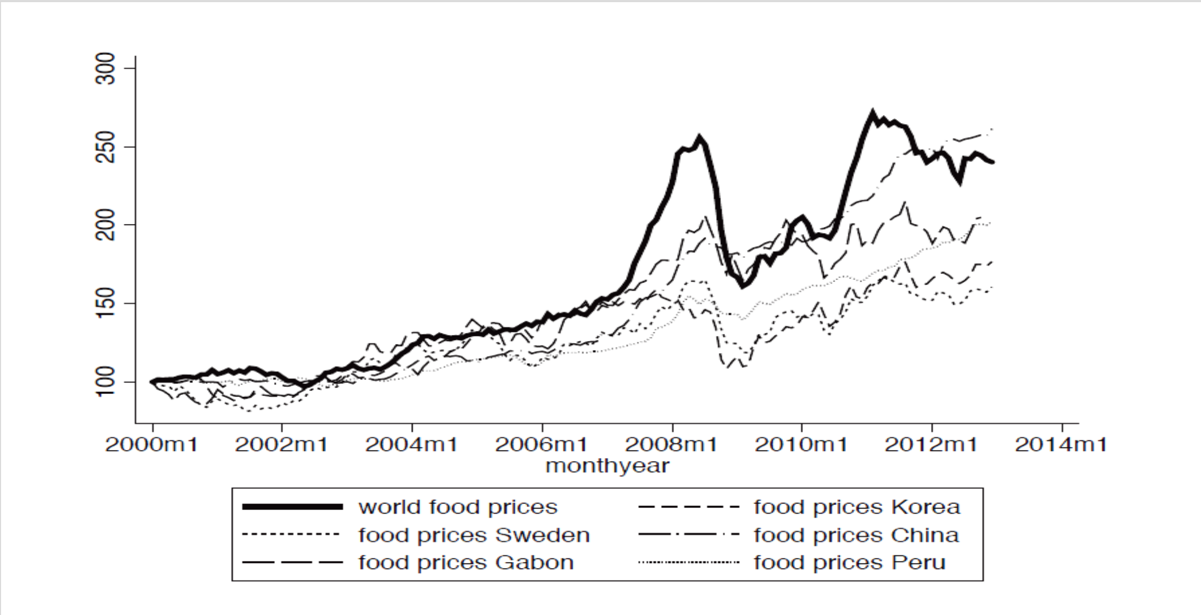

Figure 2.1 The world food price and local dollar food price indices, selected countries

***Source*:** Food and Agricultural Organization of the United Nations (FAO), 2013. International Labour Organization (ILO), 2013.

In this paper we examine the determinants of world food price pass-through, employing a worldwide sample of monthly local food price indices from 147 countries. We proceed in two steps. In the first step we estimate the long run pass-through on a country by country basis

[1] Countries with relatively stable exchange rates *vis-à-vis* the USA were selected for this figure. The fact that local food prices in the poor African country Gabor seem relatively insulated from world food price movements is reflecting that African countries have a significantly lower pass-through than other countries, controlling for income levels. We explore this later in the paper.

with regressions of local food price indices on a world food price index. The local food price indices are collected by the ILO while the world food price index is from the FAO. Following the recent exchange rates pass-through literature (Campa and Goldberg, 2005; Nakamura and Zerom, 2012), we first regress the first difference of the local food price index on a series of lags of the first difference of the world food price index, defining the long run pass-through as the sum of the coefficients on all of these lags. In the second step we relate the estimated long run pass-through rates to income levels and various indicators of market integration.

We find that a key indicator for cross-country variation in primary food price pass-through to consumers is the level of income. The elasticity of the pass-through with respect to income per capita is about -0.3 and income per capita is very robust to variations in estimation methods and inclusion of different control variables. Richer countries have a lower pass-through of the world food price to the local food price index, because their cost share of primary food in consumed food is lower. This reflects two forces. First, rich countries demand higher quality food with larger expenditures on additional retail services. Second, the price of the additional services in consumed food rises as countries grow richer due to Harrod-Balassa-Samuelson effects (Balassa, 1964; Baumol, 1967). Critically, this means that when we have observed spikes in global food commodity prices, as observed in the past and as expected with the continued impact of climate change, we can expect far larger food price increases for consumers in low-income countries than for consumers in high income countries, which in turn means greater pressure for regional demand adjustment to global price shocks in low-income countries. Essentially, the burden of adjustment falls on the poor. Examining the share of margin services in countries with different income levels in multi-country general equilibrium models like the Global Trade and Analysis Project (GTAP) (Hertel and Tsigas, 1997) supports this interpretation with the share of margin services rising in the level of income.[2]

On the role of market integration we obtain three broad results. First, larger policy related trade costs like the costs to import a 20 foot container and the Trade Restrictiveness Index (TRI) measuring specific import protection in agriculture (Kee, *et al.*, 2009) significantly reduce the food price pass-through. Second, geography and infrastructure related trade costs

[2] See for further discussion Baltzer (2013). The role of margin services in exchange rate pass-through is explored in Burstein *et al.* (2003) and Francois *et al.* (2013) without relating it to income per capita. Yang *et al.* (2015) focus specifically on margin service costs and income levels in a Computable General Equilibrium (CGE) model based assessment of pass-through of food price shocks.

do not affect the pass-through once policy related trade costs are controlled for. And third, we find a significantly higher pass-through in countries with a larger Import Dependency Ratio (IDR).

We also find that the long run pass-through is significantly lower in African countries relative to the rest of the world (more than 10% controlling for income per capita) and significantly higher in Asian countries relative to the rest of the world (about 5% larger). The "African effect" is largely explained by higher policy related trade costs like the costs to import and export (serving to insulate local prices from movement but at the cost of substantially higher baseline price levels), an effect that loses significance once these underlying factors are controlled for in the regressions.

We are not the first to examine local transmission of global food price increases. Several scholars have studied food price pass-through in the aftermath of recent episodes of soaring food prices, but the focus has generally been on single countries or a small set of countries (International Monetary Fund (IMF), 2008, 2011; Dawe, 2008; Cudjoe, *et al.*, 2010; Minot, 2010; Rigobon, 2010; Gilbert, 2010; Ghoshray, 2011; Baltzer, 2013). In contrast to this literature, by focusing on food price indices instead of individual sets of commodity prices, we are able to explore variations in pass-through across a large set of almost 150 countries.[3] Our main contribution to the existing literature is calculating and formally examining the determinants of food price pass-through for a large, global sample of countries. Because we work with a global sample, we are able to evaluate the contribution of income per capita and various forms of market integration measures in explaining variations in food price pass-through rates.

2.2 Food price pass-through in theory

The consumption of a bundle of food products Q_f in a certain country can be decomposed into a bundle of primary food components Q_{pf} of food traded internationally like wheat, meat and milk and a bundle of additional services in food consumption Q_{sf} not traded

[3] Pass-through was estimated as well at the aggregate level for more than 70 countries in IMF (2011), but these authors did not attempt to formally explain the variation in the pass-through. Meyer and von Cramon (2004) and Vavra and Goodwin (2005) survey the earlier literature on food price pass-through and Fackler and Goodwin (2001) go into the broader question of spatial price transmission.

internationally such as shipping, local processing, storage, and distribution. Suppose Q_f is a homothetic function of Q_{pf} and Q_{sf}.[4] We can then write the price index of food consumption P_f in a country as a function of the local price index of primary food P_{pf} and the local price index of food services P_{sf}:

$$P_f = G(P_{pf}, P_{sf}) \tag{2.1}$$

The local price index of primary food P_{pf} is related to the international price index of primary food P_{ipf} times the exchange rate E. E is the exchange rate of the country related to the currency in which international food prices are denominated, i.e. the price of the international currency expressed in our local currency. With perfect market integration, P_{pf} and EP_{ipf} will be equal, but due to both natural barriers to trade like transport costs and policy measures like import tariffs or local food subsidies then two prices can differ. We define ε_{mi} as the elasticity of P_{pf} with respect to EP_{ipf} indicating the degree of market integration.

Log differentiating Equation (2.1) and applying Shephard's lemma, the relative change of the price of food consumption can be expressed as a function of the relative change of the international price of primary food, the exchange rate and the price of food services:

$$P_f = s_{pf}\varepsilon_{mi}(P_{ipf} + E) + (1 - s_{pf})P_{sf} \tag{2.2}$$

s_{pf} is the share of primary food in total food consumption, $s_{pf} = \dfrac{P_{pf}Q_{pf}}{P_f Q_f}$ and $1 - s_{pf}$ the share of local food services. The share of local food services tends to rise as countries grow richer for two reasons. First, the Harrod-Balassa-Samuelson effect (Balassa, 1964; Baumol, 1967) tends to raise the price of local services as countries get richer. With limited possibilities for substitution between primary food and food services, this will increase the share of food services. Second, consumers' demand for quality will rise as countries grow and supply chains develop to provide higher, more consistent quality along with additional services as

[4] With non-homothetic preferences we get identical results (see Appendix 2.A), but the exposition with homothetic preferences is clearer.

part of retail food expenditures. This raises the share of the local services component in total food consumed.

2.3 Methodology and data

We turn Equation (2.2) into an estimating equation using data on log changes in local and international prices and exchange rates. In particular, we follow a common practice in the literature on exchange rate pass-through (Campa and Goldberg, 2005; Nakamura and Zerom, 2012) and regress the first difference of the log price of total food consumption on the first difference of the log price of internationally traded food:[5]

$$\Delta \log P_{f,jt} = \sum_{k=0}^{K} \beta_{jk} \Delta \log P_{ipf,jt-k} + \sum_{k=0}^{K} \gamma_{jk} \Delta \log E_{jt-k} + \varepsilon_{jt} \qquad (2.3)$$

j is a country subscript and t is a time subscript. The sum of pass-through coefficients, $\sum_{k=0}^{K} \beta_{jk}$ generates the long run pass-through of the world food price index to the local food price index in country j. The number of lags K is determined by the rule followed in Nakamura and Zerom (2012) that adding more lags does not change the long-run elasticity (Appendix 2.B). We implement this rule by calculating the average long run pass-through across all countries in the sample and evaluating at which lag length this average stabilises. Based upon this rule we work with 15 lags. More specifically, the lag length at which the long run pass-through stabilises is defined as the lag length where the relative difference in long run pass-through with the average of long run pass-through with 1 and 2 lags less is smaller than a certain threshold (5%). We do not vary the lag length by country, since this would distort the comparison of long run pass-through across countries. Also Campa and Goldberg (2005) and Nakamura and Zerom (2012), respectively calculating pass-through for different countries and pass-through for retail and wholesale coffee prices, choose one lag length for all their regressions.

Several scholars estimate a Vector Error Correction (VEC) model to determine the long run pass-through (Baffes and Gardner, 2003; Conforti, 2004; Gilbert, 2010; Minot, 2010;

[5] Based upon unit root tests, we estimate the relationship between local food prices and world food prices in first differences.

Cudjoe, *et al.*, 2010). In line with the cited literature on the determinants of exchange rate pass-through, we do not follow this route for three reasons. First, world and local food prices do not co-move because of poor market integration (see Adam (2011) and Ianchovichina, *et al.* (2012) for further discussion). Second, there is an important local cost component in the food prices analysed, making it less likely that the world food price index and local food price indices are cointegrated. Third, Engle-Granger tests of the existence of cointegration show that in only 4 of the 147 countries we can reject the hypothesis of no cointegration. In a robustness check we test for cointegration with the Johansen test and estimate a VEC model for the countries where a cointegration relationship exists according to the Johansen test. We discuss results of VEC models in section 5 on robustness checks.

The price of total food consumption in country j, $P_{f,jt}$, is measures with the food component in country j's Consumer Price Index (CPI) and the price index of international traded food, $P_{ipf,jt-k}$, is measures with an international food price index in dollars, both measures on a monthly basis.[6] The exchange rate E_{jt-k} is defined as the price of dollars in local currencies. We allow for different pass-through coefficients of the world food price β_{jk} and the exchange rate γ_{jk} since tests of equality of the world food price and exchange rate pass-through reject the hypothesis that the two sets of pass-through are equal.[7] In the exposition below we concentrate on the long run pass-through of the world food price.[8]

To analyse the determinants of the long run food price pass-through we proceed in two steps. In the first step, we estimate Equation (2.3) country by country allowing for Autoregressive (AR) (1) disturbances in order to eliminate autocorrelation. In the second step, we regress the calculated long run pass-through on income levels and other determinants of pass-through related to the degree of market integration. In the second step we use weighted

[6] We do not think that the omission of a local price index of food services creates an omitted variable bias problem, as services prices tend to remain constant on a monthly basis and only change over longer time horizons. We did not explore this assertion in the data since data on services prices are only available on a yearly basis for our large sample of countries.

[7] The weighted average across countries of the t-statistics of the difference in the world food price index and the exchange rate long run pass-through is 2.61 with 15 lags. This implies that we have to reject the hypothesis that the two sets of long run pass-through are equal. Including more than 10 lags the average t-statistic is exceeding 2, so this result is robust to variation in the lag length (Appendix 2.B).

[8] An analysis of the determinants of the exchange rate pass-through is available from the authors upon request. We argue that we should not attach too much value to these results. The reason is that countries with fixed exchange rates and only some realignments bias the results on the analysis of the exchange rate pass-through.

least squares, with the standard errors of the estimated long run pass-through as weights, thus giving more weight to more precisely estimated pass-through.

Our price data consist of monthly data over the period 2000-2012. The price of internationally traded food $P_{ipf,jt}$ is calculated from the world food price index composed by the FAO. The price index is based upon 55 items in five broad categories: cereals, oils and fats, dairy, meat and sugar. The price of total food consumption in country j in period t, $P_{f,jt}$, is calculated from the food component in country j's consumer price index as composed by the ILO. Monthly exchanges rates are from the International Monetary Fund International Financial Statistics (IMF IFS) and the World Bank. Income per capita levels in Purchasing Power Parity (PPP) terms are from the World Bank. We define three income groups: poor (less than $US 770 per capita GDP at year 2000 prices), middle ($US 770-$US 9300 per capita GDP) and rich (more than $US 9300 per capita GDP).

2.4 Estimation results

We start our analysis of the determinants of the long run pass-through in Table 2.1, where we analyse the impact of GDP per capita and evaluate continent differences.[9] The first column of the table displays the results of a regression of estimated pass-through rates on GDP per capita (GDP PC) showing that its impact is highly significant - it well characterises the cross-country pattern of pass-through. Estimation in logs (second column) generates an elasticity of the long run pass-through with respect to GDP per capita of -0.28.[10] In the third column we add the income group dummies. With rich being the omitted category, we see that the difference in pass-through between rich and middle-income countries and between rich and poor countries is highly significant. GDP per capita is still significant at the 5% level and its coefficient falls by about half. Besides the significant within group impact of GDP per capita within the three income groups, there is a significant difference in the long run pass-through

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[9] In Appendix 2.B we present the long run pass-through estimated in the first stage.

[10] Since estimation in logs drops the negative long run pass/through observations, it is fair to drop the outliers on top as well. The elasticity is still -0.28 after omitting the countries with a long run pass-through larger than 1 and remains highly significant. To evaluate the impact of dropping the negative observations, we also ran the levels regression without the negative observations. The coefficient on GDP per capita becomes about 10% larger, indicating that dropping the negative observations leads to a somewhat higher elasticity in the logs regression. Results are available upon request from the authors.

between the rich countries on the one hand and the middle-income and poor countries on the other hand.

Table 2.1 Effect of GDP per capita and continent dummies on long run pass-through [1)]

	(1) LRPT[2)]	(2) ln(LRPT)	(3) LRPT	(4) LRPT	(5) LRPT	(6) LRPT
GDP PC	-4.3e-06*** 5.4e-07)		-2.0e-06** (9.4e-07)	-8.3e-06*** (1.9e-06)	-2.1e-06** (9.0e-07)	-1.7e-06* (9.4e-07)
ln(GDP PC)		-0.28*** (0.04)				
Poor			0.10** (0.04)		0.19*** (0.05)	0.11** (0.04)
Middle			0.08*** (0.030)		0.11*** (0.03)	0.09*** (0.03)
GDP PC Squared				9.5e-11** (4.2e-11)		
Africa					-0.12*** (0.03)	
Asia						0.05** (0.02)
Constant	0.24*** (0.01)	0.57* (0.33)	0.17*** (0.03)	0.27*** (0.02)	0.17*** (0.03)	0.15*** (0.03)
Observations	147	139	147	147	147	147
R^2	0.30	0.31	0.34	0.33	0.40	0.36
Adjusted R^2	0.30	0.31	0.33	0.32	0.38	0.35

Note: 1) Standard errors in parentheses. $*p < 0.10$, $**p < 0.05$, $***p < 0.01$. 2) LRPT (Long Run Pass-Through); PC (Per Capita).

Source: Own estimation.

In the fourth column we explore a possible nonlinear relation and add GDP per capita squared. Both terms are significant, with the linear term negative and the quadratic term positive. This indicates an L-shaped relationship: income growth has a stronger impact on the pass-through at lower levels of income. In the fifth and sixth columns we add dummies for respectively Africa and Asia. The long run pass-through is about 10% lower in African countries, whereas it is about 5% higher in Asia, both controlling for GDP per capita and income groups. The other continent dummies are not significant and the Asian dummy becomes insignificant when including both Asia and Africa.[11] Ferrucci *et al.* (2012) study food price pass-through within the EU and argue that internal EU prices should be used for raw food as EU prices are largely insulated from world food prices due to the CAP. In our

[11] This result is available from the authors upon request.

study, a dummy for EU countries is not significant, implying that pass-through of world food prices in EU countries is not smaller than in countries with comparable income levels.

The difference in long run pass-through across the different income groups reflects the larger share of margin services in food consumption in the rich countries, the term s_{pf} in Equation (2.2). As a next step we explore the possible influence of the degree of market integration, represented by the term ε_{mi} in Equation (2.2). We study three types of measures and trade outcome measures. Table 2.2 provides an overview of the variables included in the regressions. The expectation is that countries with a lower degree of market integration have a lower long run pass-through. The role of geography and infrastructure is evaluated using a landlocked dummy and indicators collected by the World Bank on the quality of infrastructure. Policy related trade costs are measured with three different types of data. First, the trade cost measures on the costs of doing business internationally collected by the World Bank (2012); second, the National Rate of Assistance (NRA) measuring both trade related and domestic distortions in agriculture, collected by Anderson *et al.* (2008); third, the Trade Restrictiveness Index (TRI) measuring the uniform tariff equivalent of tariff and non-tariff barriers to trade (Anderson and Neary, 1994), calculated for the agricultural sector by Kee, *et al.* (2009). As trade outcome measure we include the Import Dependency Ratio (IDR) in the regression, calculated from FAO data as food imports divided by food absorption (food production plus food imports minus food exports).

Table 2.2 An overview of the variables included in the regression

Variable	**Description**	**Source**
Port Infrastructure	Quality of port infrastructure from business executives surveys of port facilities	World Economic Forum, 2012
Import Cost	All official fees levied on importing a 20-foot container	World Bank, 2012
NRA	National rate of assistance in the total agricultural sector including decoupled payments and non product specific assistance reflecting trade related and domestic distortions in agriculture	Anderson *et al.* (2008)
TRI	Uniform tariff equivalent of tariff and non-tariff measures in agriculture based upon MFN[1)] tariffs	Kee, *et al.* (2009)
IDR	Food imports divided by food absorption (food production plus food imports minus food exports)	FAO (2013)

Note: 1) MFN (Most Favoured Nation).

Source: Own elaboration based on different sources.

To interpret the coefficients as elasticities we run all regressions on market integration in logs (Table 2.3).[12] We control for GDP per capita in all regressions. So, the regression in column two of Table 2.1 serves as a baseline. We add the different market integration measures one at a time to the baseline specification and include the significant measures all together in the end.[13]

Table 2.3 Effect of market integration on long run pass-through [1)]

	(1) ln(LRPT[1)])	(2) ln(LRPT)	(3) LRPT	(4) ln(LRPT)	(5) ln(LRPT)	(6) ln(LRPT)	(7) ln(LRPT)
ln (GDP PC)	-0.36***	-0.29***		-0.36***	-0.47***	-0.47***	-0.32***
	(0.05)	(0.03)		(0.04)	(0.06)	(0.07)	(0.05)
ln(Port infrastructure)	0.66***					-0.06	0.25
	(0.29)					(0.39)	(0.29)
ln(Import cost)		-0.55***				-0.23	-0.56***
		(0.12)				(0.19)	(0.13)
GDP PC			-4.0e-06***				
			(8.8e-07)				
NRA			-0.06**				
			(0.03)				
ln(TRI)				-0.33***		-0.24**	
				(0.06)		(0.09)	
ln(IDR)					0.17**	0.01	
					(0.07)	(0.11)	
Constant	0.25	4.53***	0.25***	0.44	2.38***	3.27**	4.49***
	(0.38)	(0.90)	(0.02)	(0.31)	(0.56)	(1.61)	(1.06)
Observations	121	138	74	80	94	52	121
R^2	0.34	0.41	0.33	0.58	0.47	0.65	0.43
Adjusted R^2	0.33	0.40	0.31	0.57	0.46	0.62	0.41

Note: 1) Standard errors in parentheses. $*p < 0.10$, $**p < 0.05$, $***p < 0.01$.

Source: Own estimation.

We start in the first column of Table 2.3 with the impact of infrastructure, using as measure the quality of port infrastructure collected by the World Economic Forum's Executive Opinion Survey (Schwab, 2012). The effect is significant and has the right sign: a better port infrastructure raises the pass-through. Other measures like the percentage of paved road, the liner shipping connectivity index measuring the connection to global shipping routes or a logistics performance index all have the wrong sign and are not significant. The wrong

[12] Most of the regressions in Table 2.1 are in levels, since they contain mostly dummy variables.
[13] We checked the impact of influential data points and report the results where relevant.

coefficient probably reflects that richer countries have better logistics and part of the GDP per capita effect is picked up by the logistics measure. The reduced coefficient on GDP per capita provides support for this interpretation. We also explored the effect of being landlocked. Its effect on pass-through is negative as expected, but the significance is driven by one outlier (Switzerland). Minot (2010) finds a larger pass-through in landlocked countries in a study of food pass-through of African countries, speculating that the larger price increases in landlocked countries might be caused by the co-movement of world food and world fuel prices and food prices in landlocked countries being affected more by increases in fuel prices. We find a highly insignificant coefficient of landlocked restricting the sample to African countries.

Next we move to policy related trade costs. The first variable in this respect is import costs as collected by the World Bank, measuring the official fees levied on a 20-foot container imported into the country. Its coefficient has the right sign and is strongly significant. Larger fees to import a container reduce the pass-through. Export costs, measured in the same way as import costs, the number of days to import and the number of days to export, measuring the number of days needed to comply with all procedures to import or export goods, and a variable measuring the burden of custom procedures also have a significant negative impact on the long run pass-through.

The second policy related trade cost variable is the NRA. There are several NRA measures and we work with the national rate of assistance in the total agricultural sector including decoupled payments and non product specific assistance. Since the NRA is negative for some countries we run this regression in levels. Column three shows that controlling for GDP per capita this variable have a significant (at the 10% level) negative impact on pass-through, as expected. Also some other NRA measures have a significant negative impact, but for example the NRA measures based upon covered products only are not significant.

The third policy related variable is the TRI in agricultural products. Column four shows that the TRI based upon MFN tariffs has a highly significant negative impact on the pass-through, as expected. Also the other TRI measures in the agricultural sector based upon MFN tariff and non tariff barriers and based upon applied tariffs and applied tariff and non tariff barriers affect the pass-through negatively and significantly, but the effect is not as large as for the TRI based upon MFN tariffs.

In column five we move to the trade outcome measure IDR, the import dependency ratio. The effect of a larger import dependency ratio on the pass-through is positive and significant at the 5% level. Therefore, countries more dependent upon imports display higher pass-through, as expected.

Next, in column six we include all significant trade cost measures in the regression. Being left with only 52 countries in the regression, per capita GDP and TRI are significant with the right sign; whereas port infrastructure switches sign.[14] The wrong sign on port infrastructure partially reflects the changed sample: regressing the pass-through only on per capita GDP and port infrastructure in the reduced sample generates an insignificant positive coefficient on port infrastructure. To examine the relative importance of infrastructure versus trade policy in the larger sample we regress in column six the pass-through on per capita GDP, port infrastructure and import costs. Port infrastructure keeps the right sign, but the coefficient falls by about half and becomes insignificant. Import costs and GDP per capita instead retain their strong significance and the size of the coefficient stays about the same.

We take three lessons away from the analysis on the effect of market integration on pass-through. First, market integration does matter and the policy related component of market integration seems to be most important. The infrastructure and geography measures do not have a significant impact once controlling for import costs or TRI.[15] Second, import costs can explain most of the lower pass-through in Africa. Repeating the regressions in table 2.3 including the dummy for Africa shows that the coefficient on the African dummy loses significance after adding import costs to the regression. This is not the case for the other market integration measures.[16] Third, the impact of GDP per capita remains strongly significant and the effect becomes even more profound in most cases once controlling for market integration.

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[14] Including also the NRA in the regression and conducting the analysis in levels reduces the sample size to 34. Per capita GDP and TRI are significant with the correct sign, whereas import costs become marginally significant with the correct sign.

[15] We cannot evaluate the impact of variation in markup adjustments as a result of variation in concentration and market power in the retail sector in our broad sample, because of a lack of data. OECD (Conway, 2005; Woelfl, 2009) reports indices of product market regulation in retail trade for up to 40 countries. We examined the impact of these indices on the long run food price pass-through, finding that only the indices for opening hours and protection of existing firms have a significant impact on the pass-through and display the correct sign (more regulation leading to a lower pass-through).

[16] The additional results are available from the authors upon request. In the case of the NRA and TRI the African dummy becomes insignificant in the reduced sample without including the NRA and TRI themselves. So, the sample drives the insignificance and not the inclusion of the market integration measures themselves.

2.5 Robustness checks

We conduct five robustness checks, extending the basic estimation framework in several directions, confirming the results of the main analysis. Detailed results are available from the authors upon request. First, we tested for the existence of cointegration between the world food price index and the local food price index. Engle-Granger tests indicate that the residual series are stationary implying the presence of a cointegration relationship only in three cases. Johansen tests instead provide support for cointegration in 41 countries. Therefore, as a robustness check we estimated a VEC model for these 41 countries and analysed the resulting long run pass-through. The cointegration results confirm the baseline estimation results on the role of income. The long run pass-through is strongly correlated with per capita income. But the market integration variables do not have a significant impact on the cointegration pass-through, except for IDR which is marginally significant.

Second, we followed IMF (2008) and Ianchovichina, *et al.* (2012) using a somewhat different estimation method including lagged dependent variables of local food price increases. Analysing the long run pass-through following this approach does not lead to different results. The elasticity of the pass-through with respect to GDP per capita falls somewhat to 0.18, the NRA is not significant anymore and port infrastructure stays significant in the specification with import costs.

Third, we addressed possible endogeneity of world food prices in two ways. On the one hand we repeated estimation of the pass-through omitting the contemporary lag on the right hand side and conducted the same analysis as above. On the other hand we repeated the analysis omitting the 12 biggest food exporters. Most of the conclusions from the main analysis remain intact, only port infrastructure becomes insignificant in both cases.

As fourth and fifth robustness check, we conducted two additional exercises. On the one hand we estimated the long run pass-through with the world food price and the exchange rate integrated as one variable. On the other hand, we repeated estimation of the pass-through with 12 and 18 lags. In both cases the main results remain intact, although NRA and the Asian dummy loss significance when varying the lag length.

2.6 Concluding remarks

The impact of global food price increase on patterns of food security at the local level hinges on the mechanics of food price transmission. As such, the food security debate weaves patterns of price transmission together with poverty, politics, and the determinants of trade policy. In this paper we estimate food price pass-through for a large sample of countries and analysed the determinants of variations in pass-through. We find that market integration does play a role in the form of policy related trade costs, but income per capita is a stronger and more robust determinant of pass-through. This implies that in calculating the poverty impact of world food price spikes (for example future price shocks linked to climate change), studies should take into account the variation in pass-through across countries as a function of the level of income as well as market integration.[17] Obviously, poorer countries and countries more integrated into the world market are more vulnerable to world food price volatility. Less obvious is the implication for the effect of strong income growth in emerging countries on world food price volatility and the subsequent volatility in countries that remain behind. As emerging countries grow, a larger share of their food consumption will consist of additional margin services, with a consequent fall in pass-through rates. This means that swings in the prices of primary food have a smaller impact on the price of consumed food in these countries. So, shocks will be accommodated less by adjustments in demand and thus have a larger impact on primary food prices. As a result prices may display even larger swings, with the poorer countries facing increased food price volatility.

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[17] The study by Valenzuela *et al.* (2007) goes in this direction by including active market insulation by importers in the GTAP model to match price volatility in the data and in the model. But this paper is not focused on poverty impacts of food price volatility.

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Appendix

Appendix 2.A Non-homothetic preferences

In this appendix, we demonstrate that with non-homothetic preferences we get identical results as those reported in the main text with homothetic preferences.

Assume the demand across primary food and food services is non-homothetic. We can then write the average spending on total food consumption $\tilde{P}_f$ (as a proxy for its price) as the minimum expenditure on total food $\tilde{G}(P_{pf}, P_{sf})$ divided by the consumption of primary food $\tilde{Q}_f$:

$$\tilde{P}_f = \frac{\tilde{G}(P_{pf}, P_{sf})}{\tilde{Q}_f} \tag{2.A1}$$

Log differentiating Equation (2.A1) and applying Shephard's lemma generates an expression for the relative change of $\tilde{P}_f$:

$$\tilde{P}_f = \frac{Q_{pf} P_{pf}}{\tilde{P}_f \tilde{Q}_f} P_{pf} \tag{2.A2}$$

Hence, the elasticity of total food prices with respect to primary food prices generates an expression for the primary food share also with non-homothetic preferences.

Appendix 2.B First stage results and motivation specification

In this section, we present the first stage estimation results and unit root tests on the local food price indices, discuss into more detail how the lag length was selected and provide further motivation for entering the world food price index and the exchange rate as separate Regressors.

Table 2.B1 displays the estimated long run pass-through of the 147 countries in our sample ranked by income per capita. In more than half of the countries the estimated long run pass-through is significantly larger than zero at 5% level. Instead of throwing away valuable information, we decided to keep the estimated long run pass-through for countries where the long run pass-through is not significantly larger than 5%. By weighting observations by the inverse standard error of the long run pass-through, imprecise observations have relatively little impact in the second stage estimations.

Augmented Dickey Fuller (ADF) tests on local consumer price indices for each country show that only in the case of Suriname and Romania, we can reject the presence of a unit root. Running ADF tests on the first differences of the local food price indices shows that for all countries we can reject the presence of a unit root, except for Zimbabwe, which is dropped from the sample because of hyperinflation. This analysis implies that the pass-through should be estimated in the first differences.

Table 2.B1 First stage long run pass-through in different countries[1)]

Country	LRPT[2)]	IPC	Country	LRPT	IPC	Country	LRPT	IPC
Burundi	1.225	135	Phillipines	0.185*	1055	Venezuela	0.18	4845
Malawi	0.004	144	Congo	0.032	1109	Saint Lucia	0.23	4899
Niger	0.375	155	Honduras	0.324*	1123	Croatia	0.25*	4911
Chad	0.282	186	Albania	0.172	1190	Chile	0.333*	5041
Sierra Leone	0.360*	204	Syria	0.384	1203	Grenada	0.263	5181
Rwanda	0.23	214	Samoa	0.37	1226	Czech Republic	0.388*	5721
Burkina Faso	0.446	214	Kazakhstan	0.514*	1230	Trin. and Tobago	0.153	6461
Nepal	0.34	235	Morocco	-0.03	1301	Mexico	0.127	6859
Mali	0.286	236	Eq. Guinea	0.104	1321	Uruguay	0.261*	6914
Mozambique	0.153	236	Swaziland	-0.999	1404	Seychelles	0.108	7579
Madagascar	0.386*	240	Iran	0.646*	1510	Argentina	0.061	7917
Cent. African Rep.	0.377	247	Guyana	0.344*	1512	Oman	0.441*	8097
Uganda	0.18	269	Guatemala	0.231*	1530	Saudi Arabia	0.238*	9204
Togo	0.093	277	Paraguay	0.505*	1542	Slovenia	0.160*	10091
Kyrgyzstan	0.254	278	Egypt	0.310*	1566	Malta	0.208*	10271
Guinea-Bissau	0.446*	278	Romania	0.261*	1672	South Korea	0.116	11347
Cambodia	0.456*	288	Jordan	0.347*	1742	Barbados	0.240*	11514
Tanzania	0.212	303	Russia	0.379*	1775	Portugal	0.101*	11539
Laos	-0.081	308	Macedonia	0.361*	1786	Greece	0.054	11662
Zambia	0.079	311	Algeria	-0.067	1795	Bahrain	0.097	11890
Moldava	0.296	355	Tonga	0.194	1926	Cyprus	0.224	13186
Benin	0.314	362	Thailand	0.111	1983	New Zealand	0.150*	13736
Bangladesh	0.156	368	Peru	0.143*	2117	Spain	0.104	14456
Guinea	0.370*	371	Fiji	0.208	2118	Taiwan	0.179	14641
Nigeria	0.2	390	Namibia	0.158*	2140	Kuwait	0.275	17013
Kenya	-0.114	399	Tunisia	-0.029	2245	Brunei	0.174*	18477
Ghana	-0.236	400	El Salvador	0.342*	2399	Italy	0.064*	19451
Vietnam	0.722*	402	Colombia	0.155*	2480	Israel	0.330*	20764
Mauritania	0.09	409	Suriname	0.101	2713	Bahamas	0.134*	20894
Lesotho	0.146*	411	Dominican Rep.	0.289*	2871	France	0.039	22600
Haiti	0.504*	461	Maldives	0.5	2967	Belgium	0.064	22791
India	0.259*	465	South Africa	0.266*	2986	Singapore	0.128*	22791
Gambia	0.244*	469	Latvia	0.388*	3271	Germany	0.128*	23020
Mongolia	1.098*	476	Lithuania	0.442*	3286	Finland	0.312*	23576
Senegal	0.330*	494	Botswana	0.168*	3441	Canada	0.078	23653
Pakistan	0.463*	539	Jamaica	0.335*	3497	Austria	0.115*	24045
Angola	0.089	585	Saint Vincent	0.358*	3740	Netherlands	0.075	24250
Armenia	0.483	593	Brazil	0.291*	3762	United Kingdom	0.232*	25110
Ivory Coast	0.294	624	Slovakia	0.324*	3791	Hong Kong	0.250*	25199
Ukraine	0.870*	636	Panama	0.214*	3942	Ireland	0.177*	25792
Cameroon	0.282*	655	Mauritius	0.358*	3991	Sweden	0.123*	28154
Georgia	0.337	686	Malaysia	0.207*	3992	Denmark	0.159*	30034
Indonesia	0.411*	800	Estonia	0.331*	4136	Iceland	0.105	30621
Solomon Islands	0.469	910	Turkey	0.284	4147	United States	0.105*	35252
Sri Lanka	0.505*	917	Costa Rica	0.444*	4185	Switzerland	0.017	35739
China	0.397*	946	Gabon	0.136	4204	Japan	0.068	37304
Nicaragua	0.428*	947	Poland	0.252*	4431	Norway	-0.078	37391
Bolivia	0.533*	998	Hungary	0.284*	4538	Luxembourg	0.075*	46592

Note: 1) Pass-through with a * is significantly larger than 0 at the 5% level. 2) LRPT (Long Run Pass-Through). IPC (Income Per Capita), $US

Source: Own estimation.

To select the lag length we applied the rule in Nakamura and Zerom (2012) that the long run pass-through does not change anymore upon adding additional lags. To implement this rule we estimated the long run pass-through for each country in the sample and calculated the weighted average long run pass-through across all countries.[18] Figure 2.B1 displays the weighted average long run pass-through as a function of lag length. We defined the lag length where the relative differences in the long run pass-through with the average of long run pass-through with 1 and 2 lags less is smaller than a certain threshold (5%). This rule generates a lag length of 15 to be used in the estimations.

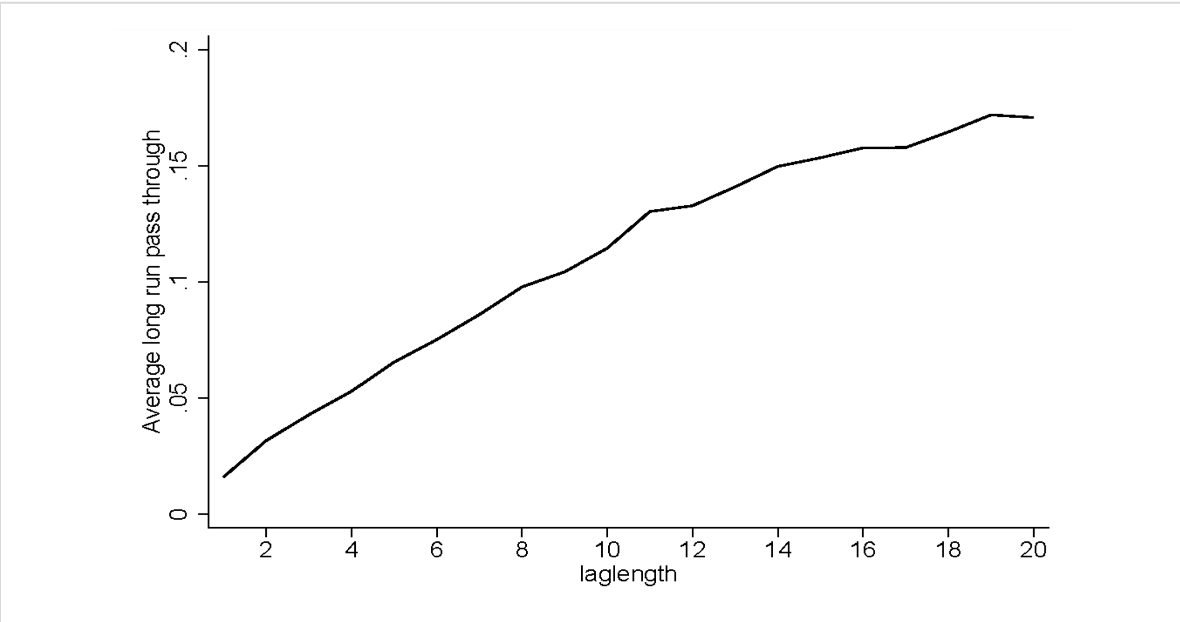
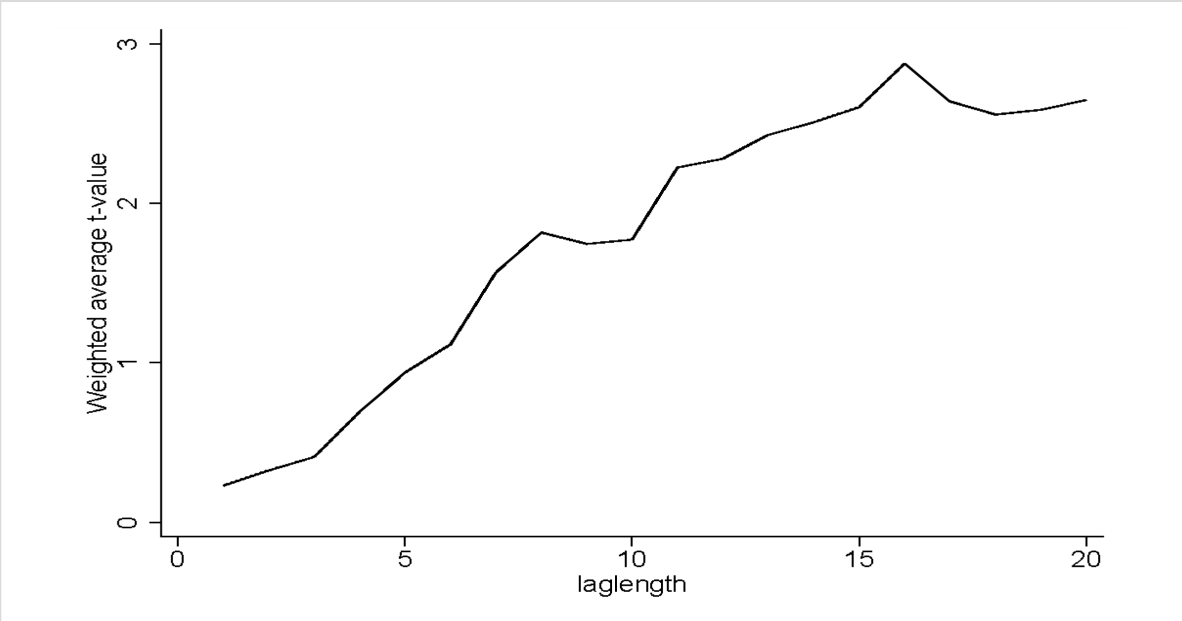


Figure 2.B1 The average long run pass-through
Source: Own estimation.

To motivate the inclusion of the world food price index and the exchange rate as separate regressors, we determined the t-values of the difference in the world food price index long run pass-through and exchange rate long run pass-through for all countries at varying lag length. We calculated the weighted average of these t-values across all countries in the sample with the variance of the test statistic as weights. At 15 lags, we find an average t-statistic of 2.61.

[18] As weights we use the variance of the long run pass-through. This corresponds with employing the standard errors in the weighted least squares regression of the long run pass-through on its explanatory variables.

We can hence reject the equality of the world food price index and exchange rate long run pass-through. Figure 2.B2 displays the evolution of the weighted t-statistic as the lag length



rises. We see that for larger lag lengths (more than 10 lags) the t-statistic is larger than 2.

Figure 2.B2 Weighted average t-values across countries of the difference in the world price index and exchange rate long run pass-through

Source: Own estimation.

3 Food Price Pass-Through and the Role of Domestic Margin Services

Authors: Yang, F., Bekkers, E., Brockmeier, M., & Francois, J.

Published in: *Journal of Agricultural Economics, 66 (3), 796-811*.

Abstract

The recent volatility in international agricultural markets has provoked attention to the impact of rising international agricultural prices and the induced price-insulating measures on consumer food prices. Analyses based on simulation models on this topic typically ignore the role of domestic margin services. We extend the standard Global Trade Analysis Project (GTAP) model to allow for variations in the share of domestic margin services in consumed food across countries. This approach enables us to differentiate consumer prices from producer prices. Following the extension, the results show that domestic margin services reduce the consumer food price volatility for all countries, and especially in high-income countries, where the share of domestic margin services in final food consumption is higher. The effect of price-insulating border policies is also reduced in the extended model. We find that our extension of the GTAP model greatly improves simulations of the 2007 surge in international agricultural prices. We validate our extension of the GTAP model by showing that the econometrically estimated food price pass-through is decreasing with income and thus, is smaller in high-income countries.

Keywords: Food Price Pass-Through, Domestic Margin Services, Trade Restrictions, GTAP

JEL codes: Q11, Q18

3.1 Introduction

The commodity crises of 2007/2008 and 2010/2011 appeared to underscore the vulnerability of the global food system to shocks from diverse sources. Extreme weather events, disruptions in energy and financial markets, increased bioenergy production, growing demand for meat in emerging countries, exchange rate volatility, and low stock levels led to substantially increased and highly volatile international prices for food (von Braun, 2007; Timmer, 2008; Gilbert, 2010; Trostle, 2010; Abbott *et al*., 2011; Wright, 2011). Soaring food prices strongly affected the poor, especially in urban areas of net food importing countries (e.g., Dessus *et al*., 2008; Ivanic and Martin, 2008), sometimes resulting in social unrest. This phenomenon caused many nations to adopt protectionist measures to insulate domestic markets from rising international agricultural prices. This, in turn, exacerbated the increase in agricultural prices on international markets (Anderson, *et al.*, 2013). On the other hand, others (e.g. Aksoy and Hoekman, 2010, and Swinnen, 2011) have pointed out that high agricultural prices are not necessarily a problem, while more recent work (Ivanic and Martin (2014) and others at a World Bank conference on the topic of food prices and security, and trade policy[1]) suggests that the impact of higher prices on the poor in the short term may well be ameliorated in the longer run as adjustments and adaptations occur.

In analysing the effect of shocks in international agricultural prices on consumer food prices, it is important to note that agricultural commodities traded on international markets are not identical to the food bought by consumers. A large part of consumed food consists of domestic margin services like transport, distribution, food-processing services and retailing. This insulates consumers partially from price shocks in international agricultural markets. The share of domestic margin services in consumed food is larger in high-income countries (Abbott, 2012), implying that domestic margin services vary with income and that consumers in high-income countries are more insulated from shocks of international agricultural prices.

The issue of food price pass-through from international agricultural market to consumers has been intensively examined in the literature.[2] Recent commodity crises motivate most

[1] See http://www.worldbank.org/en/events/2014/07/21/food-price-volatility-food-security-and-trade-policy-conference-2014

[2] Most of the literature on food price pass-through concentrates on variations in the degree of integration of local food markets into international markets to explain variations in food price pass-through in a single country or a small set of countries (Baffes and Gardner, 2003; Myers and Jayne, 2011; Conforti, 2004; Ferrucci et al., 2012).

authors to combine a single country Computable General Equilibrium (CGE) model with a micro-simulation model to evaluate the impact of increasing international agricultural prices on different income groups (Arndt *et al*., 2008; Breisinger *et al*., 2008). Many of these authors emphasise that net food importing countries, and particularly urban and poor food deficit rural households suffer from international price increases (Diao, 2008; Nouve and Wodon, 2008; Ahmed and O' Donoghue, 2010), whereas net food exporting countries and food surplus households benefit (de Souza 2008). However, Warr (2008) points out that poverty has risen with higher international agricultural prices since the main beneficiaries are the owners of agricultural land. Ivanic and Martin (2008) and de Hoyos and Medvedev (2011) analyse effects in several countries and conclude that the majority of these countries suffer from an increase in poverty.

Several authors analysing the impact of a surge in international agricultural prices identify the value of marketing margins (e.g., Nouve and Wodon, 2008), but none of them integrate domestic margin services with the production in different sectors in their CGE model based analysis. In CGE models such as the Global Trade Analysis Project (GTAP) model domestic margin services are treated as separate sectors which implies that domestic margin services do not have a price insulating effect. An increase in international agricultural prices translates one-to-one into higher consumer food prices. Dawe and Maltsoglou (2014) mathematically derive the role of fixed margins in final consumption and use household data in Peru to show empirically that consumer prices change less than producer prices. Peterson (2006) modifies the GTAP model and merges margin services with consumption in different sectors. By extensively modifying demand and supply structures for all agents in the model, including consumers, producers and governments, he develops the GTAP-MARGIN model that accounts for the value of margin services for nearly all countries in version 5.4 of the GTAP database. However, the data on domestic margin services for different agents and sectors in many countries are weak, making the model difficult to apply. Moreover, Peterson (2006) does not employ the GTAP-MARGIN model to evaluate the effect of changes in international agricultural prices on consumer food prices. Siddig and Grethe (2014) also examine how the price transmission in CGE models can be reconciled with estimated pass-through of prices. Using a single-country CGE model of Israel they identify modelling characteristics like the

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IMF (2011) estimates pass-through in more than 70 countries, but does not formally relate the pass-through to income levels. In this paper, we focus on literature that study price pass-through using CGE models.

Armington structure and the related elasticities of substitution and transformation as well as trade shares that can generate imperfect food price pass-through. However, the authors do not take domestic margin services into account and thus, are also not able to relate price pass-through to income levels.

In this paper we extend the domestic margin services in the standard GTAP model. In our extended version of the GTAP model we treat the originally separate domestic margin services sector as part of their respective food and manufacturing sectors. This new approach to handling domestic margin services leads to less pronounced consumer food price changes in all regions, when international agricultural prices increase and export restrictions are implemented by exporters of wheat and rice. Additionally, the price pass-through is considerably smaller in high-income countries than in middle- and low-income countries, where domestic margin services are less important.

Our paper is organised as follows. In section 2 we describe how the standard GTAP model is extended. In section 3 we present two policy simulations with the extended GTAP model and discuss the results. Additionally, we utilise the estimated food price pass-through to validate our results. Section 4 concludes.

3.2 Extension of the GTAP Model

The standard GTAP model is a multi-regional CGE model that captures world and regional economic activity in 57 different industries of 134 regions (Version 8.1 of the database with base year 2007). It assumes perfect competition and constant returns to scale, whereas bilateral trade is managed via the Armington assumption (Hertel and Tsigas, 1997).[3] Due to its broad data coverage and simple but firm economic assumptions, GTAP has obtained growing attention in policy analysis under a global context. In the standard GTAP model domestic margin services are summarised in a separate sector called “margin service”,[4] which contains the values for retail sales, wholesale trade and other costs incurred during the transportation of goods (compare “margin services” in the standard GTAP model, Figure 3.1).

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[3] The framework of the standard GTAP model is well documented in Hertel and Tsigas (1997) and available on the Internet (see www.gtap.org).
[4] In the original GTAP database this sector is called "trade". To avoid confusion, we keep to the name "margin service" throughout the text.

Because of this structure of the standard GTAP model, the value of transportation and processing of paddy rice is for example not tied to consumable rice.

Generally, the domestic margin services generate a difference between international agricultural prices and consumer food prices. In our extended version of the GTAP model, we therefore redistribute the value of domestic margin services to each food and manufacturing sector. We use Figure 3.1 to explain how domestic margin services are treated in the standard and the extended GTAP model by focusing on the consumption structure. Regional household expenditure is distributed to the components of final demand, namely, private household expenditure, savings and government household expenditure according to a Cobb Douglas (CD), per capita utility function. In the standard GTAP model, the constrained optimising behavior of private households is represented by the Constant Difference of Elasticity (CDE) implicit expenditure function, whereas the choice between domestically produced and imported goods is determined on the basis of the Armington assumption and a Constant Elasticity of Substitution (CES). Domestic margin services are treated identically to other sectors, such as food, manufacture and other services. Therefore, in the standard GTAP model, we have a separate sector of "margin service" in addition to food, manufacture and other services (compare Figure 3.1). However, domestic margin services are actually attached to goods, and these sectors complement each other. To extend the standard GTAP model, we assign the value of the margin sector across traded goods according to their original share in total private household final consumption. In the extended GTAP model, consumers purchase goods and domestic margin services compositely. We assume Leontief substitution between consumed goods and delivered domestic margin services. In this way, the share of domestic margin services in final consumption only varies among countries. Within a country, we assume that the cost of transportation, processing, storage or distribution does not differ among goods. Similar wage levels and infrastructures might explain this phenomenon.

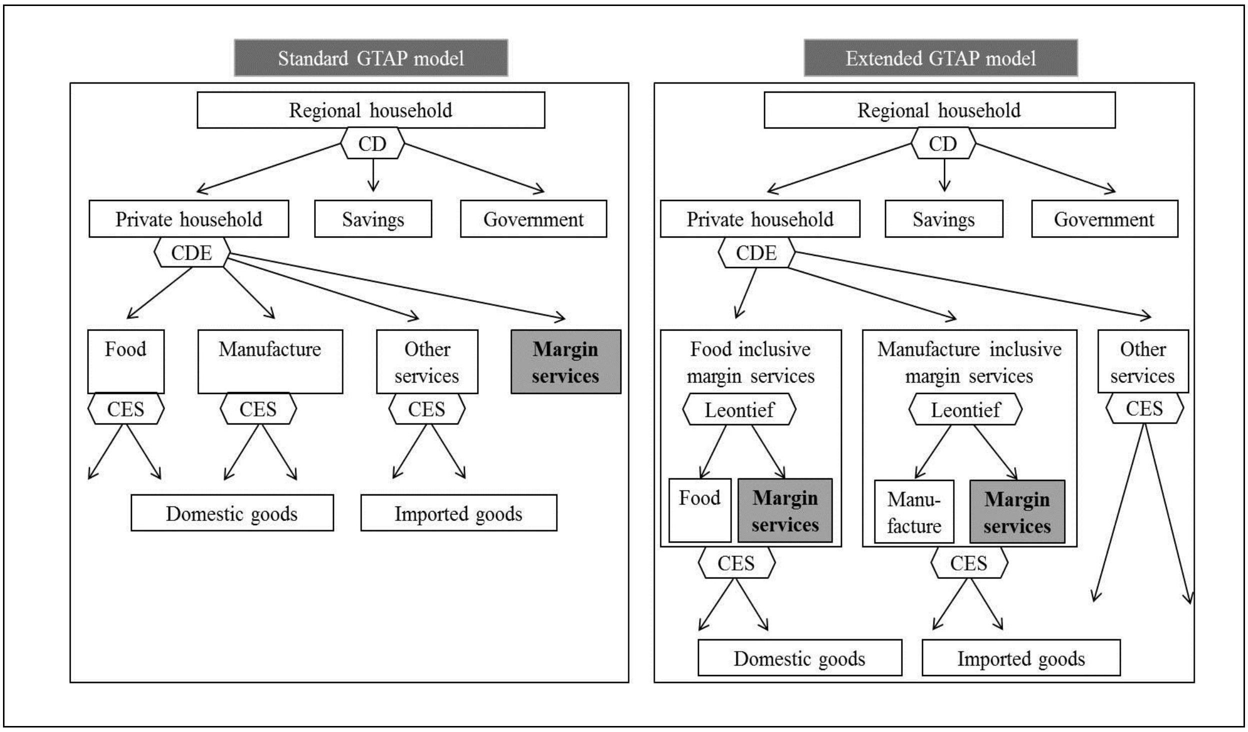

Figure 3.1 Modification of regional household expenditure structure in GTAP

Note: The sector "margin service" comprises retail sales, wholesale trade and other costs incurred during the transportation of goods in the original GTAP database. Please refer to Table 3.B2 in the Appendix (on-line) for more information.

Source: Own elaboration based on Hertel and Tsigas (1997).

In the standard GTAP model, the percentage change of private household consumption for composite food, manufacture, margin service and other services ($qp_{i,r}$) in region r is derived from the CDE function and defined using equation (3.1):

$$qp_{i,r} = \left(\sum_k EP_{i,k,r} \cdot pp_{k,r} \right) + EY_{i,r} \cdot yp_r \tag{3.1}$$

In this equation (3.1) $EP_{i,k,r}$, and $EY_{i,r}$, represent the uncompensated price elasticity and the income elasticity of private household demand with respect to good *i*, whereas $pp_{k,r}$ and yp_r stands for the percentage change in the price of consumption good *i* and in the utility of private household consumption in region *r*, respectively.

The price of the consumption good of private household, $pp_{i,r}$, is defined over food, manufacture, other services, and margin services according to equation (3.2):

$$pp_{i,r} = PSHR_{i,r} \cdot ppm_{i,r} + (1 - PSHR_{i,r}) \cdot ppd_{i,r} \tag{3.2}$$

Here, $ppm_{i,r}$ and $ppd_{i,r}$ define the price of imports and domestic goods *i* demanded by private household in region *r*. The coefficient $PSHR_{i,r}$ represents the share of imports in private households expenditure.

We adapt this equation structure of the standard GTAP model to reflect the changes in the extended GTAP model presented in Figure 3.1. For the food and the manufacturing sectors, we introduce two additional variables, namely the percentage change in the quantity ($mqp_{mi,r}$) and price ($mpp_{mi,r}$) of consumption *inclusive* of domestic margin services of each good *mi* in region *r*. Equation (3.3) presents the relationship between the percentage change in quantity, $mqp_{mi,r}$, and the percentage change in quantity of produced goods i in region r exclusive margin, $qp_{i,r}$. Due to the assumed Leontief structure, the percentage changes of $mqp_{mi,r}$ and $qp_{i,r}$ are equal. In equation (3.4), we define the percentage change in the consumer price $mpp_{mi,r}$ to be equal to a weighted share of percentage changes in producer price, $pp_{i,r}$, and the price of domestic margins services, $pp_{m,r}$. The coefficient $MSHARE_r$ represents the share of domestic margins in total goods consumption in region *r*.

$$mqp_{mi,r} = qp_{i,r} \tag{3.3}$$

$$mpp_{mi,r} = [1-MSHARE_r] \cdot pp_{i,r} + MSHARE_r \cdot pp_{m,r} \tag{3.4}$$

3.3 Simulations

3.3.1 *Simulation Design*

We design two sets of simulations to analyse how the extended private demand structure accounts for domestic margin services in the GTAP model and how it affects food price pass-through.

In the first set of simulations (I), we only run one scenario that examines how the volatility of international agricultural prices influences final consumer food prices in different regions. We aggregate the data into 11 regions and 9 sectors. Countries are aggregated according to their levels of per capita income and geographic locations. Sectors are disaggregated into agriculture, manufacturing and services. Primary and processed food sectors are separated. According to the FAO, average international agricultural and food price indices increased by approximately 70% from the beginning of 2007 to the middle of 2008.

Therefore, we simulate the impact of this increase in international agricultural prices in the primary food and processed food sectors. Because prices are endogenously determined in the GTAP model, we swap world market prices with the rates of technical change for food sectors worldwide. Accordingly, the model reduces food production globally by an amount sufficient to generate the increase of international agricultural prices by 70%. Thereafter, we examine the changes in consumer food prices in different regions by comparing the results between the standard and the extended GTAP model.

In the second set of simulations (II), we run two scenarios to examine how countries' border policies imposed on specific food commodities affect food prices. In response to the soaring international agricultural prices, many governments in developing countries established policy instruments to stabilise their domestic food markets during the years 2007-2010. Trostle (2010) and Sharma (2011) list all the countries that imposed protective policies during the food crisis. We summarise the main countries that enforced export restrictive measures in the year 2007 in Table 3.1.

Table 3.1 List of countries that imposed trade restrictive measures during the 2007 food price crisis

Country	**Products**	**Policy Instruments**
Argentina	Oilseeds, cereals	Export tax raised to around 35% for oilseeds, 25% for wheat and maize
China	Cereals	Export tax introduced at 20% for wheat, 5% for rice and soybean
India	Rice, wheat	Export ban for ordinary rice and wheat
Russia	Wheat, barley	Export tax raised to 40% for both wheat and barley
Vietnam	Rice	Export ban

Note: Some of these policy instruments were removed when food prices decreased after 2007/08.
Source: Trostle (2010) and Sharma (2011).

Accordingly, we aggregate the data into 16 regions and 22 sectors (see Annex C, Aggregation II). Countries that applied restrictive measures are treated as separate. Commodities that are affected by these measures are also singled out. To simulate the restrictive trade policies and the surge of international agricultural prices simultaneously, we reduce technical change in the food sectors globally. This procedure results in a supply shortfall that would increase the international agricultural prices by 70% according to simulation (I).[5] In Scenario 2, we additionally implement the export taxes and fixed the export quantities of India and Vietnam according to Table 3.1. We further shorten the supply of wheat and rice on the international markets in Scenario 3 and accompany the export taxes by the export ban in India and Vietnam also indicated in Table 3.1. In the simulations, we investigate how domestic margin services alter the impact of these policies using the standard and the extended GTAP model. Table 3.2 summarises our scenarios.

Table 3.2 Scenarios conducted with the standard and the extended GTAP model

	Simulations (I)	**Simulations (II)**	
	How does the volatility of international agricultural prices influence final consumer food prices in different regions?	How do countries' border policies for specific food commodities affect food prices?	
	Scenario 1	**Scenario 2**	**Scenario 3**
Surge of international agricultural prices by 70%	☒	☒	☒
Export taxes[a)]		☒	☒
Export bans[a)]			☒

Note: a. Export taxes and export bans are implemented according to Table 3.1.

3.3.2 *Simulation Results*

Figure 3.2 demonstrates the changes in the final consumer food prices in response to the increase in international agricultural prices of both primary and processed food by 70% assumed in Scenario 1. We compare the results of the standard and the extended GTAP, so that we consider results for the scenarios with and without domestic margin services. The food price changes in different regions are calculated as a weighted average of the price changes of both primary and processed food using the budget shares of those two items as weights.

[5] We utilize the information on the global technical change obtained in simulation (I) that is necessary to accommodate the 70% surge of international agricultural prices in both the standard and extended GTAP model without implementing any trade distortions. We apply those technical changes to the exogenous technical change variable in simulation (II) which results in a 70% increase of international agricultural prices.

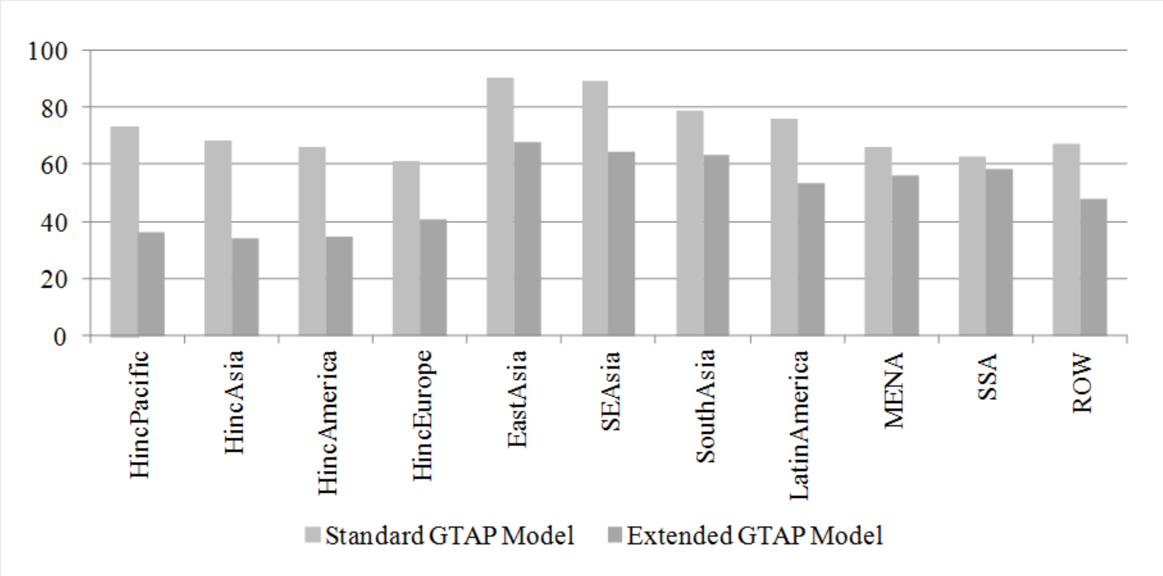

Figure 3.2 Change in consumer food prices due to a 70% increase of international agricultural prices (%)

Note: Hinc (High-income); SEAsia (South East Asia); MENA (Middle East and North America); SSA (Sub-Saharan Africa); ROW (Rest of the World).

Source: Own calculation based on GTAP simulations.

Figure 3.2 shows that in the standard GTAP model shocks of international agricultural prices are distributed unevenly among regions, with the highest impact in Asia. A possible explanation for this uneven distribution is that the production of processed food in Asia uses primary food more intensively than factor endowment inputs, such as land and capital. Decomposing the results shows that the international agricultural prices increase in primary food leads, on average, to an increase of 15% in processed food prices in Asia. Apart from Asia, low-income regions such as Sub-Saharan Africa (SSA) experience similar food price changes as do high-income regions, i.e., high-income Pacific, Asia, America and Europe, as indicated by the first four bars in Figure 3.2.

The results change substantially when margin services are taken into account (Figure 3.2). First, the price changes are less pronounced for all regions compared with the standard scenario. Second, for high-income countries (e.g., high-income Asia, high-income America), the extent of consumer food prices is reduced by almost half, whereas in low-income regions (such as SSA), the margin effect is less noticeable. Therefore, we conclude that considering margin services makes high-income regions less responsive to changes in international agricultural prices. A greater share of margin services insulates consumers in high-income countries from shocks in international agricultural prices.

To examine the overall impact of the food price increase, we display the weighted average change in the overall consumer price index on the map in Figure 3.3. In the figure, higher changes in the CPI are indicated by the darker shading. As expected, areas that experience stronger consumer food price increases also face greater turbulence in their CPI inflation (e.g., SSA, India), whereas high-income countries in the Northern Hemisphere experience smaller CPI changes, 3% on average. This conclusion is consistent with the fact that consumers in low-income countries spend a greater amount of their household income on food. For instance, countries in SSA, where food accounts for 50% of the total expenditure, experience higher CPI increases than do countries in Asia, where the food share is less than 30% on average. Consumers in industrialised countries are even less sensitive to the price change in food basics because their total expenditure on food is less than 10% (GTAP, Version 8.1, 2007).

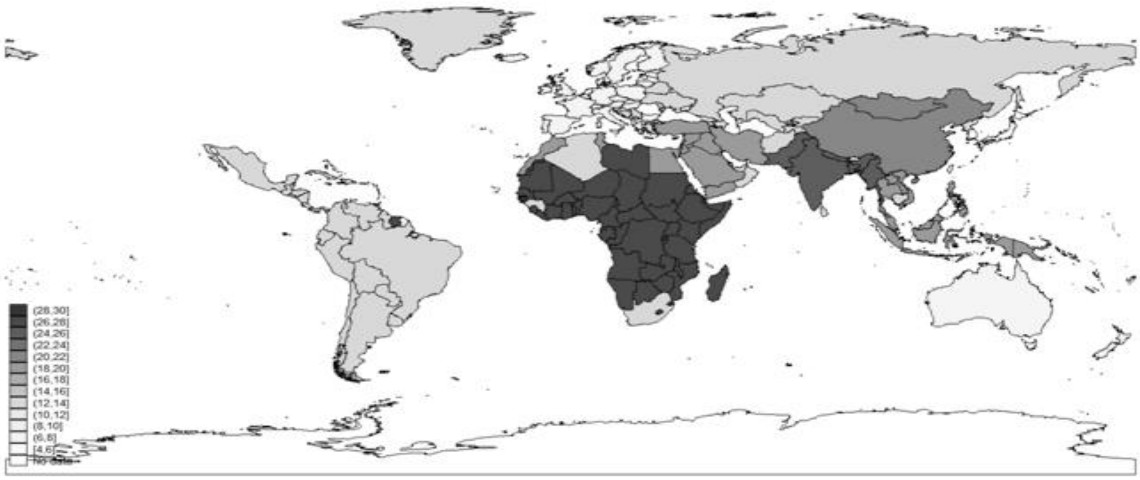

Figure 3.3 Change in overall consumer price index for food due to a 70% increase in international agricultural prices (%)

Source: Own calculation based on GTAP simulations.

In the second sets of simulations (II) we evaluate the effect of food export-restricting policies imposed in response to the surge of international agricultural prices. Again, we utilise both the standard and the extended GTAP model in our simulations. In Table 3.3 we compare the changes in consumer prices for wheat and processed rice,[6] when countries implement

[6] The ideal method of examing the impact of wheat prices on consumers is to examine prices for wheat flour and wheat products. These sectors are not singled out in GTAP, so we focus on the prices of wheat, which is involved in wholesale processes or consumed directly, especially in poor regions.

export taxes (Scenario 2) and additionally export bans (Scenario 3). We also include the results of Scenario 1 for convenience.

Table 3.3 Consumer price changes (%) for wheat and processed rice in the standard and the extended GTAP model

	Standard GTAP Model						**Extended GTAP Model**					
	Wheat Scenario[a)]			**Processed Rice Scenario**			**Wheat Scenario**			**Processed Rice Scenario**		
	1	**2**	**3**	**1**	**2**	**3**	**1**	**2**	**3**	**1**	**2**	**3**
Countries												
Argentina	83.2	***53.8***[b)]	***54.2***	68.2	64.6	66.0	51.4	***35.7***	***39.7***	43.4	41.4	45.2
China	70.1	***67.7***	***67.8***	71.3	***71.5***	71.9	52.5	***50.3***	***54.9***	53.9	***54.0***	***57.9***
India	71.7	78.5	***77.4***[c)]	51.5	51.5	***48.3***	56.1	61.0	***65.2***	40.8	40.8	***40.7***
Russia	82.5	***61.6***	***61.6***	66.8	65.9	77.0	50.1	***37.7***	***42.0***	40.9	40.4	49.6
Vietnam	72.2	81.9	82.3	92.4	97.5	***56.3***	61.2	70.0	76.2	77.1	80.9	***51.6***
Regions												
HincPacific	89.3	92.2	92.5	30.4	30.7	31.5	42.0	43.3	47.2	16.9	17.0	18.1
HincAsia	69.2	74.3	74.6	85.3	86.0	86.6	34.4	36.9	40.3	40.8	41.1	44.4
HincAmerica	75.9	80.6	81.0	43.0	44.3	46.3	40.2	42.6	46.6	23.2	23.9	26.3
HincEurope	60.3	62.1	62.3	40.1	39.9	44.2	39.9	41.1	45.2	26.9	26.9	31.1
EastAsia	81.8	84.7	84.9	74.9	77.4	82.3	51.2	52.9	58.0	48.0	49.6	56.0
SEAsia	71.8	78.9	79.2	98.7	98.2	115.6	53.1	58.5	64.4	69.6	69.3	86.5
South Asia	75.1	78.6	80.8	60.0	61.1	69.3	67.1	70.5	79.4	53.5	54.7	66.4
LatinAmerica	76.3	81.4	81.6	57.4	58.1	58.9	54.7	58.2	63.8	41.2	41.7	45.2
MENA	63.1	66.7	67.0	54.6	56.2	59.2	52.9	56.0	61.6	46.1	47.5	53.6
SSA	62.3	65.3	65.5	56.0	58.1	70.6	57.9	60.7	67.0	51.6	53.7	68.7
ROW	68.9	71.8	72.0	43.1	44.5	51.3	49.3	51.3	56.5	31.3	32.5	38.8
World	70.0	83.6	98.8	70.0	73.3	150.5	70.0	84.1	107.8	70.0	73.6	158.0

Note: a) Refer to Table 3.2 for details on the scenarios. b) Numbers in bold and italics indicate countries that implemented an export tax in the prevailing market. c) Numbers in italics and highlighted in grey indicate countries that implemented an export ban in the prevailing market. Hinc (High-income); SEAsia (South East Asia); MENA (Middle East and North America); SSA (Sub-Saharan Africa); ROW (Rest of the World).

Source: Own calculation.

The results in Table 3.3 demonstrate once again that the surge of international agricultural prices increases consumer food prices significantly for all regions. Additionally, the results in Table 3.3 demonstrate that simulations analysing surges of international agricultural prices with the standard GTAP model lead to increases of consumer food prices which are highest in high-income countries (e.g., 89.3% in high-income Pacific countries). This result of the standard GTAP model is inconsistent with our findings in the literature (Abbott, 2012). After adjusting domestic margin services in the extended GTAP model, consumer food prices in high-income countries are less responsive.

In the first part of Table 3.3, we combine the results for those countries which apply export restrictions. The wheat export tax of Argentina, China and Russia implemented in Scenario 2 further reduces the increase of consumer prices for wheat in these countries to 53.8%, 67.7%, and 61.6%, respectively. This effect is related to income and is more pronounced in the extended GTAP model. For example, the increase of consumer wheat prices in the export tax implementing countries Argentina, China and Russia is equal to 35.7%, 50.3% and 37.7%, respectively, under the extended GTAP model. Also, the consumer price increase in high-income Pacific countries in Scenario 2 amounts to 92.2 % and 43.3% in the standard and extended GTAP model, respectively. In South Asia, where the income per capita is lower, the margin services only reduce the wheat price change from 78.6% to 70.5%. As a result, the change of consumer wheat prices is noticeably lower in high-income regions than in middle- and low-income regions under Scenario 2 in the extended GTAP model. In the rice market, we observe a somewhat different pattern. The implementation of China's rice export tax in Scenario 2 also reduces the increase of domestic market prices of rice from 71.5% to 54.0 %, when we employ the extended GTAP model. However, the level of China's export tax is rather low (compare Table 3.1). Comparing Scenario 1 and 2 for the extended model, we observe a slight increase of rice prices in China but a small decrease for Argentina and Russia. This might be explained by the substitution effect in Argentina and Russia, countries that not only implement high export tax for wheat but also for maize and barley. This further reduces prices of these products and entices consumers to substitute away from rice towards maize and barley. This would decrease the price for rice in Argentina and Russia, as observed in the results. Similar to Scenario 1, we also observe a reduced increase of consumer rice price in all other regions and for international agricultural market prices in the rice market in Scenario 2, when the extended GTAP is employed. The price changes are halved for high-income regions, but considerably less for middle- and low- income regions.

These impacts are more noticeable in Scenario 3, when India imposes an export ban for wheat. Comparing Scenario 2 and 3 based on the standard GTAP model, we observe that the Indian consumer prices increase less when export bans are in place. At the same time, consumer prices of wheat in all other regions, as well as in the international market, increase even further compared to Scenario 2 in the standard GTAP model. In the extended GTAP model, the international wheat price increases by 107.8% under the Indian export ban, whereas the consumer wheat price in India increases by 65.2%, which is even less than in Scenario 3 based on the standard model (77.4%). However, the increase of the Indian consumer price for wheat is higher than before the export ban in Scenario 2 (61.0%), which indicates that export restricting policies in different markets are not independent and might lead to contra-productive results for the consumers.

In the rice market, Vietnam and India implement an export ban, which also lessened their increase of consumer prices. In Scenario 3 based on the standard model, we observe an increase in consumer prices for Vietnam and India[7] of 48.3% and 56.3%, respectively. We also observe, that all other regions witness a further increase of their consumer rice prices. Southeast Asia and South Asia heavily depend on the imports of rice from India and Vietnam. Consequently, South-East Asia experiences an increase of greater than 100% of its consumer prices, whereas South Asia faces an increase of 69.3%.

The rice price on the international agricultural markets surges by 150.5% under the export ban of Vietnam and India. Following a similar pattern to the wheat market, this effect is even further pronounced when the simulations are based on the extended model. Accordingly, Vietnamese and Indian consumer price changes are reduced to 40.7% and 51.6%, respectively, when Scenario 3 is simulated with the extended GTAP model. Again, the consumer rice prices raise less for high-income regions in the extended GTAP model due to their higher share of margin services. In High-income Asia, the consumer price for rice increases is reduced from 86.6% to 44.4%. In Sub-Sahara Africa, we observe a smaller reduction of the increase from 70.6% to 68.7%.

To summarise, the results of our extended GTAP model are closer to what we find in the literature. For example, Martin and Anderson (2011) conclude that the insulating trade restricting policies contribute substantially to the surge of international prices for wheat and rice during 2005-2008. Abbott (2011) specifically points out that longer supply chains, namely margins in developed countries absorb the shocks from international agricultural markets. He finds that most farm-gate prices of agricultural products in different countries during 2007 and 2008 realised substantial gains from high international prices, with smaller

[7] The impact is greater for paddy rice in India, which is not presented in the table, more results are available from the author upon request.

gains in the countries that restricted exports. But the inflation of consumer food prices is substantially lower in the high-income countries like U.S., Canada and Australia than in low-income countries like Pakistan.

3.3.3 *Validation of the GTAP model*

To validate our extension of the GTAP model, we compare the share of primary agricultural commodities in the final food consumption calculated with the help of the GTAP database with an econometrically estimated pass-through of international agricultural prices to consumer food prices.[8] Our starting point is the (1 - $MSHARE_r$), which represents the share of consumed goods in total goods consumption in region *r* presented in section 2. This sector-generic share needs to be adjusted taking the specific information of the primary agriculture and processed food in the GTAP database into account. In equation (3.5), we therefore relate the general share of consumed goods in final private household consumption, (1 - $MSHARE_r$), to the share (*S*) of primary agricultural products (*PrimAgri*) in final food consumption (*finalFoodC*) and the share of processed food (*ProcFood*) in final food consumption. Additionally, we take the share of primary agricultural as intermediate input (*IS*) in the costs of processed food (*CostofProcFood*) into account. Thereby, we assume that primary agriculture is either consumed directly in final food consumption or used as an intermediate input together with other inputs to produce processed food, which is thereafter consumed by the private household. Basically, in our data consumer expenditures on primary food are both direct (households purchase some primary agricultural goods directly) and indirect (households also purchased food only after being further processed by the food processing industry). This means we take into account the combination of direct purchases, and indirect purchases, with the latter defined as the portion of total expenditure on processed foods that reflects the cost of primary food inputs to the food processing sector. Together, this provides a mapping from primary food to consumer food purchases. Thus, the share of primary agricultural commodities in the final food consumption is jointly determined by these two terms:

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[8] The consumer food price consists of prices of international agricultural products and domestic margin services according to their share in the final food consumption. If we assume perfect price transmission from international to domestic market, the share of internationally traded agricultural products in the final consumed food, should approximately be equal to the pass-through of international agricultural prices to consumer food prices.

$$S_{PrimAgri,r}^{finalFoodC} = S_{PrimAgri,r}^{finalFoodC} \times (1 - MSHARE_r) + S_{ProcFood,r}^{finalFoodC} \times IS_{PrimAgri,ProcFood,r}^{CostofProcFood} \times (1 - MSHARE_r) \quad (3.5)$$

Table 3.4 shows the value of *(1-MSHARE)*, the value of $S_{PrimAgri,r}^{finalFoodC}$, and the estimated long-run pass-through [9] in three income groups as classified by the World Bank World Development Indicators for 2014. High-income countries have higher share of margins and an accordingly lower share of consumed good in final consumption (0.61) compared to low-income countries (0.84). Similarly, high-income countries also have a lower share of primary agricultural commodities in final food consumption (0.17), and a comparable lower price transmission from international to domestic market (0.12). [10] The larger share of domestic margin services in high-income countries reduces the pass-through, indicating once again the importance of taking margin services in CGE models explicitly into account.

However, Table 3.4 also demonstrates that the variation in the importance of domestic margin services does not solely explain the variation in estimated pass-through. What we have neglected thus far is that international agricultural prices might differ from domestic agricultural prices due to imperfect market integration. This could also explain that the disparity between the estimated pass-through (0.29) and the share of primary agricultural commodities (0.54) is considerably larger for low-income countries than for high-income countries. This is also in accordance with the literature (Rapsomanikis, 2004; Abbott and de Batisti, 2011),[11] where the authors show that low-income countries are poorly integrated into international agricultural markets. Nonetheless, if we were able to distinguish the impact of market integration from the effect of domestic margin services in the econometric framework, we could in principle use these econometric estimates and attribute different weights of margin services among different sectors in different countries. However, there is currently incomplete coverage of international agricultural prices, producer prices and consumer prices for the agricultural product in the countries that are covered in the GTAP database.

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[9] Please refer to more information on the econometric method to Appendix A (available on-line).

[10] Formal tests show that the difference in long-run pass-through between high- and middle-income and between high- and low-income countries is highly significant, but the difference between middle- and low-income countries is not significant.

[11] These studies do not compare pass-through in developing countries with developed countries, but point out that market integration is imperfect in developing countries.

Table 3.4 Share of goods and share of primary agriculture in final private consumption of goods and food, respectively, compared to the Long-Run Pass-Through

Income Group	(1 – *MSHARE)*	$S^{finalFoodC}_{PrimAgri,r}$	Long-Run Pass-Through
High-income	0.61	0.17	0.12*** (0.01)
Middle-income	0.74	0.36	0.25*** (0.01)
Low-income	0.84	0.54	0.29*** (0.03)

Note: Standard errors in parentheses*** p<0.01, ** p<0.05, * p<0.1.
Source: Own estimation results.

3.4 Conclusions

Booms in international agricultural prices in recent years and their domestic welfare and poverty impact have been intensively studied in recent literature employing CGE models. The role of domestic margin services in the transmission of international agricultural prices to consumer food prices is often ignored in this literature. In this paper, we introduce an extension of a standard CGE model (the GTAP model) to account for the role of domestic margin services more accurately. In standard models, margin services are treated as a distinct consumption category. In contrast to this approach, we link margin services to consumption of different food and manufacturing products, motivated by the observation that margin services facilitate consumer access to goods. Thereafter, consumed goods are a composite of produced goods and margin services. This approach reduces price pass-through from international agricultural prices to consumer food prices depending on the share of margin services in final consumer prices. Because service prices (and the share of consumer prices) vary systematically with income level, this means that price pass-through varies systematically according to regional income, i.e., the price pass-through is lower in high-income countries, where margin services play a more important role.

We use the modified GTAP model to study two sets of simulations to answer the following questions: (1) How do changes in international agricultural prices influence final consumer food prices in different regions? (2) How do countries' border policies for specific food commodities affect consumer food prices? Utilising the standard and the extended GTAP model, we simulate a surge of the international prices for all agricultural products. Our results reveal that the impact on consumer food prices is more modest when we accurately account for domestic margin services in the extended GTAP model. To answer the second question, we explicitly simulate an export tax and additionally a supplementing export ban taking the trade restrictions imposed by countries on staple food commodities during the 2007 food price crisis into account. Applying again the standard and the extended GTAP models, we are able to demonstrate that the impact of those policies is weakened due to domestic margin services. Implementing export restrictive policies, low-income countries reach their goal of stabilising domestic prices, but at the same time other countries, and particularly the poor in net-food importing low-income countries, are exposed to higher international agricultural price. We also reveal that the extended GTAP model structure of the domestic margin services insulates consumers from the effect of trade restriction policies in high-income countries. The magnitude of these results is also more in accordance with the literature than those obtained from the standard GTAP model. Our simulation results therefore reveal that the negative impact of shocks to international agricultural prices on consumer food prices tends to be overestimated particularly for high-income countries, when domestic margin services are not taking into account. Dawe and Maltsoglou (2014) draw a similar conclusion in their empirical study. Existing multi-country CGE models studying food price transmission do not take into account the weakening effect of margin services on price pass-through. We validate our simulation results with econometric estimates of pass-through from international agricultural prices to consumer food prices in different countries grouped according to income and find, that the pass-through is considerably smaller in high-income countries.

There are two issues for further research we need to point out. First, domestic margin services are quantified in the extended GTAP model by the share of goods in total private household consumption. This approach does not account for different weights of margin services among different sectors. However, the aim of the study is to distinguish between domestic margin services of the food sector in countries differing according to income. Here, improved availability of data on domestic margin services will help to obtain more detailed econometric estimates of domestic margin services, which could be substituted for our information in the GTAP model and improve the realism of the results. Secondly, the food price data collected for the panel analysis does not distinguish between different food items. Some countries cover broader commodities for their calculation of consumer food price index, but the incomplete regional coverage prevents us from taking this information into account. Our approach may therefore lead to a bias in our econometric estimation use to validate our simulation results. However, we assume that food commodities omitted in the calculation of the food price index usually have small shares of total consumption, and thus presume that the results do not differ substantially.

Nonetheless, our study highlights the importance of accounting for domestic margin services in studying food prices and food security under policy reforms in CGE models. We also call attention to an approach that draws on the advantages of both econometric analysis and CGE modelling in empirical analysis on food price pass-through. Accounting for domestic margin services and consumer prices explicitly in this way appears to be essential in the analysis of food policy intervention in the world market.

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Appendix

Appendix 3.A: Econometric Analysis of Food Price Pass-Through

To explore the effect of income levels on food price pass-through, we follow the literature on exchange rate pass-through (Campa and Goldberg, 2005; Nakamura and Zerom, 2010) and regress first differences[12] of the local food price index on the first differences of the international agricultural price index and the exchange rate and their various lags:[13]

$$\Delta logCPI_{it} = \sum_{k=0}^{K} \beta_k \Delta \log WFPI_{t-k} + \sum_{k=0}^{K} \gamma_k \Delta logFX_{it-k} + \eta_i + \varepsilon_{it} \qquad (3.A1)$$

where CPI_{it} is the consumer food price index in country i in period t; $WFPI_t$ is the international agricultural price index; FX_{it} is the exchange rate of country i in period t vis-a-vis the US dollar; β_k and γ_k represent the pass-through coefficients of the world food price and the exchange rate to consumer prices, respectively; and η_i is a country fixed effect. We split the sample of countries into the three groups with high-, middle- and low- income and estimate equation (3.A1) with country fixed effects.[14] We allow for heteroskedasticity across countries and for AR1 disturbances.

The long-run pass-through of the international food price index to the local food price index in country i is equal to the sum of the pass-through coefficients, $\sum_{k=0}^{K} \beta_k$. To determine the number of lags, we follow the rule, proposed by Nakamura and Zerom (2010), that the long-run elasticity does not continue to change when additional lags are added. This rule generates a lag length of 15. We allow for different pass-through coefficients of the world food price β_k and the exchange rate γ_k, as tests of the equality of the world food price and

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[12] Panel unit root tests imply that we should estimate in first differences.

[13] Others have estimated pass-through with a cointegration framework (e.g., Baffes and Gardner, 2003). We do not use this framework, as local food prices do not comove with world food prices due to poor market integration (refer to Adam (2011) and Ianchovichina *et al*. (2012) for further discussion).

[14] The long-run pass-through following a country fixed effects regression per income group is a consistent estimator of the average pass-through in the income group and of differences in the pass-through within the income group. Parameter heterogeneity only leads to biased results in dynamic panels with lagged dependent variables included in the regression (Robertson and Symons, 1992). However, we do not work with lagged dependent variables.

the exchange rate pass-through strongly reject the hypothesis that the two pass-through rates are equal. Below, we concentrate on the long-run pass-through of the world food price.

Our dataset contains monthly data over the period 2000-2012 for 147 countries. We use the international agricultural price index composed by the Food and Agriculture Organisation of the United Nations (FAO) to measure $WFPI_t$. We work with the consumer food price index composed by the International Labour Organisation (ILO) as a measure for CPI_{it}. The composition of the consumer food price index differs from the composition of the international agricultural price index. Since the CPI is based on prices inclusive of margin services and the WFPI on prices of agricultural commodities without margin, this partially reflects the goal of our study. International agricultural prices are denominated in US$, and consumer food prices are based on domestic currency. The data for the exchange rates are from the International Monetary Fund, International Financial Statistics (IMFIFS) and the World Bank. The estimation long-run pass through for the three groups is displayed in Table 3.4 of the main text and the estimation results are further discussed there.

Appendix 3.B: GTAP Region and Sector Aggregation

Table 3.B1: Detailed region aggregation in GTAP

Aggregation I	Aggregation II	Description
1. High-income Pacific	1. High-income Pacific	Australia; New Zealand
2. High-income Asia	2. High-income Asia	Hong Kong; Japan; Korea; Taiwan; Singapore
3.High-income America	3. High-income America	Canada; United States of America
4. High-income EU27	4. High-income EU27	Austria; Belgium; Cyprus; Czech Republic; Denmark; Estonia; Finland; France; Germany; Greece; Hungary; Ireland; Italy; Latvia; Lithuania; Luxembourg; Malta; Netherlands; Poland; Portugal; Slovakia; Slovenia; Spain; Sweden; United Kingdom; Bulgaria; Romania.
5. East Asia	5. China	
	6. Other East Asia	Mongolia; Rest of East Asia
6. SE Asia	7. Vietnam	
	8. Other Southeast Asia	Cambodia; Indonesia; Lao People s Democratic Republic; Malaysia; Philippines; Thailand; Rest of Southeast Asia
7. South Asia	9. India	
	10. Other South Asia	Bangladesh; Nepal; Pakistan; Sri Lanka; Rest of South Asia
8. Latin America	11. Argentina	
	12. Other Latin Americas	Mexico; Rest of North America; Bolivia; Brazil; Chile; Colombia; Ecuador; Paraguay; Peru; Uruguay; Venezuela; Rest of South America; Costa Rica; Guatemala; Honduras; Nicaragua; Panama; El Salvador; Rest of Central America; Caribbean
9. Middle East and North Africa	13. Middle East and North Africa	Rest of Western Asia; Egypt; Morocco; Tunisia; Rest of North Africa
10. Sub-Sahara Africa	14. Sub-Sahara Africa	Benin; Burkina Faso; Cameroon; Cote d Ivoire; Ghana; Guinea; Nigeria; Senegal; Togo; Rest of Western Africa; Central Africa; South Central Africa; Ethiopia; Kenya; Madagascar; Malawi; Mauritius; Mozambique; Rwanda; Tanzania; Uganda; Zambia; Zimbabwe; Rest of Eastern Africa; Botswana; Namibia; Rest of South African Customs
11. Rest of the World	15. Russia	
	16. Rest of the World	Rest of Oceania; Switzerland; Norway; Rest of EFTA; Albania; Belarus; Croatia; Ukraine; Rest of Eastern Europe; Rest of Europe; Kazakhstan; Kyrgyzstan; Rest of Former Soviet Union; Armenia; Azerbaijan; Georgia; Bahrain; Iran Islamic Republic of; Israel; Kuwait; Oman; Qatar; Saudi Arabia; Turkey; United Arab Emirates; South Africa

Table 3.B2: Detailed sector aggregation in GTAP

Aggregation I	Aggregation II	Description
1. Primary Food	1. Paddy rice	
	2. Wheat	
	3. Other Cereal grains	
	4. Vegetables, fruit, nuts	
	5. Oil seeds	
	6. Sugar cane, sugar beets	
	7. Other crops	
	8. Cattle, sheep, goats, horse etc. and other animal products	
	9. Raw milk	
2. Processed Food	10. Meat and meat products	
	11. Vegetable oils and fats	
	12. Dairy products	
	13. Processed rice	
	14. Sugar	
	15. Other food products	
3. Other agricultural products	16. Other agricultural products	Plant-based fibres; Wool, silk-worm cocoons
4. Mining and extraction	17. Mining and extraction	Forestry; Fishing; Coal; Oil; Gas; Minerals nec.
5. Textiles and clothing	18. Textiles and clothing	Textiles; Wearing apparel.
6. Light manufacturing	19. Light manufacturing	Leather products; Wood products; Paper products, publishing; Metal products; Motor vehicles and parts; Transport equipment nec; Manufactures nec.
7. Heavy manufacturing	20. Heavy manufacturing	Petroleum, coal products; Chemical, rubber, plastic prods; Mineral products nec; Ferrous metals; Metals nec; Electronic equipment; Machinery and equipment nec.
8. Trade	21. Trade	Margin service
9. Other services	22. Other services	Electricity; Gas manufacture, distribution; Water; Construction; Transport nec; Sea transport; Air transport; Communication; Financial services nec; Insurance; Business services nec; Recreation and other services; PubAdmin/Defence/Health/Educat; Dwellings.

4 Impact of Increasing Agricultural Domestic Support on Food Price Transmission

Authors: Yang, F., Urban, K., Brockmeier, M., Bekkers, E., & Francois, J.

Submitted (2015) to: *China Agricultural Economic Review*

Abstract

Purpose – The paper aims to explore how increased agricultural domestic support might affect China's domestic market under the assumption of incomplete price transmission caused by border measure adjustments.

Design/Methodology/approach - We extend the standard Global Trade Analysis Project (GTAP) framework in two respects. First, we incorporate price transmission elasticities so that the extended model accounts for border measures to stabilise domestic prices. Second, we update the current representation of agricultural domestic support in China to analyse the impact of long-term food security policies. Running a set of simulations, we examine how different policy assumptions affect the agricultural market.

Findings – Adjustments of border measures as responses to high international agricultural prices mitigate the domestic prices increase, which also lead to an increase in China's trade deficit and prohibits net food sellers from receiving high prices. In the long term, an increase in China's agricultural domestic support to its WTO *de minimis* commitment level would increase domestic agricultural production and reduce its demand pressure on the international market.

Originality/Value - This paper contributes to the literature by examining the impact of increased agricultural domestic support on the domestic market while innovatively accounting for incomplete food price transmission caused by border measure adjustments. We combine econometric estimated price transmission elasticities and an extended GTAP framework to underscore the importance of interdependencies of different agricultural policies in affecting domestic markets.

Keywords: Food price transmission, Border measures, Agricultural domestic support, GTAP

JEL classification: Q11, Q18

4.1 Introduction

China's agricultural market has become increasingly integrated into the international agricultural market since its accession to the World Trade Organisation (WTO), narrowing the gap between international and domestic prices for agricultural commodities (Martin, 2001; Huang *et al.*, 2009). Nonetheless, maintaining stability and self-sufficiency in the domestic market remains a key target of China's agricultural policy (Ministry of Agriculture of the People's Republic of China (MOA), 2014). During the surge in international agricultural prices in 2007/08, the Chinese government released grain stocks, reduced import tariffs and adopted protectionist measures such as limiting exports to prevent price transmission from the international to the domestic market (Yang *et al.*, 2008). As a result, China's trade deficit of agricultural products increased to its highest level since it became a net agricultural importer in 2004 (Carter *et al.*, 2009). In 2011/12, the surge in international agricultural prices led to a repetition of similar measures of the government, resulting in an even further increase in the trade deficit and lower food price transmission from the international market to China (Food and Agriculture Organisation of the United Nations (FAO), 2014).

International agricultural prices are likely to remain high and stay volatile in the future, given the uncertain developments of factors that caused the price crises in 2007/08 and 2010/11 (World Bank, 2014). In China, the booming demand for agricultural products coupled with disruptions in energy and financial markets particularly stresses the volatility of domestic prices (Organisation for Economic Co-operation and Development (OECD), 2009). China might continue to alter border measures to maintain stable domestic prices; however, the consequences of adjusted border measures are reduced selling prices for domestic producers and an increased competition with net agricultural imports, which could also exacerbate the situation in the international market (Martin and Anderson, 2012; Yang *et al.*, 2015). Timmer (2010) states that stabilising agricultural domestic production might be more effective to prevent food crises in the long run. In China, subsidies provided to agricultural producers have steadily increased since the nationwide abolishment of agricultural taxes in 2004 (Lohmar *et al.*, 2009). Agricultural Producer Support Estimate (PSE) for example accounts for only 6.64% of total agricultural receipts in 2004, whereas this share increased to 20.21% in 2014 (OECD, 2015). This growth was mainly induced by the increase in commodity specific transfers including market price support[1] and output subsidies classified as trade-distorting measures by the WTO (WTO, 2001; OECD, 2015).

The development of agricultural domestic support in China is well documented in the literature (Lohmar *et al.*, 2009; Gale, 2013; Ni, 2013), while other studies highlight the increasing linkage between subsidies and grain production. Based on producer surveys, Huang *et al.* (2011) show that the current protection level in China is rather low and appears to be non-distorting for agricultural production so far. However, they also mention that the increase in agricultural domestic support may have mixed impacts. In this case, utilising a global CGE (Computable General Equilibrium) model, Yu and Jensen (2010) find that using all domestic support permitted to China under WTO *de minimis* limits with existing instruments, i.e., direct payments given to the grain production and purchased inputs, lead to an increase in China's agricultural production and thus boost farm income. Furthermore, decoupled payments have less impact on grain production, although the categorization of decoupled payment such as direct payments in China is still disputable according to Cheng (2008). The same author shows that China may even exceed its WTO *de minimis* level for its agricultural domestic support under certain domestic prices for particular commodities, indicating further impact of such measures on grain productions.

The literature exploring the impact of domestic support measures in the presence of incomplete food price transmission caused by border measure adjustments is rather scarce. To our knowledge, only Yu and Jensen (2014) conduct a study that quantifies the interaction between border measures and domestic subsidies. Retrospectively, they assess the joint impact of existing agricultural domestic support and short-term trade policies responding to the 2007/08 international agricultural prices surge on China's domestic market. Their findings show that the short-run insulating trade policies during the price surge tend to reduce domestic agricultural prices. This offsets the effect of long-run agricultural domestic support designed to increase domestic agricultural prices and to enhance grain production.

However, given the uncertainties in the international agricultural market and continuing growth of China's agricultural domestic support, it is important to also address this issue in an *ex ante* manner. Additionally, during the price surge, not only China, but also many other

[1] Xi (2011) notices that farmers often received lower prices than promised by officials and locations for state grain depots are unclear, which diminishes farmers' interest in selling grains to the authorised depots.

countries curbed food price transmission to insulate their domestic markets. Therefore, the objectives of this paper are twofold: We examine how a surge in international agricultural prices affects China's domestic market under different border measures causing a variation of price transmission. Additionally, we analyse whether a growing agricultural domestic support in 2020 enhances or reduces the magnitude of the incomplete price transmission. To achieve these goals, we first extend the standard CGE model GTAP (Global Trade Analysis Project) so that it accounts for the incomplete price transmission. Second, we update the representation of China's agricultural domestic support in the framework to facilitate the support increase. In so doing, this paper contributes to the literature by examining the impact of increasing agricultural domestic support on the domestic market while innovatively accounting for incomplete food price transmission caused by border measure adjustments. We combine econometric estimated price transmission elasticities and an extended GTAP framework to underscore the importance of the interdependencies of different agricultural policies in affecting domestic markets.

Our paper is organised as follows. Chapter 2 explains the extensions of the GTAP framework with regard to both food price transmission and agricultural domestic support. In Chapter 3 we simulate the changes in agricultural domestic support in China using both the standard and extended GTAP framework. Chapter 4 compares the results. Conclusions and discussions are presented in Chapter 5.

4.2 Extensions of the GTAP framework

The standard GTAP framework is a comparative-static, multi-regional CGE model with a detailed, but global representation of economic activities. The model assumes perfect competition and constant returns to scale while bilateral trade is handled via the Armington assumption (Hertel and Tsigas, 1997).[2] Given its firm economic assumptions and the broad data coverage in the underlying database, GTAP has been used extensively in economy-wide policy analyses in a regional/global context. For the purpose of our study, we extend the standard GTAP framework by including incomplete price transmission and by updating agricultural domestic support at a very detailed level.

[2] The framework of the standard GTAP model is well documented in Hertel (1997) and is available on the internet (see www.gtap.org).

4.2.1 Including incomplete price transmission into the GTAP model

4.2.1.1 Theoretical development

The standard GTAP model assumes homogenous market integration, which does not take account of the imperfect price transmission from the international to domestic market (Valenzuela et al., 2007). Imperfect price transmission is caused by different factors e.g., market structures, the existence of transaction costs, exchange rates fluctuation and implementations of domestic and border policies (Baltzer, 2013). This paper focuses on political measures that affect price transmission. Equation (4.1) shows the linkage between international and domestic prices in the standard GTAP model:

$$pms(i,r,chn) = pcif(i,r,chn) + tm(i,chn) + tms(i,r,chn) \qquad (4.1)$$

All variables in lower cases indicate percentage changes, whereas i stands for traded goods, r the origin and s the destination of traded goods. We use China (chn) as an example and present the price linkage for imports because China is a net agricultural importer. As elaborated by the equation, changes in domestic prices $pms(i,r,chn)$ equal changes in international prices $pcif(i,r,chn)$ plus changes in the country specific or source generic border *ad valorem* tariffs ($tms(i,r,chn)$ or $tm(i,chn)$). When border measures are unchanged, $tm(i,chn) + tms(i,r,chn) = 0$, thus $pms(i,r,chn)$ equals $pcif(i,r,chn)$. This indicates a complete price transmission for imports, unless there are specific tariffs, which stay constant regardless of the value of traded goods (Siddig and Grethe, 2014). Because changes in private consumption prices in the GTAP model are weighted shares of changes in prices of imported goods, i.e., the international prices, and changes in prices of domestically produced goods, the setup in the standard GTAP model would overestimate the volatility transmitted from the international to domestic market when international prices surge.

To enhance the validity of the standard GTAP model in assessing agricultural price volatility, Valenzuela *et al.* (2007) incorporate active market insulation measures by importers into the model, which leads to imperfect price transmission between international and domestic agricultural prices. The authors notice substantial evidence of incomplete wheat price transmission from international to domestic markets, and their extension of the model adequately represents this issue, demonstrated as follows. On one hand, Equation (4.1) indicates that changes in domestic prices $pms(i,r,chn)$ depend on changes in international prices $pcif(i,r,chn)$ and changes in border measures $tm(i,chn)+tms(i,r,chn)$. On the other hand, the theory of price transmission elasticity developed by Bredahl *et al.* (1979) indicates that the percentage change in domestic prices $pms(i,r,chn)$ given one percentage change in international prices $pcif(i,r,chn)$ could be defined by Equation (4.2), where $\beta(i,r,chn)$ is defined as $pms(i,r,chn)$ in response to $pcif(i,r,chn)$:

$$pms(i,r,chn) = \beta(i,r,chn)\,pcif(i,r,chn) \tag{4.2}$$

Combining Equation (4.1) and (4.2), Valenzuela *et al.* (2007) generate Equation (4.3) that links the shift of border measures and the price transmission elasticity, i.e., governments alter border measures to keep a certain level of price transmission from the international to the domestic market. In other words, $\beta(i,r,chn)$ implicitly captures the effect of all border measure adjustments that increase or decrease imperfect price transmission:

$$tm(i,chn) + tms(i,r,chn) = (\beta(i,r,chn) - 1)\,pcif(i,r,chn) \tag{4.3}$$

Obtaining $\beta(i,r,chn)$ and incorporating it into the GTAP model enhances its capability to capture incomplete price transmission. For our purpose, we only allow the adjustment in $tms(i,r,chn)$ to accommodate the changes in $\beta(i,r,chn)$. As a result, when international agricultural price increases, i.e., $pcif(i,r,chn)$ is positive, $tms(i,r,chn)$ becomes negative, so that domestic prices increase less than the increase in international prices, i.e., $\beta(i,r,chn)$ is smaller than 1. The following part illustrates the estimation of $\beta(i,r,chn)$.

4.2.1.2 Estimation of price transmission elasticities

We estimate price transmission elasticities $\beta(i,r,chn)$ for China by regressing the first difference of the log domestic agricultural prices on the first difference of the log international agricultural prices (Campa and Goldberg, 2005; Nakamura and Zerom, 2010):

$$\Delta \log PMS(i,r,chn)_t = \alpha_t + \sum_{k=0}^{k} \beta(i,r,chn)_k \Delta \log PCIF(i,r,chn)_{t-k} + \varepsilon_t \tag{4.4}$$

$PMS(i,r,chn)$ and $PCIF(i,r,chn)$ represent domestic price index and international agricultural price index, respectively.[3] The subscripts t and k in Equation (4.4) represent a time index and the number of lags, respectively, whereas ε_t represents the error term. The sum of pass-through coefficients $\sum_{k=0}^{k} \beta(i,r,chn)_k$ generates the price transmission elasticity of the international agricultural prices to the domestic prices. The number of lags k is determined by the rule developed by Nakamura and Zerom (2012) that the transmission elasticity does not change when additional lags are added.

We estimate price transmission elasticities for major agricultural products in China by utilising monthly price indices over the period from January 2004 to October 2013.[4] For domestic grain prices, we collect farm-gate prices of different agricultural commodities based on National Bureau of Statistics of China. Because only seasonal data are available, we interpolate the data by assuming an equal monthly growth rate during the same season. Domestic prices for other agricultural and food commodities are available from the Ministry of Commerce (MOFCOM) of China. Data of international agricultural prices are retrieved from the FAOSTAT. For different prices reported for the same product, we choose prices from the major trading partner with China. Lastly, because domestic prices are denominated in Chinese Yuan, we use the monthly exchange rates from the International Monetary Fund (IMF) to convert domestic prices from Chinese Yuan to US Dollar.

Table 4.1 summarises the estimation results.[5] The first column in Table 4.1 shows the lengths of lags differ considerably across all commodities. The second column shows the values of the price transmission elasticities. The transmission elasticity of soybeans for example remains at 0.25 after two months, i.e., when the price of internationally traded soybeans changes by 1%, prices of soybeans in China would change by 0.25%. For dairy products, the elasticity reaches 11% after two years. Products such as soybean oil and chicken have higher value price transmission elasticities, indicating their higher trading volumes and

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[3] In GTAP, price indices included in Equation (4.4) are country specific. However, in our econometric analyses, we do not differentiate agricultural products according to their origins because we focus on the price transmission from the aggregated international agricultural market to China.

[4] We collect data rice including paddy rice and processed rice, wheat, maize, soybean, soybean oil, pig and pig meat, cattle and cattle meat, goat and goat meat, poultry and poultry meat, sugar and dairy products.

[5] We also tested the cointegration of international agricultural prices and China's domestic prices excluding the period 2007/08, the short-term adjustments of most products remain unchanged.

better market integration. Yet, the price fluctuation does not fully transmit from international to the domestic market for any of the commodities, partially reflecting the existing border and domestic measures the Chinese government uses to stabilise domestic prices. For meat products such as pork, beef and lamb, we see reversed relationships between international and domestic prices, and the coefficients are not statistically significant. The reason is that price fluctuations of meat products other than chicken are mainly affected by domestic factors.

Table 4.1 Price transmission elasticities from the international market to China [1)]

Commodities i	**Lag length (months)** k	**Price transmission elasticities** $\sum_{k=0}^{k}\beta(i,r,chn)_k$	**Mapping with GTAP sectors**[2)]
Wheat	19	0.25* (0.15)	Wheat
Maize	5	0.18*** (0.05)	Other grains
Soybean	2	0.25*** (0.05)	Oilseeds
Pork	27	-3.69 (1.77)	Pork and chicken
Beef	9	-0.04 (0.18)	Cattle meat
Chicken	13	0.46** (0.20)	Pork and chicken
Soybean oil	12	0.52*** (0.09)	Vegetable oils
Sugar	12	0.15* (0.08)	Sugar
Dairy products	24	0.11* (0.06)	Dairy products
Rice	7	0.11** (0.04)	Processed rice

Note: 1) Standard errors in parentheses; *** p<0.01, ** p<0.05, * p<0.1; 2) Refer to Table 4.A2 for details on the sectors.

Source: Own estimation.

The last column in the table shows corresponding sectors in GTAP model to which these elasticities are applied in the following simulations.[6] Due to the higher aggregation of the

[6] Please refer to Appendix 4.A2 for a detailed sector aggregation.

GTAP data base we are not able to facilitate a perfect match. For example, in the GTAP database, a sector such as grains includes not only maize. For the purpose of our analysis, we select maize, soybean, soybean oil in the econometric estimation to represent grains, oilseeds and vegetable oils, respectively, due to their large shares in these sectors in China and limited data availability of other sectors. Finally, we obtain 8 sectors in the GTAP model that incorporate the price transmission elasticities covering the major agricultural and food commodities in China, which are wheat, grains, oilseeds, pork and chicken, vegetable oils, sugar and dairy products and processed rice. We need to apply the price transmission elasticity of chicken to pork as well, because these sectors are combined in one sector in the initial GTAP framework. For other sectors, we retain the assumption of perfect price transmission.

4.2.2 Updating the representation of agricultural domestic support in the GTAP framework

The standard GTAP model and database depict policy instruments as *ad valorem* tax equivalents that create wedges between the distorted and undistorted prices. Accordingly, agricultural domestic support is modelled in the form of five price wedges affecting producers' transactions at agents' and market prices. These include output, intermediate inputs, land, capital, and labour. The standard GTAP framework thus accounts for budgetary transfers based on OECD PSE data, whereas market price support is implicitly included via border measures.

However, the structure of China's agricultural domestic support is much more complex than it is currently captured within the standard GTAP framework. It has undergone major changes in recent years, covering a wide range from reductions in agricultural taxes and fees to a gradual introduction of direct subsidies provided to agricultural producers (Yu and Jensen, 2010). Between 2004 and 2012, the total value of agricultural subsidies increased from $US 2.1 to $US 32.5 billion. These subsidies are split up into Product Specific (PS) subsidies, including e.g., direct payments for grain production and subsidies for improved crop varieties and into Non-Product Specific (NPS) subsidies, including e.g., comprehensive subsidies for agricultural inputs and farm machinery purchases. NPS subsidies have increased the most since 2004, and particularly striking is the growth of input subsidies, which account for more than 50% of total subsidies (Gale, 2013). Those subsidies are categorised according to the WTO Amber Box, including measures that affect production decisions and distort international trade (WTO, 2004).

To analyse the increase in China's domestic support and the change in its structure, we require a framework that depicts these subsidies at a more detailed level than the standard GTAP framework. Particularly important is the consideration of eligibility criteria specifying production requirements that needs to be met by agricultural producers to receive subsidies. These criteria determine how different subsidies create incentives to produce and affect production decisions at the farm level and thus how much they distort trade. We follow the approach of Urban *et al.* (2014) that builds upon the PSE concept. The PSE concept allocates producer subsidies according to their production requirements. It therefore distinguishes between four payments categories that reflect the allocation either to a specific product, a specific group of commodities, and all commodities or to producers without a requirement of any production. In addition, the PSE distinguishes between different payment types, such as payments based on output, input use, area, animal numbers, receipts, incomes, and non-commodity criteria that are predicted on a current or fixed basis (OECD, 2009). The integration of domestic support at such detailed level requires an extension of the GTAP framework. In doing so, we further subdivide the price wedges, which enables us to consider different production requirements. They assure that PS subsidies are linked to a specific product, whereas NPS subsidies are allocated at a homogenous rate across agricultural commodities belonging to a specified commodity group. In the literature, the decoupled support in China is still criticised for not being fully decoupled from production (Cheng, 2008). We therefore distribute these payments according to the factor usage at a homogeneous rate across all primary agricultural sectors, reflecting a partially decoupled payment in the GTAP framework. As a result, we obtain a detailed representation of domestic support in the underlying value flows and corresponding price linkage equations that account for the effect on farm level output decisions.

4.3 Simulations design

After introducing the two extensions in the GTAP framework, this section outlines our development of the underlying database, followed by the simulations design based on the different extensions of the GTAP framework.

4.3.1 Updating the database

The underlying GTAP database Version 9.1 (Narayanan *et al.*, 2015) with base year 2011 links 140 regions and 57 sectors, including bilateral trade and protection data and additional information from the OECD PSE tables. We aggregate the GTAP database into 14 countries and regions as well as 26 sectors by keeping agricultural and food sectors disaggregated (compare Appendix A). In addition, we utilise OECD PSE data (OECD, 2015) and a complex update procedure (Urban *et al.*, 2014) to improve the representation of China's domestic support in the GTAP database along the lines indicated in Chapter 2.2.

We set a target year of 2020 to explore how increased agricultural domestic support might affect China's domestic market under the assumption of incomplete price transmission. As demonstrated in Figure 4.1, the updated database is the starting point to establish a baseline, i.e., to move the global economy from the year 2011 to 2020 assuming there are no policy shifts during this period. In addition, with regard to the development of China's domestic support value, we deflate the value of domestic support payments during the same period to consider inflation. Thereafter, we conduct two sets of simulations as shown in the figure.

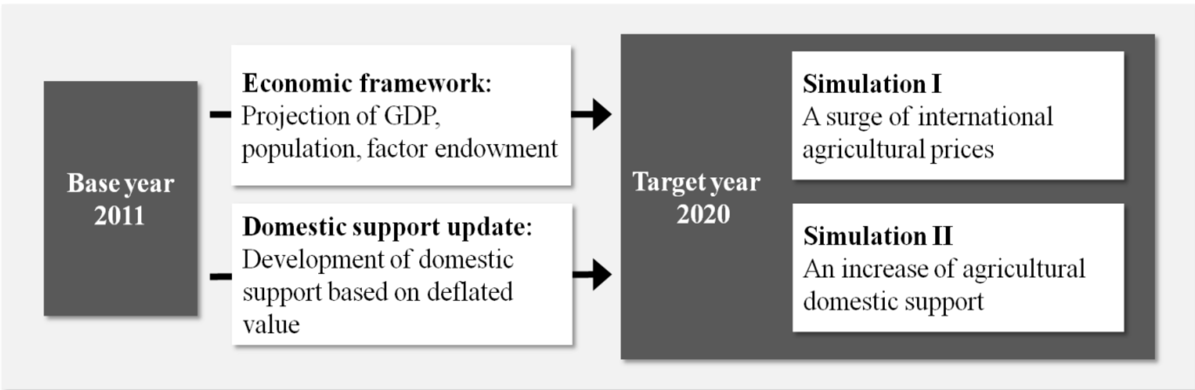

Figure 4.1 Development of the database
Source: Own illustration.

4.3.2 Simulations design

Table 4.2 shows the detailed design of three counterfactual scenarios summarised by two sets of simulations based on the updated database with target year 2020.

Table 4.2 Simulations design

Simulations		**I**		**II**[1)]
Scenarios		**1**	**2**	**3**
GTAP framework	**Database**	Updated structure of agricultural domestic support, target year 2020		
	Parameter	Standard	Estimated tariff-equivalent price transmission elasticity	
	Model	Standard	Border measure adjustments[2)]	
Shocks	International agricultural prices surge	☒	☒	☒
	Agricultural domestic support increases			☒

Note: 1) We utilise the information on the global technical change obtained in simulation I to accommodate the surge of international agricultural prices. 2) Refer to Chapter 4.2.1 for details on the extended GTAP model.

***Source**:* Own elaboration.

In Simulation I, we explore how a surge in international agricultural prices affects China's agricultural domestic market when the standard GTAP framework (Scenario 1) and the extended GTAP frameworks with the tariff equivalent price transmission elasticities (Scenario 2) are used. We assume that international agricultural prices for all primary agricultural products and processed food increase by 20% in 2020. Because prices are endogenously determined in the standard GTAP model, we swap international prices for all agricultural and food sectors worldwide with the total factor productivity. This swap and the corresponding shock facilitate the model to reduce agricultural production globally by an amount sufficient to accommodate the increase of 20% in international agricultural prices. Thereafter, we compare the results in Scenario 1 and 2.

In Simulation II, we analyse whether an increase in agricultural domestic support alters the effect of price transmission and what it further implicates for the domestic and international market (Scenario 3). For the latter purpose, we undo the swap of international prices and total factor productivity and utilise the technical changes, which increase international agricultural prices initially by 20% according to Scenario 2. As noticed above, PS subsidies tied to agricultural output create the highest production incentives, thus categorised as trade distorting support and are categorised as WTO amber box measures.

However, the WTO provides developing countries some flexibility regarding the use of PS subsidies. For China, the ceiling commitment defined by the Bound Total Aggregated Measurement Support (AMS) is effectively limited by the *de minimis* threshold that equals 8.5%, i.e., neither PS nor NPS subsidies should exceed 8.5% of the value of production (WTO, 2001). Figure 4.2 shows the value of AMS in the year 2002 and 2010 for both PS and NPS support compared to the value of support if China would achieve its 8.5% *de minimis* threshold. There is a prominent gap between those values. According to Gale (2013), officials in China intend to increase those payments until it reaches the *de minimis* limit, which is a substantial increase that would clearly affect agricultural production. Therefore, in Scenario 3, we assume that China makes complete use of their *de minimis*, and thus imposes a unified output subsidy rate for all primary agricultural products in the GTAP sectors to the target *ad valorem* subsidy rate of 8.5% (compare Yu and Jenson, 2010).

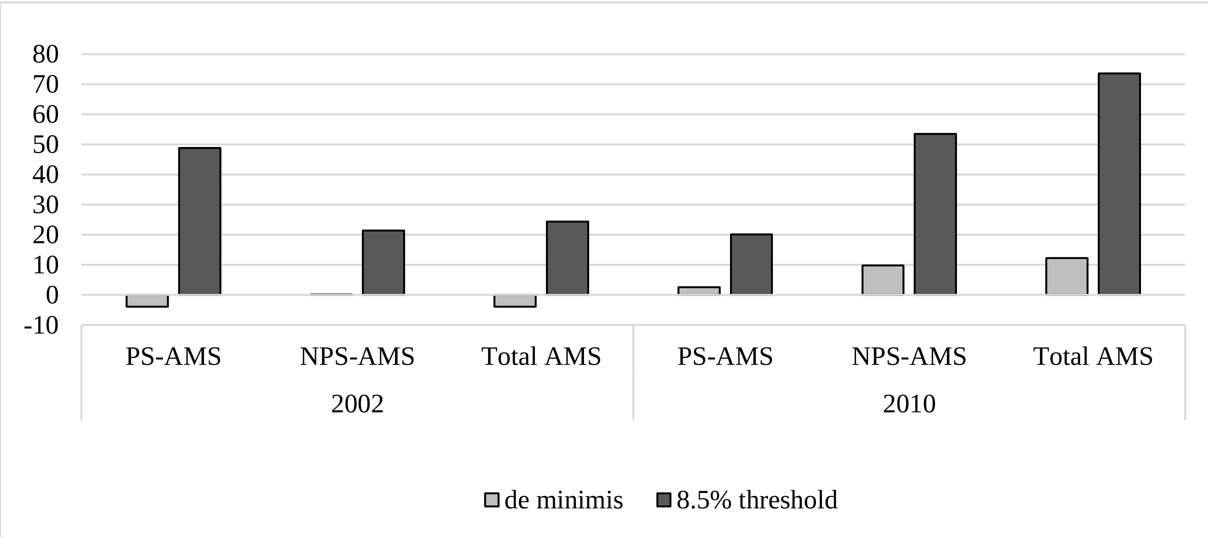

Figure 4.2 Current level of trade-distorting support compared to the *de minimis* threshold ($US billion)
Note**:** PS (Product Specific); NPS (Non-product Specific); AMS (Aggregated Measurement Support)
Source*:* Own calculation based on data from Minister of Finance (MOF), China, 2015.

4.4 Simulations results

In the first sets of scenarios in Simulation I, our results reflect the changes in price transmission in different GTAP frameworks, whereas Simulation II demonstrates whether the impact of agricultural domestic policy alters the magnitude of price transmission.

Table 4.3 presents the percentage changes in domestic prices (market prices, producer prices and consumer prices) in China in Scenario 1 and 2 compared to baseline with updated database in 2020 for the most important agricultural and food sectors in China, for which we also incorporate price transmission elasticities into the GTAP framework.[7] As shown in the table, the accounting of incomplete price transmission elasticities leads to price changes in Scenario 2, which are lower in all sectors for each price variable than in Scenario 1.

Table 4.3 Changes in domestic prices of agricultural and food commodities in China (%)[1)]

	Market Prices		**Producer prices**		**Consumer Prices**		**Applied Price Transmission Elasticities**
	1	**2**	**1**	**2**	**1**	**2**	
Wheat	23.3	21.0	23.3	21.0	23.2	21.0	0.25
Other grains[2)]	26.4	14.0	26.4	14.0	20.2	5.9	0.18
Oilseeds	21.9	14.0	21.9	14.0	17.5	5.4	0.25
Pork and chicken	28.3	20.4	28.3	20.4	28.0	19.8	0.46
Vegetable oils	24.5	22.6	24.5	22.6	23.6	20.5	0.52
Dairy products	26.1	24.7	26.1	24.7	25.3	22.0	0.11
Processed rice	24.7	19.7	24.7	19.7	24.6	19.4	0.11
Sugar	27.0	23.4	27.0	23.4	25.0	18.4	0.15

Note: 1) Refer to Chapter 4.3.2 for details on the Scenarios and to Table 4.A2 for details on the sectors, all changes are based on the updated database with target year 2020. 2) Other grains cover mainly maize in China.

Source: Own illustration based on simulation results.

In Scenario 1, market price changes in China are between 22% and 28%, and thus are higher than the presumed increase of 20% in the international agricultural prices. Because changes in international agricultural prices are the weighted share of price changes of all countries, this result indicates the small share of China's agricultural and food commodities in the international market. Therefore, domestic market prices in China increase more than 20% to accommodate the 20% increase in the international prices. However, when incomplete price transmission induced by tariff reduction is incorporated in the model (Scenario 2), market prices increase less than in Scenario 1. The difference between Scenario 1 and 2 is substantially higher for other grains and oilseeds. Examining the GTAP database, we find that

[7] We focus on those sectors which represent the major agricultural and food sectors in China.

original tariffs applied to these sectors are lower than other sectors, and both sectors have higher trading volumes than other sectors. Because incomplete price transmission is represented by tariff reductions in the model which is induced by the surge of international agricultural prices, tariff changes lead to higher changes in domestic prices for these sectors that for other sectors. Our results are in line with the response of China during the 2007/08 food crisis, when the government adjusted border measures especially for grains and soybeans to stabilise their domestic prices.

Producer prices changes are identical to the changes in market prices in both Scenario 1 and 2 compared to baseline, because domestic policies are assumed to be constant. Comparing two scenarios, changes in producer prices are lower in Scenario 2 than in Scenario 1. Thus, producers are not able to take full advantage of the price surge in the international agricultural market with the adjustment of border measures, in other words, the inclusion of incomplete price transmission in the model.

Consumer price changes are lower than market price changes for both scenarios, because consumers demand domestically produced as well as imported commodities. Accordingly, consumer price changes are represented in the standard GTAP model as weighted shares of price changes for imported and domestically produced goods. The underlying Armington assumption therefore adjusts price transmission according to the origin of goods imported in the model (Armington, 1969); however, the model still overestimates the degree of transmission. In Scenario 2, changes in consumer prices become lower than in Scenario 1. The incorporated price transmission elasticities are generated by tariff reductions for these sectors when international agricultural prices are higher (see Chapter 2.1.1). As a result, increases in international prices for imported goods only partially transmit to domestic prices, offsetting the magnitude of consumer price increases. Overall, the adopted approach of Valenzuela (2007) enables us to better reflect the incomplete price transmission in the GTAP model and thus in our analysis, so that the results correspond better to the results derived by our econometric estimates. In Scenario 2, when border measures are adjusted in response to the international prices surge, domestic prices increase less than in Scenario 1. Although this is of advantage for net food buyers, it prohibits net food sellers from benefiting from high prices. Because this is what was observed during the last price surge period (e.g., Swinnen, 2011), we feel confident to utilise our extended version of the GTAP model in the following to analyse whether the increase in agricultural domestic support in Simulation II could compensate the loss of domestic producers and what it implies for domestic and international market.

Table 4.4 shows how the increase in agricultural output subsidy to the *de mnimis* level generates a wedge between changes in market prices and producer prices in China's domestic market for selected commodities, i.e., wheat, other grains and oilseeds.[8] It also shows the response of these sectors in terms of price changes in the international market. To show how incomplete price transmission caused by border measure adjustments and increased agricultural domestic support affect the result differently in our extended framework, we decompose the changes into two parts represented by SubPT and SubDS, respectively.

Table 4.4 Changes in domestic prices and international prices of selected products in Scenario 3 (%)[1)]

		Domestic Market			International market
		Market prices	**Producer prices**	**Consumer prices**	**International prices**
Wheat	Total	15.64	25.47	15.64	18.58
	SubPT[2)]	20.94	21.88	20.93	19.89
	SubDS	-5.30	3.59	-5.29	-1.31
Other grains	Total	8.51	17.74	4.31	18.06
	SubPT	13.97	14.59	5.98	19.74
	SubDS	-5.46	3.14	-1.67	-1.68
Oilseeds	Total	11.48	20.96	4.93	18.85
	SubPT	14.16	14.79	5.38	19.85
	SubDS	-2.68	6.17	-0.45	-1.00

Note: 1) Refer to Chapter 4.3.2 for details on Scenario 3 and to Table 4.A2 for details on the sectors, all changes are based on the updated database with target year 2020. 2) SubPT indicates results initiated by extension of the framework to cover price transmission elasticity, whereas SubDS refers to the impact generated by domestic support.

Source: Own illustration based on simulation results.

Choosing wheat as an example, Table 4.4 demonstrates that the market price increases by 15.64% compared to baseline even though the international price change amounts to 18.58%. The decomposed result reveals that a change of 20.94% in market prices is caused by incomplete price transmission (SubPT) as indicated in Simulation I (Table 4.4). Noticeably, the increase in agricultural domestic support reduces the total changes in the market price by

[8] We choose those three products because their price transmission elasticities are modelled and they all receive agricultural domestic support. Results of other sectors show a similar although less considerable pattern.

5.30% (SubDS). The producer price increases by 25.47%. Here, agricultural domestic support enhances the price increase for wheat by 3.59%. Because changes in consumer prices are weighted shares of changes in prices for domestic produced goods and imported goods, the consumer price increases by 15.64%, much lower than the increase in the producer price. For other grains and oilseeds, changes are consistent and more pronounced. Those results indicate that agricultural domestic support compensates the lower increase in producer prices caused by border adjustments as shown in Simulation I, and further decreases the price surge for consumers (e.g., from 21% to 15.64% for wheat in Scenario 2 and 3, respectively).

The substantial increase in agricultural domestic support simulated in Scenario 3 also affects the international market[9]. The last column of Table 4.4 implies that the initial 20% surge of international prices as shown in Scenario 2 in for wheat, other grains and oilseeds is reduced by 1.31%, 1.68% and 1.00%, respectively. The reason for the declined changes is attributed to increased domestic production (shown in the following part) and reduced net import of those agricultural products by China from the international market. As noted in Scenario 2, the government adjusts border measures to enhance agricultural domestic supply so that domestic prices increase less. Our results for the trade balances indicate that the net import of agricultural and food commodities in China escalate in Scenario 2 from $US 105.29 billion to $US 147.49 billion.[10] In Scenario 3, due to the increased agricultural domestic support, the net import value decreases by $US 9.26 billion, which shows lower demand pressure from China on the international market. However, due to the limited trade volume of agricultural products of China, a nationwide substantial increase in agricultural domestic support to the *de minimis* threshold level imposes only to a certain extent impacts on the international market.

One of the objectives of increasing agricultural domestic support in China is to improve agricultural production. Figure 4.3 demonstrates output changes in agricultural and food sectors in Scenario 3 compared to baseline with updated database in 2020. As noted in the scenario design, price increases in GTAP are equivalent to negative augmented technical changes in certain sectors. Thus, the technical recession applied in Scenario 3 to

[9] We deliberately accommodate changes in international prices by adjustment of technical parameters in the model in Scenario 3, thus are able to observe the additional impact of domestic support on international prices.
[10] The standard GTAP model only shows the changes in trade balances, we include level index to obtain the original value of trade balances. Changes in each sector are in line with the change in the aggregated level.

accommodate the 20% international agricultural increase reduces the output of the sectors. The total changes in output are more predominant in the non-grain sectors as shown in Figure 4.3. Grain sectors are less responsive than other processed food sectors to technical shocks, due to their intensive use of sluggish land as a main input factor that is less adjustable. When the output decreases in non-grain sectors, mobile endowments including labour and capital are released from those sectors and migrate into grain sectors, boosting the output of those sectors, e.g., wheat and other grains as shown in Scenario 3 in Figure 4.3. The impact for oilseeds is different, because domestic oilseeds, mainly soybeans, are notably less competitive than imported oilseeds; border measure adjustments induced by higher international prices for oilseeds increase the net import of this product substantially, and thus curtail the domestic production.

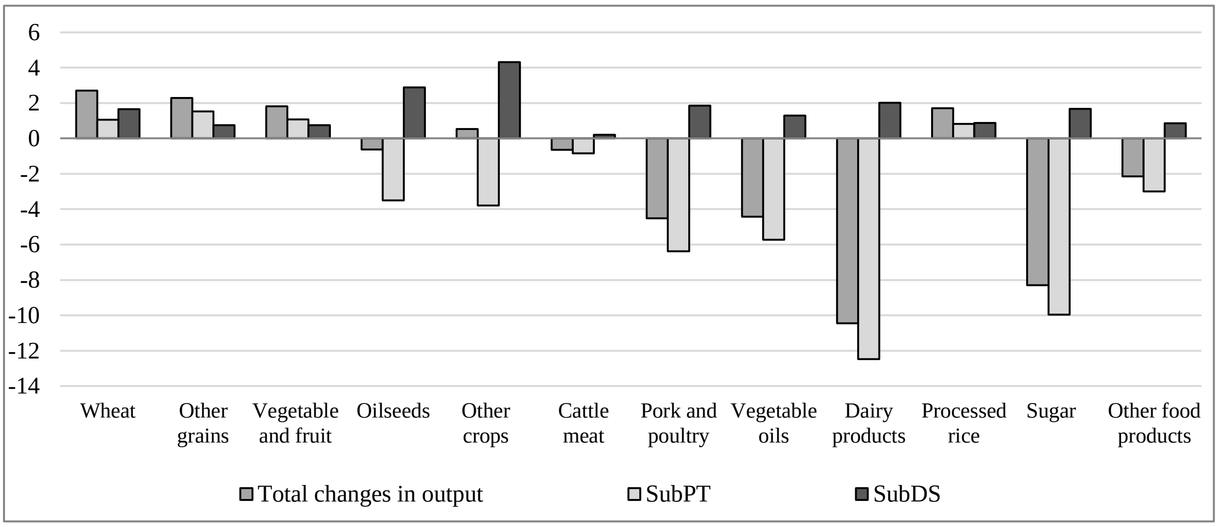

Figure 4.3 Changes in outputs of agricultural and food products in China in Scenario 3(%)[1)]

Note: 1) Refer to Chapter 4.3.2 for details on Scenario 3 and to Table 4.A2 for details on the sectors, all changes are based on the updated database with target year 2020.

Source: Own illustration based on simulation results.

Decomposing the results shows that the incomplete price transmission (SubPT) either undermines the output increase for grain sectors, or worsens the output decrease for other sectors, whereas increased agricultural subsidies (SubDS) not only improve the production for grain sectors and other primary agricultural sectors that receive the subsidy, but also the processed food sectors that utilise primary agricultural products as inputs. The results are in line with the characteristics of AMS payments, which are coupled with domestic agricultural production.

Lastly, we examine the welfare changes for all three scenarios compared to baseline with updated database in 2020. Table 4.5 demonstrates that the price surge induced by technical recession greatly reduces the welfare for all countries and regions in Scenario 1 remarkably, especially for China by approximately $US 250 billion, followed by the United States and Japan. The European Union also experiences a welfare decline by $US 188 billion. In Scenario 2, the total welfare loss decreases slightly in total, mainly due to the reduced border distortion to accommodate incomplete price transmission in the extended GTAP framework. However, welfare decreases even further in China. In Scenario 3, growing agricultural domestic support reduces the welfare loss for China by $US 4.98 billion (in the last column), with limited impact on the welfare of other countries and regions.

Our results could be justified by the “second-best policy” theory proposed by Lipsey and Lancaster (1956-1957). According to the theory, any distorting policies would reduce economic welfare. However, with the presence of market distortions, the presence of taxation and subsidization could correct the negative welfare impact as shown in the Table 4.5 for China. A further interpretation of the results is based on (Bhagawati, 1969). The authors’ argument is that for net agricultural importing countries like China whose agricultural market has limited impact on the international market, domestic subsidies on agriculture has a more important welfare-enhancing role than the import tariffs, in the presence of market distortions. Corden (1974) derives also similar arguments regarding the hierarchy of welfare generated by different policies. However, a conservative interpretation of our welfare results needs to take into account that our scenarios are built upon the target year 2020. When constructing the baseline, *ceteris paribus,* we assume all other policies remain constant between 2011 and 2020. Thus, any change in this condition could influence our results. Furthermore, our sensitivity analyses show negative welfare impact, i.e., higher Chinese welfare losses in Scenario 3 compared to Scenario 2, originating from increased agricultural output subsidy when a higher rate of output subsides is applied.

Table 4.5 Changes in welfare (($US billion) [1)]

	Simulation I		Simulation II
	Scenario 1[1)]	**Scenario 2**	**Scenario 3**
Countries			
China	-247.46	-249.17	-243.15
United States	-75.24	-61.34	-63.39
Japan	-52.06	-52.47	-51.71
Australia	-18.86	-16.52	-17.37
Canada	-15.58	-11.65	-12.15
Korea	-13.37	-12.89	-12.50
Regions			
European Union	-188.35	-181.40	-180.38
Latin America	-100.46	-85.82	-87.97
Other Asia countries	-97.60	-104.62	-104.59
ASEAN[2)]	-58.08	-55.92	-56.08
SSA	-52.79	-45.58	-46.00
MENA	-44.76	-44.06	-44.20
EFTA	-16.12	-15.91	-15.88
ROW	-163.98	-150.33	-151.64
Total	-1144.70	-1087.68	-1087.01

Note: 1) Refer to Chapter 3.2 for details on Scenario 3 and to Table 4.A2 for details on the regions, all changes are based on the updated database with target year 2020. 2) ASEAN (Association of Southeast Asian Nation); SSA (Sub-Sahara Africa); MENA (Middle East and North Africa); EFTA (European Free Trade Association); ROW (Rest of the World).

Source: Own illustration based on simulation results.

4.5 Conclusions

Future international agricultural prices appear to be volatile, which might induce the Chinese government to repeat its adjustment of border measures to insulate domestic market from potential price surges in the international market. Simultaneously, agricultural domestic support in China is limited by the WTO *de minimis* commitment, but given its current low level it has substantial room to grow. This may lead to far-reaching impacts on agricultural production and thus on food prices. Existing analyses in the literature intensively assess these two issues, but seldom address their joint impacts. In this paper, we introduce two extensions of the standard GTAP framework to account for the interdependencies of the imperfect price transmission caused by border measure adjustments and increased agricultural domestic support. The standard GTAP model only uses the Armington assumption to depict food price transmissions. In addition to this assumption, we follow Valenzuela *et al.* (2007) to incorporate econometrically estimated price transmission elasticities into the GTAP model, so that the response of the countries to the surge in international prices is better captured. Furthermore, we extend the structure of the China's agricultural domestic support in the model and update the database accordingly to portray the impact of growing subsidies provided to agricultural producers more accurately.

Utilising the extended GTAP framework, we are able to demonstrate how an increase in China's agricultural output subsidy to the WTO *de minimis* threshold affects incomplete food price transmission induced by border policies. With the assumption of incomplete price transmission, net agricultural importing countries like China experience less volatility than in the standard GTAP model. Reduced price increases benefit domestic consumers, but prohibit producers from high selling prices, so that the model improvingly depicts the observations given during the price surge period 2007 to 2011. When agricultural domestic support increases, changes in consumer prices further decrease due to the increased agricultural domestic production, whereas producers have access to high selling prices. China's trade deficit in agricultural products also decreases, leading to a slight decrease in international agricultural prices. China's agricultural domestic policy could potentially offset the negative impact of incomplete price transmission caused by border measure adjustments on domestic market and lessen its demand pressure on the international market. Our simulations show that the consideration of incomplete price transmission elasticity in studying recent developments in China's agricultural domestic support substantially improves the model's results.

There are two implications for further research we need to address. First, because the focus of this study is on China, we utilise major trading commodities in China in our econometric analyses to represent the corresponding GTAP sectors and are able to achieve the purpose for our simulations. However, in future studies, better data availability could enhance the reconciliation of these two approaches. Second, increasing agricultural domestic support is only one measure among different policies that the Chinese government pursues to support agriculture and enhance farm income. Although this policy appears to generate positive welfare in our analyses, in reality, China might not reach the *de minimis* threshold for all sectors, which might divert the allocation effects. Beside output subsidies, market price support measures are frequently implemented when market prices are low; yet they are of little importance for the analysis of price changes as long as prices are higher than the intervention prices. Other measures categorised as minimally trade-distorting measures (WTO green box) are under development in China, which could provide a springboard for future research. The conclusion of Free Trade Agreements (FTAs) such as Trans-Pacific Partnership (TPP) and the possibility of China joining such agreements may also have potential impact on agricultural domestic market.

Nonetheless, our study highlights the importance of considering the incomplete price transmission caused by adjusted border measure in assessing the impact of increasing agricultural domestic support on China's domestic market. These are two policies frequently pursued in developing countries to justify their implementations of trade-distorting policies in stabilising domestic markets. We also draw on the advantage of combining econometric analysis with a CGE framework in analysing food price transmission. Accounting for incomplete price transmission in this way appears to be essential in analysing the impact of agricultural domestic support.

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Appendix

Appendix 4.A: GTAP Region and Sector Aggregation

Table 4.A1: Detailed region aggregation in GTAP

No.	Aggregation	Description
1	China	China.
2	Association of Southeast Asian Nation	Cambodia; Indonesia; LTE People's Democratic Republ; Malaysia; Philippines; Singapore; Thailand; Viet Nam; Rest of Southeast Asia.
3	Australia	Australia.
4	Japan	Japan.
5	Korea	Korea.
6	Other Asia countries	New Zealand; Rest of Oceania; Hong Kong; Mongolia; Taiwan; Rest of East Asia; Brunei Darassalam; Bangladesh; India; Nepal; Pakistan; Sri Lanka; Rest of South Asia.
7	Canada	Canada.
8	United States	United States of America.
9	European Union	Austria; Belgium; Cyprus; Czech Republic; Denmark; Estonia; Finland; France; Germany; Greece; Hungary; Ireland; Italy; Latvia; Lithuania; Luxembourg; Malta; Netherlands; Poland; Portugal; Slovakia; Slovenia; Spain; Sweden; United Kingdom; Bulgaria; Croatia; Romania.
10	European Free Trade Association	Switzerland; Norway; Rest of EFTA.
11	Latin America	Mexico; Rest of North America; Argentina; Bolivia; Brazil; Chile; Colombia; Ecuador; Paraguay; Peru; Uruguay; Venezuela; Rest of South America; Costa Rica; Guatemala; Honduras; Nicaragua; Panama; El Salvador; Rest of Central America; Dominican Republic; Jamaica; Puerto Rico; Trinidad and Tobago; Caribbean.
12	Middle East and North Africa	Rest of Western Asia; Egypt; Morocco; Tunisia; Rest of North Africa.
13	Sub-Saharan Africa	Benin; Burkina Faso; Cameroon; Cote d'Ivoire; Ghana; Guinea; Nigeria; Senegal; Togo; Rest of Western Africa; Central Africa; South Central Africa; Ethiopia; Kenya; Madagascar; Malawi; Mauritius; Mozambique; Rwanda; Tanzania; Uganda; Zambia; Zimbabwe; Rest of Eastern Africa; Botswana; Namibia; Rest of South African Customs .
14	Rest of the world	Albania; Belarus; Russian Federation; Ukraine; Rest of Eastern Europe; Rest of Europe; Kazakhstan; Kyrgyztan; Rest of Former Soviet Union; Armenia; Azerbaijan; Georgia; Bahrain; Iran Islamic Republic of; Israel; Jordhan; Kuwait; Oman; Qatar; Saudi Arabia; Turkey; United Arab Emirates; South Africa; Rest of the World.

Table 4.A2: Detailed sector aggregation in GTAP

No.	Aggregation	Description
1	Paddy rice	Paddy rice.
2	Wheat	Wheat.
3	Other grains	Cereal grains nec.
4	Vegetables and fruits	Vegetables, fruit, nuts.
5	Oilseeds	Oil seeds.
6	Sugar cane and sugar beet	Sugar cane, sugar beet.
7	Plant-based fibres	Plant-based fibres.
8	Other crops	Crops nec.
9	Cattle	Cattle,sheep,goats,horses.
10	Swine and poultry	Animal products nec.
11	Raw milk	Raw milk.
12	Wool	Wool, silk-worm cocoons.
13	Cattle meat	Meat: cattle,sheep,goats,horse.
14	Pork and chicken	Meat products nec.
15	Vegetable oils	Vegetable oils and fats.
16	Dairy products	Dairy products.
17	Processed rice	Processed rice.
18	Sugar	Sugar.
19	Other Food products	Food products nec.
20	Beverages and tobacco	Beverages and tobacco products.
21	Textiles	Forestry; Fishing; Coal; Oil; Gas; Minerals nec.
22	Wearing apparel	Textiles; Wearing apparel.
23	Leather products	Leather products; Wood products; Paper products, publishing; Metal products; Motor vehicles and parts; Transport equipment nec; Manufactures nec.
24	Wood products	Petroleum, coal products; Chemical,rubber,plastic prods; Mineral products nec; Ferrous metals; Metals nec; Electronic equipment; Machinery and equipment nec.
25	Margin services	Trade.
26	Petroleum and coal products	Electricity; Gas manufacture, distribution; Water; Construction; Transport nec; Sea transport; Air transport; Communication; Financial services nec; Insurance; Business services nec; Recreation and other services; PubAdmin/Defence/Health/Educat; Dwellings.

5 Discussion and Conclusions

The outbreaks of international agricultural and food price crises in 2007/08 and 2010/11 scaled up discussions of their implications for global food system. Surges in international agricultural prices generated heterogeneous impacts across different countries and regions Due to variations in price transmission from the international to domestic markets. Within the current literature, econometric analyses aim to explain the different degrees of price transmission through time, whereas CGE models, e.g., the GTAP model, quantify the effectiveness of agricultural and food policies in stabilising domestic markets. However, the assumptions of the standard GTAP model do not fully address the incomplete price transmission. Thus, simulation results of the standard GTAP model could deviate from the empirical findings based on economic estimations. This thesis endeavours to enhance the realism of simulations results with regard to international agricultural price transmission and its implications for domestic markets by linking econometric estimates with the standard GTAP model. We innovatively introduce several extensions to the GTAP framework and demonstrate how the extended framework could assess the impact of agricultural and food policies on international agricultural price transmission more accurately. The final chapter summarises the major findings of three journal articles, discusses the methodology advancements and policy implications, and ends with an insight for future research.

5.1 Major findings of the thesis

As the theoretical basis of the thesis, our first article econometrically estimates to which extent various determinants affect food price transmission from the international to domestic markets. Particularly, we underline an inverse relationship between income levels and degrees of food price transmission. We discover that countries characterised as high per capita income exhibit lower price pass-through, i.e., an elasticity of about -0.3 of transmission elasticities with respect to income per capita. This is because consumers in high-income countries purchase more processed food, which contains a higher value of domestic margin services than in low-income countries. The volatility of international agricultural prices is absorbed substantially by the value of margin services in high-income countries, implying lower price transmission of international agricultural price shocks than in low-income countries. Income per capita is very robust to variations in estimation methods and the inclusion of different control variables. Other factors determining food price transmission include trade policy measures and infrastructure and geography measures. We find that higher policy related trade costs and the Trade Restrictiveness Indices (TRI) measuring specific import protection in agriculture significantly undermine the food price transmission. In contrast, countries with larger Import Dependency Ratios (IDR) as trade outcome measures are associated with higher food price transmission than countries with lower IDRs.

Following the findings of the first article, our second quantifies the impact of domestic margin services in affecting price transmission, especially under the intervention of trade restrictions. We establish the linkage between domestically delivered services and consumed goods by extending the consumption structure in the standard GTAP model. The updated database in the extended model shows that the share of domestic margin services in the final consumption increases with the income in a country. As a result, we observe lower volatility of consumer food prices in domestic markets when international agricultural prices increase in the extended GTAP model than in the standard GTAP model, with the contrast more pronounced in high-income countries. When governments in low-income countries adopt export restrictions in response to the surge in international prices, results are twofold. First, countries that apply such trade restrictions achieve stabilised domestic consumer prices at the cost of other countries experiencing even higher international agricultural prices. Second, the impact is less noticeable for high-income countries in the extended GTAP model due to their higher share of domestic margin services in final consumption, whereas consumers in less-developed countries are still exposed to higher prices. Utilising the theoretical framework developed in the first article, our econometric validation confirms the considerably lower degree of food price transmission in high-income countries, consistent with the finding of Abbott (2012) that long supply chain/high value of margins in developed countries absorbs the shock from international agricultural markets.

After enhancing the standard GTAP model in analysing the impact of agricultural border policies on international agricultural price transmission, our last article explores how an increase in agricultural domestic support might affect China’s domestic market under the assumption of incomplete price transmission caused by border measure adjustments. Simulation results show that under the assumption of incomplete food price transmission, net importing countries such as China experience less volatility than in the standard GTAP framework. Lowered price increases benefit domestic consumers but insulate producers from receiving higher selling prices. This result is consistent with the observations given during the price surge period from 2007 to 2011. When agricultural domestic support is assumed to increase substantially to the WTO *de minimis* commitment level, domestic producers have access to higher prices than in the previous simulation, thus are incentivised to achieve higher agricultural production. As a result, consumers could benefit further from the lowered price increase. China's agricultural domestic policy could potentially offset the negative impact of the incomplete price transmission caused by border measure adjustments on domestic market and lessen its demand pressure on the international market. In other words, the incomplete price transmission caused by border measures may undermine the impact of domestic support in stimulating agricultural growth, as indicated by Yu and Jensen (2014) by applying a different methodology.

5.2 Discussion of methodology advancements

This thesis presents two different types of methodologies which enhance the realism of a CGE framework in assessing international agricultural price transmission by associating econometric analyses with the standard GTAP model.

The first type of methodology is applying the econometric estimation as a validation for our extension in the GTAP model. According to our theoretical development in the first article, food price transmission elasticities from the international agricultural market to domestic food markets are comparable to the shares of internationally traded primary agricultural products in the final consumed food, with the assumption of perfect market integration. Therefore, in the second article, we calculate the shares of primary agricultural products in the final consumed food based on the extended GTAP model. As a validation, we econometrically estimate food price transmission elasticities for countries within three income groups, as indicated in the simulation model. Results show that high-income countries have a lower share of primary agricultural commodities in the final food consumption and a comparable lower price transmission from international to domestic market, *vice versa*. This finding implies the importance of accounting for margin services explicitly in CGE models. Beyond the validation, we also intensively discuss the feasibility of directly using econometric estimates to substitute the value of domestic margin services in the extended GTAP model. However, domestic margin services does not explain other impact from other factors that curb food price transmission. Nonetheless, a complete coverage of international agricultural prices, producer prices and consumer prices in disaggregated detail may enable a more adequate estimation of the shares of domestic market services in the GTAP model.

The second type of methodology is utilising econometric estimates directly as a basis for the parameterisation in the GTAP model, according to the approach developed by Valenzuela *et al.* (2007). The authors enhance the ability of the model in determining wheat price volatility by considering incomplete price transmission elasticities derived from econometric analyses. Their argument is that some grain policies that reduce market integration are designed to be deliberately ambiguous. Price transmission elasticities may implicitly account for all aspects that determine the price link between the international and domestic market. Following this approach, we estimate price transmission elasticities from the international agricultural market to domestic markets for most important agricultural commodities and other major agricultural importing countries. Then we incorporate these elasticities as tariff equivalent parameters into the standard GTAP model. As a result, governments in net importing countries, such as China, reduce the tariffs in order to mitigate changes in domestic prices when international agricultural price surges, as in most agricultural importing countries during the 2007/08 world food crisis (see discussion from Chapter 5.3). In reality, the choices of border polices may be various and depending on the purpose of a study, certain border measures need to be explicitly taken into account. Nonetheless, our simulations show that the consideration of incomplete price transmission elasticity in studying recent developments in China's agricultural domestic support substantially improves the model's results.

5.3 Discussion of policy implications

In order to demonstrate how the extensions introduced to the standard GTAP model facilitate more accurate policy analyses, this thesis focuses on two different sets of policies implemented in developing countries in order to stabilise domestic markets, i.e. border policies and domestic policies.

Regarding the impact of border policies such as trade restrictions addressed in our second article, a consensus found in the literature shows that large agricultural exporters achieved stabilised domestic food prices by imposing export taxes and bans during 2007/08 food crisis. Especially, these measures minimised governments' risk of harming political interest groups in these countries (Sheldon, 2011). However, these trade restrictions diverted income away from food producers and led directly to the reduced supply of certain crops in the international market. As a result, international agricultural prices rose even further and net food importing countries became more vulnerable (Abbott, 2011; Martin and Anderson, 2011; Anderson and Nelgen, 2012; Rutten *et al.*, 2013). This thesis reaches comparable conclusions. Furthermore, we note that current literature tends to overestimate the impact of border policies due to the ignorance of domestic margin services. Nonetheless, there is a call for alternative policies such as export licensing scheme. Liefert *et al.* (2012) address the incentives provided by governments to grain producers to sell the autarky volume of products domestically previous of exporting. This strategy may be less market-distorting than export bans in terms of stabilising consumer prices, and may also reduce the welfare loss of producers and government spending. Other measures such as enhanced international cooperation and regulations from the WTO are in need to mitigate the "beggar thy neighbour" activities and improve the resilience of low-income countries against the international agricultural price turmoil (Bouët and Debucquet, 2012; Liefert *et al.*, 2012).

The second political measure discussed in this thesis is the agricultural domestic support. In recent years, developed countries have gradually decoupled their agricultural support whereas emerging economics are gradually increasing their Aggregated Measurement of Support (AMS) in agriculture (Tangermann, 2014).[1] According to the WTO, developing countries still have substantial room in growth-enhancing measures to improve the grain production (WTO, 2004). Timmer (2010) emphasises the importance or pursuing more "far-sighted food policies" for donors and governments to stabilise agricultural production in preventing food crises. In our last paper, we show that the increasing agricultural domestic support in China would increase domestic grain production, and thus offset the negative impact generated when government adjust border policies in the short-term to mitigate domestic price surges. Although other findings show that the farm input subsidy program in countries such as Malawi and Zambia increases the maize production and decrease price only moderately, they also note that even a small decrease in grain prices would benefit the poor net buyers of these commodities (Lunduka *et al.*, 2013; Ricker-Gilbert *et al.*, 2013). The limited impact may be attributed to the low efficiency in implementing these subsidies.

[1] The decoupled agricultural support means fixed payments, which do not depend on the value of agricultural production, thus is categorised as non-trade-distorting measures. Trade-distorting measures, in terms of AMS ceiling commitment, are effectively limited by the *de minimis* threshold (5% of agricultural production for developed countries, 10% for developing countries) (WTO, 2004).

Therefore, an important prerequisite of growth-enhancing measures in low-income countries is to improve the efficiency of agricultural subsidy programs, e.g., by providing a well-targeted distribution system.

5.4 Limitations and suggestions for future research

This thesis addresses the issue of international price transmission by reconciling econometric estimations with the standard GTAP model. By drawing on the advantages of both frameworks in assessing agricultural and food policies, we are able to note the limitations for the current study, and more importantly, to give suggestions for the future research.

First, similar to other empirical studies, the thesis involves a large quantity of data analyses, and thus is subject to the limited data availability. When using the econometric framework in our first article to validate the simulations from the second article, the commodities categorised as "processed food" in the standard GTAP model have a different component as these included in the consumer food price index used in econometric analyses. As discussed in Chapter 5.2, detailed price indices resembling the model disaggregation could enable us to accurately quantify the domestic margin services in the model and thus further improve the realism of the simulation results. In the third article, we estimate food price transmission elasticities for a wide range of commodities and incorporate the results into the standard GTAP model. Because most agricultural sectors in the model contain more than one single commodity, e.g. "other grains" not only indicates maize, but also barley, rye and oats. We are not able to facilitate a perfect match between the commodities included in the econometric estimations and GTAP sectors. However, maize is the main component in the sector of other grains in China, and thus is selected to represent the price transmission in this sector. In future research, better data availability could enhance the linkage of commodities included in econometric estimations and GTAP sector representations in order to improve the accuracy of combining these two methodologies in analysing food price transmission.

Second, as discussed in the introduction, the depreciation (appreciation) of domestic currencies against $US could either reinforce (mitigate) the domestic price volatility after a price shock in international agricultural market (Ianchovichina *et al.*, 2014). This volatility of exchanges rates is not discussed in our CGE analyses. This limitation stems from the underlying assumption that the standard GTAP model does not capture the nominal exchange rate, because the model only discusses the relative change in prices but not the level of prices. Changes in the nominal values are not effective and do not lead to relative changes in traded quantity, and thus do not affect food price transmission. Therefore, we only differentiate the international agricultural price and the exchange rate transmission in the first article. In the second and third articles, we unify the currencies represented in the price indices in the econometric estimation, in order to eliminate the impact of volatilities in exchange rates on the estimated transmission elasticities. In future research, altering the closure set forth in the standard GTAP model is required in order to correlate nominal exchange rates to the model (for further information, see McDougall, 2012).

Lastly, as indicated in our discussion regarding policy implications, border adjustments implemented by major agricultural trading countries could potentially exacerbate the food availability in the international agricultural market. Although in our third article, we are able to demonstrate a positive welfare impact of increasing agricultural domestic support in China, which offsets the negative impact of border adjustments. In other developing countries, agricultural output subsidies might not reach the *de minimis* threshold due to the budgetary constraints, and thus the efficiency in subsidy allocation may also divert the welfare effects. Potentially, future research should account for other measures categorised as minimally trade-distorting measures (WTO green box) and their role in stabilising agricultural domestic prices. These measures are under development in many countries and regions. In addition, the conclusion of Free Trade Agreements (FTAs) such as Trans-Pacific Partnership (TPP) may also exert potential impact on international agricultural price transmission.

5.5 Concluding remarks

In conclusion, this thesis raises the question of how variations in international agricultural price transmission affect domestic markets, especially under the interventions of border and domestic policies. In answering this question, we introduce several extensions to the standard GTAP model in order to enhance its realism in analysing food price transmission, so that the simulation results are more in line with empirical findings based on econometric estimations. Accounting for incomplete price transmission explicitly in the GTAP model appears to be essential in assessing the impact of agricultural and food policies on the international and domestic markets.

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