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Looking Beyond the Direct Trade Effects of Public and Private Food Standards in the Crops sector

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Abstract

While tariff barriers are decreasing over time and across countries, non-tariff barriers such as food safety, quality and sustainability standards are increasing. Since these affect import and exports decisions, the analysis of trade effects of such standards has become an important topic. However, most empirical studies have focused on the direct trade effect of public or private food safety standards.

In our first essay, we analyse the trade effect of a private voluntary sustainability standard. This is especially relevant in the cocoa sector because large chocolate manufacturers have committed themselves to only using certified cocoa beans and some governments want to increase the share of certified cocoa products consumed in their countries. Thus, sustainability standards become quasi-mandatory for cocoa producers to ensure market access. It is important to understand whether these standards are trade-facilitating or trade-impeding. Therefore, we use a unique dataset that contains the UTZ Certified cocoa production quantity of cocoa-producing countries from 2010 to 2016. We estimate a gravity model to analyse the effect of the share of UTZ Certified cocoa production quantity in a country on the trade volume of raw cocoa beans, cocoa powder, cocoa paste and cocoa butter. Our results show that UTZ certification only enhances bilateral exports of cocoa beans and paste, while it reduces exports of cocoa butter and has mixed effects on cocoa powder exports.

In our second essay, we place the focus on another private voluntary sustainability standard - Rainforest Alliance Certified - and include data on coffee and cocoa. This allows us to analyse the direct trade effect of Rainforest Alliance Certified on the two most important crops of this certification scheme and the indirect trade effect through the interplay with public standards, namely Maximum Residue Levels (MRLs). MRLs are regulated at the international level by Codex Alimentarius, although national regulations can deviate from it. Most countries that set their own national standards are located in the Global North and they set stricter MRLs as suggested by Codex Alimentarius or add regulations on further pesticides. Since many cocoa- or coffee-producing countries do not have the institutional capacity to tighten their MRLs, certification to a private standard such as Rainforest Alliance Certified could be a means to bridge the occurring regulatory distance. This private standard is a good example because it refers to different regional and national legislations on MRLs. An extended gravity model of trade is used to empirically analyse the interplay of a voluntary sustainability standard and the relative stringency of public MRLs set by trading partners. Our results show that while increasing regulatory heterogeneity hinders bilateral trade, certification according to a private voluntary

sustainability standard can partially moderate the trade-inhibiting effect of public standards. This effect is only significant at the intensive margin of certification (share of certified crop area) but not at the extensive margin of certification (turning from no certification to having at least one farmer certified).

In our third essay, we analyse the determinants of the extensive and intensive margin of certification in more detail. Here, we focus on another popular private agri-food standard: Global G.A.P. Compliance with this food safety standard has become a key requirement for farmers to access high-value global markets. Nonetheless, the global spread of certification is highly uneven among countries. We assess the drivers and dynamics behind these unequal patterns, applying panel data regressions. The findings show that global agricultural trade networks and urbanisation remain relevant, but are no longer sufficient in explaining certification. Fostering a favourable business environment – via providing secure land tenure and a functioning judicial system – as well as investing in transportation and information infrastructure may facilitate farmers' participation in certification schemes. Stringency of existing public regulations in non-EU countries is helpful for overcoming entry barriers.

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List of Abbreviations

ACP	African, Caribbean and Pacific
AIC	Akaike Information Criterion
BRC	British Retail Consortium
B2B	Business-to-Business
B2C	Business-to-Consumer
CEPII	Centre d'Etudes Prospectives et d'Informations Internationales
CES	Constant Elasticity of Substitution
CoC	Chain of Custody
DB	Doing Business
DGP	Data Generating Process
EPA	European Partnership Agreement
EU	European Union
FDI	Foreign Direct Investment
FLEGT	Forest Law Enforcement Governance and Trade
FSC	Forest Stewardship Council
GDP	Gross Domestic Product
GSP	Generalized System of Preferences
HS	Harmonised System
ICT	Information and Communications Technology
IFS	International Food Standards
ISO	International Organization for Standardization
LBC	Licensed Buying Company
LDC	Least Developed Country
MFN	Most Favoured Nation
MRL	Maximum Residue Level
MSC	Marine Stewardship Council
NGO	Non-Governmental Organisation
NTM	Non-Tariff Measure
OLS	Ordinary Least Squares
PPML	Poisson Pseudo Maximum Likelihood
RQ	Research Question
RTA	Regional Trade Agreement
SDG	Sustainable Development Goal
SPS	Sanitary and Phytosanitary
STC	Specific Trade Concern
TBT	Technical Barriers to Trade
TRAINS	Trade Analysis Information System
UNCTAD	United Nations Conference on Trade and Development
VSS	Voluntary Sustainability Standard
WTO	World Trade Organization

Chapter 1

General introduction

“We welcome efforts, including those by the private sector, to expand current markets to cater for agricultural products produced in a sustainable manner [...] [and] we underscore the importance of transparency and of protecting consumer choices while avoiding unjustified barriers to trade” (Global Forum for Food and Agriculture, 2020, pp. 6-7). This excerpt from the communiqué of 72 agricultural ministers developed at the Global Forum For Food and Agriculture 2020 highlights the topicality of the debate around sustainability standards and agricultural trade. The following dissertation will analyse this topic in more detail.

In 2016, with the declaration of the Sustainable Development Goals (SDGs), the international community affirmed its commitment to not only promote development per se but in particular *sustainable* development. This went hand in hand with the rapid expansion of voluntary sustainability standards (VSSs), private agri-food standards that especially focus on social and environmental aspects. Tropical commodities such as cocoa and coffee are among the food items most targeted by VSSs (Lernoud et al., 2018). They also belong to the set of items making up half of the international agricultural trade value (Anderson, 2016).

Private agri-food standards not only reduce trade costs due to e.g. enhanced traceability along the value chain but they can also become a non-tariff trade barrier due to their strict and costly requirements. This is especially true for smallholder farmers in developing countries with limited access to financial resources and inputs (Swinnen, 2016). Therefore, more careful empirical analyses are needed to better understand the trade effects of private agri-food standards, in particular VSSs. These results could help policy-makers at the national and international level to decide whether VSSs are an appropriate instrument to promote export-led economic growth and sustainable development. Specifically, the answers to the following three outstanding issues could contribute to better decision-making: Do VSSs enhance value-added agricultural production and exports? Can VSSs help to meet strict public regulations? What are the macroeconomic drivers for the adoption of private agri-food standards? These questions will be answered in the three essays that constitute this dissertation. This chapter sets the stage by classifying agri-food standards, discussing their role in international trade and global adoption and identifying research gaps remaining in this context. It concludes with describing the research questions and outline of the dissertation.

1.1 Classification of agri-food standards

There is no standardised classification of agri-food standards used in the literature, but rather several approaches that slightly differ from each other (see e.g. Swinnen and Vandemoortele, 2009). In this dissertation, I will follow the classification by Henson and Humphrey (2010), who define four categories of agri-food standards: (1) public mandatory standards, (2) public voluntary standards, (3) private mandatory standards and (4) private voluntary standards. Mandatory standards are enforced by public authorities and could be either public regulations that are also developed by them or standards that are developed by the private sector, i.e. retailers, food companies, producers or civil society organisations. In the case of voluntary standards, the adoption is voluntary and the actors establishing them could be public or private.

In this dissertation, I am specifically interested in public mandatory standards and private voluntary standards[1]. Agri-food standards can be applied at the national, regional or international level and regulate product or process attributes. Product standards focus on the final food product characteristics, which often relate to quality or safety requirements such as maximum residue levels (MRLs) or size and weight. Process standards specify the conditions under which a food product should be produced, processed or transported (Webb, 2015). These could include e.g. environmentally-friendly practices and occupational safety and health requirements.

The most prevalent public standards in the agri-food sector are Sanitary and Phytosanitary (SPS) and Technical Barriers to Trade (TBT) measures, both of which are guided at the international level in World Trade Organization (WTO) agreements. Both include product as well as process standards. SPS measures comprise food safety as well as animal and plant health requirements such as MRLs or they require that the production site is based in a disease-free area. TBT measures refer to technical regulations that are not included in the category of SPS measures, e.g. labelling requirements (UNCTAD, 2019).

According to Henson and Humphrey (2010), private agri-food standards can be divided into two broad categories, namely those addressing food safety attributes and others addressing non-food safety attributes. Typical non-food safety attributes are environmental protection, ethical trading, animal welfare and organic production methods, among others. A clear distinction is sometimes difficult because some standards that predominantly focus on food safety attributes also include non-food safety attributes, and vice versa. For instance, GlobalGAP was developed by retailers to ensure food safety but it also includes requirements on environmental and employment practices. Rainforest Alliance Certified and UTZ Certified[2] mainly focus on sustainable production practices (non-food safety attributes) but also regulate the use of pesticides (food safety attributes). However, in this dissertation we will refer to GlobalGAP as a private food

[1] Throughout the dissertation, the terms public standards and regulations will be used interchangeably and refer to public mandatory standards. Whenever the term private standard or voluntary standard is used, it refers to private voluntary standards.

[2] In the following, we will refer to Rainforest Alliance Certified and UTZ Certified when talking about the VSSs and to Rainforest Alliance and UTZ when talking about the organizations as such.

safety standard[3] and Rainforest Alliance Certified and UTZ Certified as VSSs.
Private agri-food standards can be further categorised into Business-to-Business (B2B) and Business-to-Consumer (B2C) standards depending on their target group. The former are mainly designed to enhance traceability and mitigate risk along the supply chain, as relevant characteristics for business actors involved in the supply chain. The latter mainly aim at signalling specific product or process attributes to the consumer by placing a label on the final food product that supports product differentiation. This dissertation provides insights into B2C standards (Rainforest Alliance Certified and UTZ Certified, see Chapters 2 and 3) and a B2B standard (GlobalGAP, see Chapter 4).

1.2 The role of agri-food standards in international trade and their global adoption

As shown by Santeramo and Lamonaca (2019) in their extensive review and meta-analysis of standard-like Non-Tariff Measures (NTMs) and agri-food trade, the empirical evidence on this topic has been growing over the last two decades. However, the results remain mixed and depend on the type of agri-food standard or product studied, among other things. Most of the studies that the authors find focus on public standards and only a few on private voluntary standards. For the latter categories, they highlight the strong heterogeneity in estimates, which calls for further empirical studies. This is supported by Elamin and de Cordoba (2020) in their recent review where they identify a 'worrying lack of empirical literature on the trade impact of voluntary standards' (Elamin and de Cordoba, 2020, p. 20). Most studies included in the meta-analysis of Santeramo and Lamonaca (2019) focus on the seafood, fruits and vegetables, meat, cereals and oilseeds sectors, while few studies focus on traditional tropical agricultural export commodities such as cocoa, tea and coffee.

1.2.1 From food safety to sustainability standards

One of the reasons explaining the focus of the literature on the aforementioned products is that they are the ones mainly targeted by private (e.g. GlobalGAP) and public (e.g. MRLs) food safety standards. When looking at the development of agri-food standards, they first focused on food safety issues because they directly affect human health (Webb, 2015). Furthermore, the private sector – especially retailers – has a strong interest to avoid food scandals and trace back the supply chain if such a case happens.
As the global reach of private food safety standards increased, the debate also evolved on whether these standards are barriers or catalysts to trade. It found its first peak with a Specific Trade

[3]By classifying GlobalGAP as a private food safety standard, we follow the majority of the literature (see e.g. Asfaw et al., 2009; Kersting and Wollni, 2012). However, other authors classify GlobalGAP as a VSS (see e.g. Lernoud et al., 2018; Elamin and de Cordoba, 2020).

Concern (STC) raised by Saint Vincent and the Grenadines at the WTO in 2005 concerning EurepGAP[4] (WTO, 2005). They highlighted the *quasi-mandatory* nature of this private food safety standard to enter the European fruit and vegetables market. This led to a discussion at the WTO level concerning whether not only public but also private food safety standards should fall under the WTO SPS agreement. A WTO member country would then be able to challenge another country's private food safety standard in case they were unnecessary trade barriers. This also led to an increasing interest to analyse this issue among the science community (Santeramo and Lamonaca, 2019).

Starting in the late 2000s, another type of private agri-food standards - VSSs - became increasingly relevant for mainstream markets. These standards are the private sector's response to increasing demand by consumers and governments for sustainably- and ethically-produced products (Havinga, 2015). Most of these standards focus on tropical commodities such as cocoa, coffee and tea because they are grown in regions with environmental and social concerns (Lernoud et al., 2018). The question of whether these standards are catalysts or barriers to trade also becomes more pressing with whole nations or food companies committing themselves to only importing or using products that are certified by a VSS. However, there is a lack of empirical literature analysing this research question (Elamin and de Cordoba, 2020). To fill this lack in the empirical literature, this dissertation will focus on the trade effect of two prominent VSSs, namely UTZ Certified in Chapter 2 and Rainforest Alliance Certified in Chapter 3.

1.2.2 Beyond the direct trade effect of agri-food standards

Most studies analysing the trade effects of private agri-food standards focus on the certification of producers and the export of raw products only (e.g. Andersson, 2019; Fiankor et al., 2019). Many private food certification schemes - such as GlobalGAP, Rainforest Alliance Certified, UTZ Certified, Marine Stewardship Council (MSC) and Forest Stewardship Council (FSC) - issue Chain of Custody (CoC) certificates to ensure traceability throughout the entire supply chain. For instance, in 2016 468 producers held a GlobalGAP CoC certificate (GlobalGAP, 2016). This may also affect the export of processed products. However, few studies have explored possible spillovers along the supply chain (Arton et al., 2020). It is important to understand supply chain dynamics because the final product can only be sold as certified if all supply chain actors are CoC certified. In other words, if there are only few CoC certifications, the incentive for producers of raw products to become certified is low because they are hardly able to sell their products as certified and therefore do not benefit from their certification status compared with non-certified farmers. To better understand the effect of certification on processed product exports, we include processed products in our analysis in Chapter 2.

Another possible indirect trade effect occurring from private agri-food standards is the interplay with public agri-food standards, which is hardly covered by the empirical literature (ITC, 2011). The nuanced analysis of the effect of private agri-food standards is important to better

[4] EurepGAP was renamed to GlobalGAP in 2007 to underline its growing global importance (GlobalGAP, 2018a). For further discussion on GlobalGAP, see Chapter 4.

understand the channels through which they can affect trade flows. It might be the case that private standards initially seem to exclude smallholder farmers from access to high-value markets due to their high costs of certification and strict certification criteria. However, upon further consideration these investment costs could pay-off because the certification might be an entry ticket into markets that have strict public agri-food standards that every exporter has to meet. If private agri-food standards criteria adapt to public agri-food standards, they might lower costs for smallholders regarding up-to-date information of public agri-food standards in major destination markets, rejected products at the border, bargaining, monitoring and adjustment, as explained in more detail in Section 3.2.2. To shed more light on the interplay between private and public agri-food standards and their effect on agri-food exports, we take the example of Rainforest Alliance Certified and MRLs in the cocoa and coffee sector (see Chapter 3).

1.2.3 The diffusion of private agri-food standards

Once the aforementioned research gaps are filled, we are better able to understand trade effects occurring from private agri-food standards and draw policy implications on whether the adoption and demand of these standards should be supported or regulated. In case the further support of these standards is desirable, the question emerges concerning what macro-level determinants favour the adoption of standards in one country compared with another. This is especially important because we observe an uneven spread of private agri-food standards globally. In 2016, according to Lernoud et al. (2018), nearly half of the producers certified by GlobalGAP were located in Europe, followed by Latin America and Africa. In the case of Rainforest Alliance Certified, African producers hold most certificates (52%), followed by Latin America and Asia. The same is true for UTZ Certified, where Africa plays even a stronger role with 73% of all producers certified being located in this region. A vast number of studies have analysed factors that explain the uneven spread of private agri-food standards at the farm level, e.g. Kleinwechter and Grethe (2006), Asfaw et al. (2009) and Kersting and Wollni (2012). However, to the best of our knowledge, only two studies have analysed these determinants at the macro level, e.g. Herzfeld et al. (2011) and Mohammed and Zheng (2017). In Chapter 4, we analyse the worldwide spread of the GlobalGAP private food safety standard to provide further insights into the diffusion of private agri-food standards, especially taking into account the time dimension.

1.3 Estimating trade effects of agri-food standards

The main focus of this dissertation lies in the cross-country empirical analysis of trade policies – in particular agri-food standards – and their effect on international agricultural trade flows.[5] As highlighted by Yotov et al. (2016), the gravity model of trade is considered to be the workhorse

[5]In this section, I only focus on the detailed description of the gravity model because it is the foundation for the analyses in Chapter 2 and 3. The description of the underlying model specification for the empirical analysis in Chapter 4 will only be provided in the chapter itself.

for this kind of analysis given that it is intuitive, based on solid theoretical foundations, provides a realistic environment, has a very flexible structure and is a powerful predictive model. We particularly make use of the possibility to simultaneously analyse multiple sectors and thereby take into account their interlinkages. The basic sectoral Armington-Constant Elasticity of Substitution (CES)[6] gravity model[7] as described by Anderson and van Wincoop (2004) looks as follows:

$$\mathrm{X}_{ij}^{k} = \frac{\mathrm{E}_{j}^{k}\mathrm{Y}_{i}^{k}}{\mathrm{Y}^{k}} \left(\frac{\mathrm{t}_{ij}^{k}}{\mathrm{P}_{j}^{k}\Pi_{i}^{k}} \right)^{1-\sigma_k} \tag{1.1}$$

where σ_k is the elasticity of substitution in sector k. The underlying assumptions are geographical product differentiation and CES expenditures, which imply identical and homothetic consumer preferences (Armington, 1969). Equation 1.1 describes the dependency of observed sectoral bilateral trade flows X_{ij}^{k} on predicted frictionless trade $\mathrm{E}_{j}^{k}\mathrm{Y}_{i}^{k}/\mathrm{Y}^{k}$ and trade costs $\mathrm{t}_{ij}^{k}/\mathrm{P}_{j}^{k}\Pi_{i}^{k}$. Predicted frictionless trade is influenced by the total consumer expenditure (E_{j}^{k}) in destination j for product k, country i's domestic (Y_{i}^{k}) and the world's (Y^{k}) production of product k. The sectoral gravity model allows us to estimate sector-specific bilateral trade costs (t_{ij}^{k}) as well as sector-specific inward (P_{j}^{k}) and outward (Π_{i}^{k}) multilateral resistances. Multilateral resistances were defined by Anderson and van Wincoop (2003) and they represent the relative trade costs faced by the importer and exporter. The estimation of sector-specific trade costs is important to avoid biased results from aggregated data because trade costs vary at the sectoral level (Anderson and van Wincoop, 2004), and it enables providing more precise policy recommendations (Li and Beghin, 2012).

The gravity model framework enables estimating the effects of bilateral and unilateral trade policies (Yotov et al., 2016). The latter is especially relevant in our context because our variable of interest – private agri-food standards – can be considered a unilateral trade policy measure.[8] However, the correct measurement of this non-tariff measure can be challenging due to the lack of data and therefore the need to indirectly quantify its effect on trade. One approach commonly used in the literature is count measures, i.e. counting the number of NTMs or - in our case - the number of certified farmers in a given country (Beghin et al., 2015). As discussed by Fiankor et al. (2019), this approach does not appropriately reflect the adoption intensity of certification in a given country. Instead, the authors propose using the share of certified land area in the total harvest area of a country. We follow this suggestion in our empirical analysis in Chapter 3 and propose another intensity measure in Chapter 2, namely the share of certified production quantity in the total production quantity of a country. The latter not only captures the relative certified production in the country but also a possible yield increase due to better farming practices, which is not reflected in the area share.

[6]Please see Novy (2013) for a detailed discussion on the advantages and disadvantages of using a CES-based gravity equation.

[7]For simplicity reasons, I only describe the cross-section model specification but will apply the panel data model specification in the course of the dissertation.

[8]However, the identification of the effects of unilateral trade policies in Equation 1.1 is not possible because they are perfectly collinear with the multilateral resistance terms. The methodical adjustments to identify the effects of such policies will be explained in Chapters 2 and 3.

1.4 Research questions and outline

This dissertation comprises three essays analysing trade effects and the diffusion of agri-food standards. These essays were motivated by the literature gaps identified above. The first essay focusses on VSSs and international trade in cocoa beans and grindings. It specifically answers the following two research questions: How do VSSs (here UTZ Certified serves as an example) affect cocoa beans exports? Can we observe spill-over effects along the value chain on cocoa paste, butter and powder exports? The results for the product categories included in this analysis are mixed. This motivated the second essay, which examines the interplay of public and private agri-food standards to understand whether public regulations might influence the trade effect of private standards. The research questions guiding this analysis are: How do heterogeneous public agri-food standards (here measured by MRLs) affect coffee and cocoa exports? Are VSSs (here Rainforest Alliance Certified serves as an example) a means to overcome this trade barrier and does this effect differ at the extensive (at least one farmer is certified) or intensive margin (intensity of certification)? As we find different effects at the extensive and intensive margin of certification, we move away from analysing the trade effect of agri-food standards and take a deeper look at the drivers of the margins. To also provide insights into another private agri-food standard, the third essay uses a dataset with GlobalGAP certified producers and explores the following research questions: What are the factors explaining why some countries are left out of the GlobalGAP market, i.e. show zero certified farmers? What factors drive high certification rates?

The remainder of the dissertation is structured as follows. Chapter 2 discusses whether VSSs increase countries' access to cocoa export markets. Building on this, Chapter 3 provides insights into the interplay of public food safety standards and VSSs in the context of cocoa and coffee exports. The following Chapter 4 explains the uneven spread of private agri-food standards. Finally, Chapter 5 provides policy recommendations based on the results of the essays and some concluding remarks.

Chapter 2

Do voluntary sustainability standards increase countries' access to cocoa export markets?

Abstract

In recent years, the number and scope of private voluntary sustainability standards (VSSs) in the food sector have increased tremendously. They are especially relevant in the cocoa sector because large chocolate manufacturers have committed themselves to only using certified cocoa beans and some governments want to increase the share of certified cocoa products consumed in their countries. Thus, VSSs become quasi-mandatory for cocoa producers and grinders to ensure access to these markets. It is important to understand whether VSSs are trade-facilitating or trade-impeding, especially because they are not yet regulated under the WTO SPS agreement. However, most empirical studies have focused on private food safety standards and the effects on raw food product exports. Therefore, we contribute to the current literature by studying the effect of a VSS on raw and processed cocoa exports. We use a unique dataset that contains the UTZ Certified cocoa production quantity of cocoa-producing countries from 2010 to 2016. This allows us to estimate a gravity model of trade and analyse the effect of the share of UTZ Certified cocoa production quantity in a country on the trade value of raw cocoa beans, cocoa powder, cocoa paste and cocoa butter. Our results show that UTZ certification only enhances bilateral exports of cocoa beans and paste, while it reduces exports of cocoa butter and has mixed effects on cocoa powder exports.

This chapter is joint work with Bernhard Brümmer. Nina Grassnick's contributions are developing the research question and research design, empirical and conceptual framework, data management, empirical estimation, and writing of the manuscript. Bernhard Brümmer revised the chapter.

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2.1 Introduction

In a world of global food supply chains, retailers and large food companies set up their own private food safety standard systems to trace the production process and monitor production requirements. In addition to safe and high-quality food products, discerning consumers worldwide increasingly demand sustainably- and ethically-produced food, which has led to the growth of private VSSs.[9] Most private food safety standards were developed by retailers, e.g. British Retail Consortium (BRC) and International Food Standards (IFS). These are B2B standards that mainly aim to govern risk along the supply chain concerning food safety issues. VSSs are often developed by producer groups or NGOs, e.g. Fairtrade and UTZ Certified. These are B2C standards that focus on product differentiation by addressing social and environmental issues such as fair labour conditions or nature protection. However, a clear distinction between the two types of private food standards is difficult because some private food safety standards also include social or environmental requirements and some VSSs include food safety requirements (Henson and Humphrey, 2010). Hereafter, we refer to B2C standards that mainly focus on environmental issues when using the term VSS. For a more detailed overview of the types of food standards, see Chapter 1.

The product and / or process requirements set by private food standards can affect import and exports decisions, but they are not yet regulated under any WTO agreement. The WTO SPS and TBT agreements regulate public food quality and safety standards to ensure that they are scientifically justified and non-arbitrary (WTO, 2010). Private food safety standards such as GlobalGAP or BRC have rapidly become a major requirement particularly to enter the European market. Therefore, empirical studies have analysed the trade effect of these standards to understand whether they are an additional barrier to trade and might be regulated at the international level. Scientific evidence remains ambiguous. Some authors - e.g. Anders and Caswell (2009), Disdier and Marette (2010) and Fiankor et al. (2019) - find that private food safety standards induce positive trade effects at the macro level, while others estimate negative (Shepherd and Wilson, 2013) or no effects (Xiong and Beghin, 2012; Schuster and Maertens, 2015). Some studies find mixed effects depending on the product and export region (Ehrich and Mangelsdorf, 2018) or estimation method (Ferro et al., 2015).

To the best of our knowledge, Guan et al. (2019) is the only empirical study analysing the trade effect of a VSS at the macro-level. They show that FSC certification reduces net exports of raw wood products and increases net exports of processed wood products. Possible reasons explaining why the empirical literature has paid little attention to VSSs at the macro level include the lack of data on VSS certified farmers or hectares per country (Elamin and de Cordoba, 2020) and VSSs only recently gaining importance for international trade as they are increasing their market share (Lernoud et al., 2018). Several empirical studies have examined the effect of VSSs on producers' market access at the micro-level and find mixed results. Kleemann et al. (2014) find positive effects on market access for organic-certified pineapple producers that are already active in the export market. Masakure et al. (2009) confirm increased export sales due to ISO

[9] Hereafter, we only refer to private VSSs when using the term VSSs.

9000 certification only for firms that started to export later and find no effect for long-time established export firms.

With our study, we aim to provide further insights into the macro-level trade effects of VSSs. In 2016, the top five commodities certified by VSSs in terms of share of total area were coffee, cocoa, tea, oil palm and cotton (Lernoud et al., 2018). The analysis of VSSs is especially relevant in the cocoa sector because large chocolate manufacturers such as Ferrero and Hershey have committed themselves to only using sustainably-produced and certified cocoa beans by 2020. Furthermore, the Netherlands government wants to transform cocoa consumption to only certified products by 2025 (Barrientos, 2016) and Germany's agriculture minister Julia Klöckner stated at the 4th World Cocoa Conference that Germany wants to consume 70 percent certified cocoa by 2020 (Deutsche Welle, 2018). Hence, one could argue that compliance with VSSs such as UTZ Certified becomes quasi-mandatory for cocoa producers and grinders when it comes to trade. Most cocoa producers are located in the Global South due to climatic conditions in a weak institutional environment and the majority are smallholders with limited access to finance and inputs (Fold and Neilson, 2016). These circumstances make it difficult to meet strict and costly requirements set by standard-setting organisations that might not only aim at the protection of human and plant life or health but could also create additional barriers to trade. If this is the case, regulations and control mechanisms may be introduced by international organisations or national governments to ensure that VSSs are scientifically justified and non-arbitrary.

In addition to sustainability and ethical issues in the cocoa sector, the structure of the cocoa-chocolate value chain is debated (Fold and Neilson, 2016). Most cocoa-grinding and -processing activities that add value to the product take place in the importing countries, which are mostly located in the Global North. Most cocoa-producing countries export low value cocoa products and are unable to benefit from value-added production. This is why VSSs follow a "theory of change" approach to not only ensure supply chain traceability but to also promote a sector-wide change. For instance, an expected industry or sector outcome stated by UTZ is: "Actors in the supply chain see a common urgency for and are willing to invest in sustainable supply chains" (UTZ, 2017, p. 6). As highlighted by Arton et al. (2020) for the case of MSC - an important VSS in the fish sector - most studies only focus on the effect on raw products and do not or rarely consider processed products. Indeed, based on our observation, this also holds for studies analysing other VSSs. Most VSS certification schemes offer so-called CoC certification to all actors along the supply chain to ensure that processing activities are also carried out sustainably and every production step can be traced back. The only study analysing trade effects of CoC certification along the supply chain is Guan et al. (2019) who apply a Heckscher-Ohlin-Vanek model and focus on raw and processed wood products. To the best of our knowledge, we are the first to particularly examine the effect of a VSS on cocoa-grinding exports.

For this purpose, we will use a gravity model of trade, which allows analysing the effect of the share of UTZ Certified cocoa beans production quantity in a country (and other trade-cost measures) on the trade value of raw cocoa beans, cocoa powder, cocoa paste and cocoa butter. Accordingly, we can measure the degree of compliant production, which increases the probability of acceptance of the exported product and thus reduces trade costs, e.g. through the reduction in information asymmetry or search costs. We use a unique panel dataset on the quantity in tonnes of UTZ Certified cocoa beans production in nineteen countries covering the 2010-2016 period. This dataset allows us to study the VSS certification scheme with the current largest certified area share in the cocoa sector (Lernoud et al., 2018).

This chapter makes four major contributions to the current debate. First, we study the trade effects of a VSS on food products, while previous studies focus on food safety standards (e.g. Shepherd and Wilson, 2013; Ehrich and Mangelsdorf, 2018). Second, we can identify trade effects for different processing stages of agricultural products, taking advantage of the various cocoa processing stages to make this contribution to the literature. Third, we analyse trade effects occurring from a VSS at the global scale and focus on UTZ Certified, which is rarely studied even at the micro-level (Bray and Neilson, 2017). Fourth, we take into account the scale of certification within a country by using the share of UTZ Certified cocoa beans production quantity in a country's total production. As highlighted by Fiankor et al. (2019), ignoring the relative size of certification within a country might lead to biased results. We will answer two research questions: How do VSSs (here UTZ Certified serves as an example) affect cocoa beans exports (RQ1)? Can we observe spill-over effects along the value chain on cocoa paste, butter and powder exports (RQ2)?

The next section explains the relevance of VSSs in the global cocoa market in general and in particular UTZ Certified. Subsequently, Section 2.3 explains the underlying conceptual framework of the chapter and the possible channels through which a VSS could affect cocoa trade flows. Therefore, Section 2.4 introduces the gravity model and data used, before the results are shown and discussed in Section 2.5. Finally, Section 2.6 concludes the chapter.

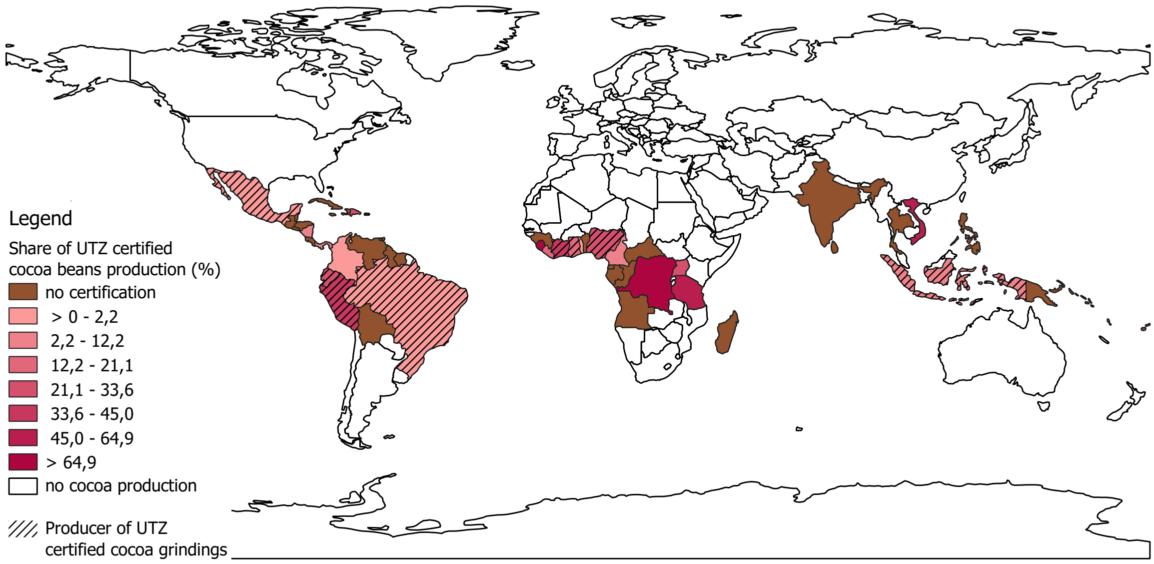
2.2 Voluntary sustainability standards and the cocoa sector

In the 1990s, the early initiatives of VSSs were designed to serve a niche market via product differentiation. In the 2000s, increasingly more VSSs entered the market and started to explicitly target global mainstream markets (Potts et al., 2014). At the same time, Non-Governmental Organisations (NGOs), consumers and governments increasingly raised concerns about the environmental and ethical issues of cocoa production, with the Netherlands and Germany committing to 100% and 70% sustainable cocoa consumption by 2025 and 2020, respectively. This resulted in the public commitment of several large chocolate manufacturers such as Hersheys, Mars and Ferrero to only source certified cocoa beans by 2020 (Lernoud et al., 2018). In 2013, these chocolate manufacturers produced 28.4% of the world's total chocolate production (Euromonitor, 2013, cited by Poelmans and Swinnen (2016)). They use the sustainability labels to signal to the consumer that the cocoa contained in the chocolate bar was produced under environmentally-sustainable and ethical conditions. The VSSs not only help the chocolate manufacturers to satisfy consumer demand, but also to reduce transaction costs; for instance, by providing quality control and traceability systems, as well as farmer training on farm management and production practices (Lernoud et al., 2018). The different channels through which VSSs potentially increase import demand and reduce trade costs will be explained in more detail in Section 2.3.

These changing demand patterns spilled over to other parts of the global cocoa value chain, downstream as well as upstream. Large retailers such as Lidl, Rewe, Migros and Coop - which produce their own branded chocolate through subsidiary companies - started to require their subsidiaries to source up to 100% of their cocoa beans in a standard-compliant manner (Fromm, 2016; Langen and Hartmann, 2016). Moreover, the eight largest cocoa grinders and traders[10] - which control 60-80% of the world market - started to produce part of their grindings in a standard-compliant manner, ranging from 3% (Continaf) to 23% (Ecom) in 2013 (Fountain and Hütz-Adams, 2015). Finally, the global cocoa production volume certified by a VSS increased nearly four-fold from 2011 to 2016 (Lernoud et al., 2018).

In 2016, cocoa was the second most certified agricultural commodity after coffee. Four of the fourteen largest VSSs certified on average[11] 30.2% of the global cultivated cocoa land. The largest share was certified by UTZ (21%), followed by Fairtrade International (7.1%), Rainforest Alliance Certified (6.4%) and IFOAM - Organics International (3.1%) (Lernoud et al., 2018).

Figure 2.1: Average share of UTZ Certified cocoa beans production tonnes (2010-2016) and producer of UTZ Certified cocoa grindings



Source: UTZ (2016) and FAOstat, own map.

Since UTZ Certified is the leading VSS in the cocoa sector, the focus of this study is placed on this scheme.[12] UTZ certifies cocoa, coffee, tea and hazelnuts, of which cocoa holds the largest share (UTZ, 2016). In 2016, 1,188,166 tonnes of cocoa in twenty producing countries was certified by UTZ (see Figure 2.1). UTZ was founded in 2002 by a Guatemalan coffee grower and a Dutch

[10]Namely Barry Callebaut, ADM, Cargill, Olam, Ecom, Touton, Blommer and Continaf.

[11]Multiple certification has to be taken into account. Here, the average is calculated between the maximum (sum of the total area certified by each VSS in a given country) and the minimum area (the area of the VSS with the largest area in the country).

[12]For a more detailed market overview of the other three VSS, please see Lernoud et al. (2018).

coffee roaster. Although it is a relatively young VSS (IFOAM, Rainforest Alliance and Fairtrade were founded in 1972, 1987 and 1997, respectively), it quickly became the leading certification scheme for cocoa (Lernoud et al., 2018). The strong connection to the Netherlands - which was among the first governments to commit to sustainable cocoa consumption - is probably one of the reasons for this development. Apart from the Netherlands and other European Union (EU) countries, the following nine countries were important export destinations for UTZ Certified products during 2011 to 2016: Argentina, Australia, Japan, Malaysia, Mauritius, Singapore, South Africa, Thailand and the USA.[13] These countries and the EU accounted for approximately 86% of the world cocoa beans imports (UN Comtrade, 2017).

Table 2.1: Composition of cocoa grinding exports of top five grinding exporters (seven-year average, 2010-16)

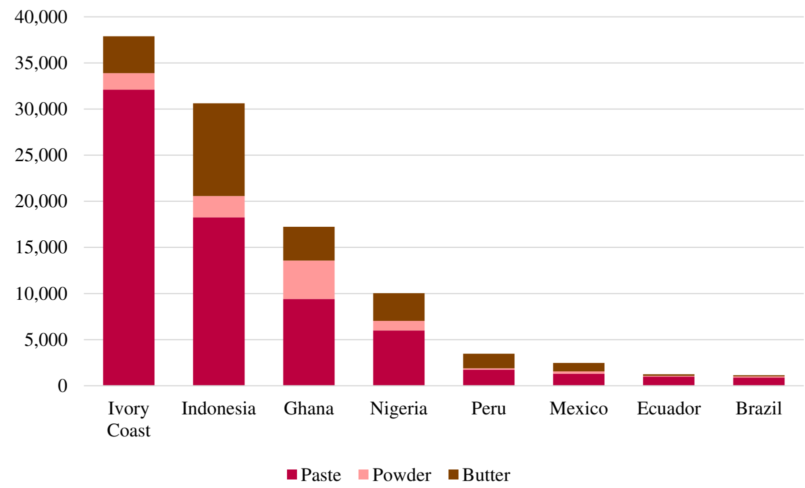
Exporter	UTZ beans (% beans production)	Grinding exports (Mio. USD)	Paste exports (% grinding exports)	Powder exports (% grinding exports)	Butter exports (% grinding exports)
Ivory Coast	25.42	1509.010	62.74	8.56	28.70
Indonesia	5.11	908.636	26.50	15.69	57.81
Ghana	13.87	720.677	56.99	15.76	27.26
Brazil	0.64	253.180	15.65	39.11	45.24
Nigeria	13.42	122.010	25.08	0.30	74.62

Source: UTZ (2015), UTZ (2016), FAOstat and UNComtrade, own calculation.

Table 2.1 shows that all five of the largest cocoa-grinding exporters also produce UTZ Certified cocoa beans. Ivory Coast and Ghana both specialise in cocoa paste exports, while the three remaining countries show a large share of cocoa butter exports. The specialisation of Nigeria, Indonesia and Brazil in cocoa butter exports can be explained by the increasing domestic demand for chocolate products in these countries, which is accompanied by investments of large international chocolate manufacturers such as Nestle, Cadbury and Mars (Talbot, 2002; Janssen and Riera, 2016; Tamru and Swinnen, 2016). The high demand for cocoa butter in the domestic market also creates incentives for cocoa grinders to upscale cocoa butter production for sales in the domestic and foreign markets.

[13]Data was provided by Phan Ha, Data analyst, Rainforest Alliance, Amsterdam, The Netherlands.

Figure 2.2: UTZ Certified paste, powder and butter on total UTZ Certified cocoa grindings, cocoa beans equivalents, tonnes (five-year average, 2012-2016)



Source: UTZ data, own elaboration.

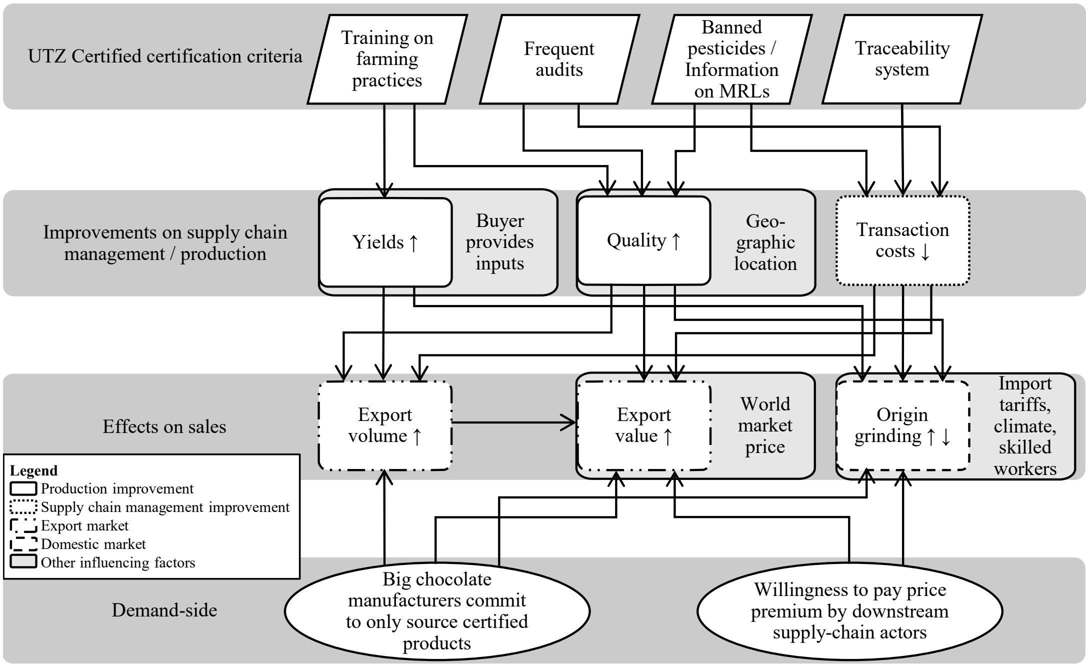
Figure 2.2 shows that eight of twenty cocoa-producing countries with UTZ Certified cocoa beans also process them into UTZ Certified cocoa grindings. Among them are all five of the largest cocoa-grinding exporters, although Brazil does not belong to the five countries producing the most UTZ Certified cocoa grindings. One factor that possibly drives this is that most Brazilian cocoa grindings exports are sent to Latin America, while UTZ Certified cocoa grindings from the other four countries mainly go to Europe.[14] They all specialised in producing UTZ Certified cocoa paste (above 50%). Indonesia, Nigeria, Peru and Mexico further process more than one-third of UTZ Certified cocoa beans into UTZ Certified butter.

2.3 The effect of voluntary sustainability standards on exports and domestic sales of cocoa beans

We want to answer two research questions in our empirical setting: How do VSSs (here UTZ Certified serves as an example) affect cocoa beans exports (RQ1)? Can we observe spill-over effects along the value chain on cocoa paste, butter and powder exports (RQ2)? In this section, we conceptualise different pathways that may moderate the effects.

[14] In the case of Indonesia, Australasia is the largest export destination, followed by Europe with a considerable quantity, on average of 94,552 tonnes cocoa grindings per year.

Figure 2.3: Simplified overview of potential pathways of the effect of VSSs on exports and domestic sales of cocoa beans



Source: own elaboration

2.3.1 Improvements in supply chain management and cocoa beans production

Figure 2.3 illustrates the channels through which VSSs may affect exports and domestic sales of cocoa beans. We identified four UTZ certification criteria that could be potential drivers for improvements in supply chain management and/or cocoa beans production.[15]

Increasing yields

Training in good agricultural practices is mandatory for certified producers; for instance, training on the correct use of agrochemicals, better soil management and fertilisation as well as fermentation and drying. Since the cocoa plant is very sensitive to pest and diseases (e.g. witches broom, frosty pod rot or cocoa pod borer (Bateman, 2015)), knowledge on their identification, prevention and control can increase cocoa yields (Deans et al., 2018). However, the empirical evidence on whether the training offered by UTZ results in increased cocoa yields is rare and

[15]We refer to the 'UTZ Certified Good Inside Code of Conduct - For Cocoa. Version 1.0' (UTZ Certified, 2009), because it was valid from 2009 to 2015 and therefore covers most of the years included in our study.

mixed. Ingram et al. (2018) find no significant increase in cocoa productivity for UTZ Certified farmers compared with non-certified farmers in Ghana, whereas in Ivory Coast such an increase was found for farmers who received additional services such as input provision. This might also explain the positive results found by Deans et al. (2018) for UTZ Certified cocoa farmers selling to Armajaro, a Licensed Buying Company (LBC) that provides inputs to its suppliers in Ghana. Sellare et al. (2020) find a significant increase of cocoa yields for Fairtrade certified farmers in Ivory Coast, but no additional effect if these farmers are Fairtrade-UTZ double certified.

Quality improvement

The proper fermentation and drying procedure of cocoa beans is an important determinant for high-quality cocoa paste and powder (Fold, 2001; Lemeilleur et al., 2015; Beg et al., 2017). Training offered by UTZ could help farmers to achieve this quality. However, geographical characteristics of the cocoa beans production location can limit the potential of quality improvements (Fold, 2001). Two other certification criteria can potentially increase the quality of cocoa beans, namely frequent audits and compliance with the list of banned pesticides. UTZ requires annual audits conducted by third-party auditors during a four-year certification cycle (UTZ Certified, 2009), whereby the auditor checks whether the farmers fulfil the critical criteria imposed by UTZ. These frequent controls can increase the consistency of the cocoa beans quality, which is especially important for large chocolate manufacturers to guarantee the specific flavour of their chocolate products (Fold, 2001; Millard, 2011). The UTZ list of banned crop protection products 2012 (UTZ Certified, 2012) included 110 pesticide components mainly based on the US, EU and Japanese legislation on MRLs which are a substantial component of the quality control at US, EU and Japanese borders (Jonfia-Essien, 2012). Therefore, compliance with the list of banned crop protection products can have a positive effect on the quality of cocoa beans export, especially to the US, EU and Japanese markets. For a more detailed discussion on the interplay of MRLs and VSSs, please see Chapter 3.

Reduction of transaction costs

Frequent audits and the list of banned crop protection products can also reduce transaction costs through several pathways. First, if a certified farmer wants to sell its cocoa beans to a new intermediary that exports to the US, EU or Japan, adjustment costs are low because the food safety requirements of these export destinations are similar to the certification requirements. Second, UTZ not only provides a list of banned crop protection products but also information on MRLs of destination markets (UTZ Certified, 2012), which reduces information costs and the risk of border rejections. Frequent audits ensure that these requirements are met and therefore they reduce the monitoring costs of supply chain actors (Banterle et al., 2013). Additionally, every UTZ Certified supply chain actor has to participate in the traceability system, which reduces the search costs of buyers because they can easily access the list of all certified producers in the region (Terlaak and King, 2006). In global and fragmented supply chains, traceability systems can substantially reduce asymmetric information because processes are standardised, transparency is increased and rapid detection of non-compliance is possible. Hereby, bargaining costs can be reduced because less complex contract structures are needed to safeguard both parties against potential fraud (Millard, 2011). However, aside from reducing asymmetric information between producers, traders, grinders, manufacturers and retailers, consumers also benefit from the additional information provided through the placement of the UTZ Certified seal on the final chocolate products (Banterle et al., 2013).

2.3.2 Effect on sales

Export volume

The above-discussed improvements in production (increasing yields and quality) and supply chain management (reduced transaction costs) can have a positive effect on the export volume. The mass balance programme of UTZ only allows mixing of conventional and certified cocoa beans if "100% of the cocoa content needed for [the final product are] covered with purchases of UTZ Certified cocoa" (UTZ Certified, 2015, p.15). Therefore, UTZ Certified cocoa processors need high quantities of certified cocoa beans to benefit from the production of certified cocoa grindings and satisfy the demand of large chocolate manufacturers (Ingram et al., 2018). Higher production quantities of certified cocoa beans give farmers the opportunity to provide sufficient supply and negotiate high-volume contracts (Fenger et al., 2017). They can expand existing trading relationships or find additional trading partners. The latter can be reinforced due to quality upgrading. Higher quality products offer the opportunity to enter new export markets. For instance, Esco Uganda Ltd - a cocoa processor, trader and exporter in Uganda - only buys cocoa beans "that had been fully fermented and properly dried" (Jones and Gibbon, 2011, p.1599). Lower transaction costs - especially through search costs - can increase the quantity sold to traders because they prefer to buy quickly following the principle of "first come - first serve" (Fold, 2001). This can increase the quantity of certified cocoa beans sold, even if they will not be processed by a certified grinder. In the situation of oversupply of certified cocoa beans, this is how certified farmers can nevertheless benefit (Fenger et al., 2017). Between 2011 and 2016, the share of UTZ Certified cocoa beans that were sold as certified increased from 20% to 54% (UTZ, 2016).

Export value

UTZ does not officially require the first buyer to pay a price premium for certified cocoa beans. Nevertheless, some supply chain actors incentivise the production of certified cocoa beans by offering a price premium to guarantee a constant supply of certified cocoa grindings and chocolate.

For instance, Ansah et al. (2020) ascertain that the local LBCs in Ghana negotiate price premiums with cocoa processors even before starting the certification process. This is also confirmed by Deans et al. (2018), who find that Armajaro - a Ghanaian LBC - receives price premiums at the world market for certified cocoa beans and partially passes it on to its producers. Moreover, Borsky et al. (2018) highlight that in the case of VSSs, the sustainable product quality effect (supply side) and preferences of consumers for sustainable products (demand side) play a crucial role in increasing export values.
Additionally, we could expect higher export values resulting from quality upgrading and lower transaction costs. Many cocoa processors have developed technologies that enable them to produce good quality grindings out of low-quality cocoa beans, and thus they are unwilling to pay a price premium for high-quality cocoa beans. Nevertheless, some processors are willing to pay a price premium if the manufacturing cost reduction through the use of high-quality beans is higher than the additional price premium they have to pay for high-quality cocoa beans (Fold, 2001; Lemeilleur et al., 2015). Some buyers pay a price premium for certified products to compensate producers for their additional costs, e.g. costs for external auditing, while benefiting from lower monitoring costs (Millard, 2011; Rueda and Lambin, 2013). Evidence on paid price premiums to UTZ Certified farmers remains mixed. Deans et al. (2018) show that UTZ Certified farmers generate on average an income of 355 USD per hectare of cocoa beans compared with only 217 USD for conventional farmers. In the study conducted by Marie-Vivien et al. (2014), UTZ Certified coffee farmers received a small price premium, albeit which was not sufficient to cover certification costs, which were fully paid by traders. Vanderhaegen et al. (2018) and Snider et al. (2017) confirm these results. Comparing six voluntary coffee certification schemes in Costa Rica, Snider et al. (2017) find the lowest price premium for UTZ Certified coffee and when world market prices are high buyers are hardly willing to pay the price premium.
Not only the per unit price will increase a country's export value, but also an overall increase in the export volume, as discussed above. Taking this and all discussed potential improvements on production and supply chain management through requirements of VSSs into account, we posit the following hypothesis:

> *H1:* A country's export value of cocoa beans increases if a higher volume share of cocoa beans among total cocoa beans is certified.

Origin grinding

The improvements in production and supply chain management can not only increase sales of cocoa beans to foreign markets but also domestic markets. The quality and flavour of cocoa grindings can vary by cocoa bean variety. Cocoa grinders are dependent on high quantities of cocoa beans with the same quality. Higher certified quantities of cocoa beans in a producing country increase the probability that a cocoa grinder sets up a factory in the same country (Fold, 2001). Quality upgrading - especially through correct drying and fermentation of certified cocoa beans - reduces the risk of cocoa beans being rejected for grinding and therefore increases the

origin grinding volume (Beg et al., 2017). The UTZ traceability system not only helps domestic grinders to find suppliers but it also helps - once they have received CoC certification - to find potential chocolate manufacturers to export to. This especially facilitates market access for local firms that have low export experience compared with the large transnational cocoa processors (Talbot, 2002).
The commitment by chocolate manufacturers to sourcing only certified cocoa products increases supply risk because supply shortages cannot be compensated by uncertified cocoa beans (Millard, 2011). This provides an additional incentive for origin grinding because it shortens the supply chain and thereby supply risk. As discussed above, another way to incentivise a constant supply of certified products is to pay a price premium. Price premiums paid by chocolate manufacturers for certified cocoa powder, butter and paste can create net benefits in otherwise non-profitable origin grinding locations. Fold (2001) highlights four factors that might make origin grinding unprofitable and could be compensated by a price premium. First, cocoa grinders located in humid regions have to invest in specific facilities that prevent cocoa products from mould and other bacterial problems that would lead to the rejection of the product, especially at the EU border. Second, contrary to cocoa bean production, cocoa grinding is capital-intensive and requires skilled workers who can be scarce in some cocoa-producing countries. Third, cocoa butter is usually shipped in solid form, which requires an additional processing step by the chocolate manufacture before it can be processed into chocolate. Fourth, the cocoa market faces the problem of tariff escalation, i.e. the higher the processing level of the cocoa product, the higher the import tariff. However, in recent years major importing regions such as the EU and the USA have provided preferential market access to Least Developed Countrys (LDCs) or African, Caribbean and Pacific (ACP) countries through the Generalized System of Preferences (GSP) or the European Partnership Agreements (EPAs) (Fold, 2001; Mohan et al., 2013). We therefore hypothesise:

> *H2:* A country's export value of cocoa grindings increases if a higher volume share of cocoa beans among total cocoa beans is certified.

2.4 Model specification and data

2.4.1 Gravity model

An extended gravity model is used to estimate the effects of UTZ Certified cocoa beans production on cocoa beans and cocoa-grinding exports. In recent decades, the gravity model of trade has become the most popular model to ex-post analyse trade policy effects. Recently, it has also been preferably used by agricultural economists to analyse the effect of private food standards on agricultural trade flows (e.g. Andersson, 2019; Ehrich and Mangelsdorf, 2018; Fiankor et al., 2019). The traditional log-linearised form of the gravity model looks as follows:

$$\ln X_{ijt} = \ln E_{jt} + \ln Y_{it} - \ln Y_t + (1-\sigma)\ln\tau_{ijt} - (1-\sigma)\ln P_{jt} - (1-\sigma)\ln\Pi_{it} + \epsilon_{ijt} \quad (2.1)$$

where X_{ijt} denotes export values (in current USD) from country i to country j in year t. To proxy the importer purchasing power, the nominal Gross Domestic Product (GDP) of country j in year t (E_{jt}) is included. Y_{it} is usually the GDP of country i, which proxies the exporting country i's supply potential. We instead include agricultural value added (in current USD), because we argue that it is a good proxy for a country's agricultural supply capacity. Y_t is the aggregated worldwide supply and σ_t is the elasticity of substitution. $\epsilon_{ij,t}$ are robust standard errors clustered at the country-pair level. Π_{it} and P_{jt} are the outward and inward multilateral resistance terms, respectively, which control for the remoteness of the trading partners. Controlling for multilateral resistance is crucial because not only distance to trading partners matters but also the distance to all other potential trading partners. Thus, trade flows are not only affected by absolute but also relative trade barriers (Anderson and van Wincoop, 2003). However, the multilateral resistance terms are not observable. A common approach to account for them in a panel dataset is to use exporter-time and importer-time fixed effects (Feenstra, 2004). τ_{ijt} are trade costs, which we define as the following log-linear function:

$$\begin{aligned}\ln\tau_{ijt} =& \beta_1 \text{UTZ volume share}_{it} + \beta_2 \text{Export procedures}_{it} + \beta_3 \text{RTA}_{ijt} \\ &+ \beta_4 \ln(1+\text{Tariff}_{ijt})\end{aligned} \quad (2.2)$$

We include our variable of interest - *UTZ volume share*$_{it} \in [0, 100]$ - in our trade-cost function because we argue that a higher share of certified cocoa beans among the total cocoa beans production volume reduces transaction costs and thereby trade costs (see Section 2.3). As we are unable to include exporter-time fixed effects because they would absorb all variation in our variable of interest, we add the variable *Export procedures*$_{it} \in [0, 100]$ to control for other time-variant exporter-specific trade costs. Specifically, it is a score value that captures the ease of trading across borders and includes e.g. the time to export and costs to export. Time-varying bilateral trade costs are proxied by $Tariff_{ijt}$ and RTA_{ijt}. $Tariff_{ijt}$ is the applied tariff rate charged by country j on imports from country i in year t. RTA_{ijt} is a binary variable that takes the value one if both countries are members of the same Regional Trade Agreement (RTA) and zero otherwise.

2.4.2 Estimation issues

We face two major estimation issues. First, as discussed above, our variable of interest is exporter-time-specific and would be absorbed by exporter-time fixed effects when controlling for outward multilateral resistance (dependence of country i's exports to country j on trade costs across all possible export destinations). Therefore, we only include exporter-fixed effects in our cocoa beans and exporter-product-fixed effects in our cocoa-grinding model specifications. This might lead to a potential bias in our trade-cost estimates because the omitted terms are correlated with the trade-cost term (Baldwin and Taglioni, 2007). This has to be considered when interpreting the results. However, we argue that this bias is small because we include the variable *Export procedures*$_{it}$, which captures most of the outward multilateral resistance. Furthermore, most importers did not change their trade measures regarding cocoa products during our period of study and this time-invariant outward multilateral resistance is captured by exporter-fixed effects.

Second, agricultural trade data contains many zeros or missing trade flows. This dataset contains 79.6% and 86.0% observations with zero trade value for cocoa beans trading partners and cocoa-grinding trading partners, respectively. Furthermore, trade data suffers from heteroskedasticity due to Jensen's inequality. To account for both, we use the Poisson Pseudo Maximum Likelihood (PPML) estimator, which allows us to estimate the non-linear form of the gravity equation and include zero trade flows.[16]

We insert Equation 2.2 into Equation 2.1, include fixed effects to account for multilateral resistance and estimate the multiplicative form of the received equation, as suggested by Santos Silva and Tenreyro (2006):

$$\begin{aligned} X_{ijt} =& \exp(\pi_i + \eta_{jt} + \theta_{ij} + \beta_0 + \beta_1 \text{UTZ volume share}_{it-1} + \beta_2 \text{ln Agricultural GDP}_{it} \\ & + \beta_3 \text{Export procedures}_{it} + \beta_4 \text{RTA}_{ijt} + \beta_5 \text{ln(1+Tariff}_{ijt}))\epsilon_{ijt} \end{aligned} \tag{2.3}$$

where π_i denotes exporter-fixed effects, θ_{ij} country-pair fixed effects and η_{jt} importer-time fixed effects. The latter not only control for inward multilateral resistance, but also for other time-variant importer-specific factors such as purchasing power and unilateral non-tariff measures. We use a one-year lag of the variable *UTZ volume share*$_{it-1}$ in the model specification to overcome endogeneity due to reverse causality. As discussed in Section 2.3, certification might increase trade flows. At the same time, exporters that have strong trading relationships with destinations that require certification might be more likely to become certified. By using the lag of *UTZ volume share*, we are able to avoid reverse causality because current trade relationships cannot influence previously-certified cocoa production quantity. In order to estimate the time-invariant part of the variables RTA_{ijt} and $Tariff_{ijt}$, we re-estimate model specification 2.3 while excluding country-pair fixed effects and adding observable time-invariant bilateral trade costs:

$$\begin{aligned} X_{ijt} =& \exp(\pi_i + \eta_{jt} + \beta_0 + \beta_1 \text{UTZ volume share}_{it-1} + \beta_2 \text{ln Agricultural GDP}_{it} \\ & + \beta_3 \text{Export procedures}_{it} + \beta_4 \text{RTA}_{ijt} + \beta_5 \text{ln(1+Tariff}_{ijt}) + \beta_6 \text{ln Distance}_{ij} \\ & + \beta_7 \text{Contiguity}_{ij} + \beta_8 \text{Language}_{ij})\epsilon_{ijt} \end{aligned} \tag{2.4}$$

where $Distance_{ij}$ measures the population-weighted distance[17] between country i and country j. $Language_{ij}$ and $Contiguity_{ij}$ are binary variables that take the value one if both countries speak the same language or share a common border, respectively. Equations 2.3 and 2.4 describe

[16] For a detailed discussion of the advantages and disadvantages of the PPML estimator, see Santos Silva and Tenreyro (2006).

[17] This variable is time-invariant because the Centre d'Etudes Prospectives et d'Informations Internationales (CEPII) dataset uses population data from 2004 to weight bilateral distances and applies it to all following years.

our one-product model specifications for raw cocoa beans exports.
As discussed before, we also want to estimate the effect for cocoa-grinding exports that comprise cocoa paste, cocoa powder and cocoa butter. Therefore, we include product-specific tariff rates, exporter-product fixed effects, country-pair-product and importer-product fixed effects. To account for possible product heterogeneity, we estimate a model specification in which we interact product dummies (i.e. cocoa powder and cocoa butter) with the $UTZ\ volume\ share_{it-1}$ variable. The resulting estimation equation is:

$$\begin{aligned} X_{ijkt} =& \exp(\lambda_{ik} + \psi_{jkt} + \gamma_{ijk} + \beta_0 + \beta_1 \text{UTZ volume share}_{it-1} + \beta_2 \text{UTZ volume share}_{it-1} \\ & * \text{Powder dummy}_k + \beta_3 \text{UTZ volume share}_{it-1} * \text{Butter dummy}_k \\ & + \beta_4 \text{ln Agricultural GDP}_{it} + \beta_5 \text{Export procedures}_{it} + \beta_6 \text{RTA}_{ijt} \\ & + \beta_7 \text{ln(1+Tariff}_{ijkt}))\epsilon_{ijkt} \end{aligned} \tag{2.5}$$

where λ_{ik}, ψ_{jkt} and γ_{ijk} are exporter-product, importer-product-time and country-pair product fixed effects, respectively. ϵ_{ijkt} are standard errors clustered at the country-pair-product level.

2.4.3 Two-step procedure

Finally, to check the robustness of our results to the choice of fixed effects, we apply the two-step procedure suggested by Head and Mayer (2014). In the first stage, we re-estimate model specification 2.3 but include exporter-time fixed effects to control for outward multilateral resistance. These absorb all exporter-time varying variables (including our variable of interest) and only RTA_{ijt} and $ln(1 + Tariff_{ijkt})$ remain to be estimated:

$$X_{ijt} = \exp(\phi_{it} + \eta_{jt} + \theta_{ij} + \beta_0 + \beta_1 \text{RTA}_{ijt} + \beta_2 \text{ln(1+Tariff}_{ijt}))\epsilon_{ijt} \tag{2.6}$$

where ϕ_{it} are exporter-time fixed effects. We save the predicted exporter-time fixed effects from estimation 2.6 and regress them on $UTZ\ volume\ share_{it-1}$ and the remaining exporter-time-varying controls to assess their impact on the exporter's market access. To control for other time-invariant exporter-specific confounding factors, we also include exporter-fixed effects. The second-stage estimation takes the following form:

$$\begin{aligned} \widehat{\phi_{it}} =& \pi_i + \beta_0 + \beta_1 \text{UTZ volume share}_{it-1} + \beta_2 \text{ln Agricultural GDP}_{it} \\ & + \beta_3 \text{Export procedures}_{it} + (\kappa_{it} + \nu_{it}) \end{aligned} \tag{2.7}$$

where ν_{it} is the error contained in $\widehat{\phi_{it}}$ from the first-stage regression and κ_{it} is the error term from the second-stage regression.

2.4.4 Data

The dataset provided by UTZ covers the period from 2010 until 2016. Since we use the lag of certified cocoa beans, we include bilateral imports in current USD of cocoa beans (HS 1801), cocoa paste (HS 1803), cocoa butter (HS 1804) and cocoa powder (HS 1805) for 2011 until 2017 retrieved from the UN Comtrade database - at the four-digit level of the Harmonised System (HS)-2007 classification. We include 42 cocoa bean-producing countries[18] as exporters and the 38 largest importers[19] according to their average import value of cocoa beans during the study period from 2011 to 2017 (see Table 2.A.1 and Table 2.A.2 for an overview of all exporting and importing countries considered in this chapter). Thus, the raw dataset contains N = 11,088 observations (excluding intranational trade). We exclude eight exporters from our cocoa-grinding analysis because they neither produce nor export any types of cocoa grindings. Therefore, our raw dataset for cocoa grinding contains N = 26,880 observations (excluding intranational trade). The final datasets reduce to N = 3,733 and N = 6,611 because we exclude all observations that are either singletons or separated by a fixed effect.

Data for agricultural value added in current Mio. USD and Ease of Doing Business indicators were retrieved from the World Bank. Cocoa beans production data was taken from FAOstat. Data on applied tariff rates at the four-digit level of the HS 2007 classification was downloaded from the United Nations Conference on Trade and Development (UNCTAD) Trade Analysis Information System (TRAINS). Following Fernandes et al. (2015), we interpolate observations to fill in missing tariffs. For cases where applied tariff data is not available for a given importer-exporter-time combination, we replace the missing values with Most Favoured Nation (MFN) tariffs of the corresponding importer-time combination or with preferential tariffs of the given importer-exporter-time combination if they have a preferential tariff agreement. We replace the remaining missing values with the value of the closest non-missing year. The time-invariant bilateral standard gravity covariates - distance, common border and common language - were obtained from the CEPII website (Head et al., 2010; Head and Mayer, 2014). Furthermore, data on RTAs was obtained from Mario Larch's Regional Trade Agreements Database from Egger and Larch (2008). See Table 2.2 for descriptive statistics of the data used.

Table 2.2: Descriptive Statistics

	Cocoa beans				Cocoa grindings			
	Mean	Std. Dev.	Min.	Max.	Mean	Std. Dev.	Min.	Max.
Export value (Mio. USD)	5.56	69.01	0	2497.20	1.00	14.10	0	649.30
UTZ Certified volume share (%)	5.38	13.29	0	69.68	6.56	14.48	0	69.68
Log (1+Tariff)	0.97	1.19	0	3.61	1.60	1.19	0	3.61
Log Agricultural GDP (Mio. USD)	7.84	2.23	3.30	12.93	8.38	2.04	3.55	12.93
Export procedures (Index 1-100)	64.08	16.40	9.37	92.09	65.85	15.17	15.99	92.09
Log Distance (weighted, km)	8.99	0.66	5.31	9.89	8.98	0.69	5.31	9.89
RTA	0.25		0	1	0.31		0	1
Common Language	0.20		0	1	0.21		0	1
Contiguity	0.02		0	1	0.02		0	1
Observations	11088				26880			

Notes: The standard deviation for dummy variables is not reported since it is one-to-one mapping of the mean.

[18]The following ten producers are excluded due to limited data availability: Guadeloupe, Micronesia, Timor-Leste, Solomon Islands, Cuba, the Democratic Republic of Congo, Sierra Leone, American Samoa, Vanuatu and Venezuela. Following Ferro et al. (2015) we also exclude the following five producers because they only exported to one destination: Angola, Central African Republic, Comoros, Guyana, Saint Vincent and the Grenadines and Suriname. Additionally, we exclude Malaysia, because although it is still producing cocoa beans it became a net importer of cocoa beans (Fold and Neilson, 2016).

[19]We include the EU27 as one country.

2.5 Results and discussion

This section shows the estimation results from equations 2.3- 2.7 and discusses their interpretation. We computed the regression coefficients using the statistical software StataSE 15 and the user-written command ppmlhdfe version 2.0.1 05mar2019 (Correia et al., 2019). Ordinary Least Squares (OLS) estimates are generated using the command xtreg.

2.5.1 Effects on cocoa beans exports

Table 2.3: The effect of voluntary sustainability standards on cocoa beans exports

	(1)	(2)
Estimation method	ppml	
Dependent variable	Export value	
UTZ volume share$_{it-1}$	0.012***	0.013***
	(0.003)	(0.004)
Log Agricultural GDP$_{it}$	−0.168	−0.316
	(0.180)	(0.303)
Export procedures$_{it}$	0.005**	0.005*
	(0.002)	(0.003)
RTA$_{ijt}$	0.055	0.341**
	(0.087)	(0.140)
Log (1+Tariff$_{ijt}$)	0.124	−0.069
	(0.098)	(0.207)
Log Distance$_{ij}$		−1.166***
		(0.155)
Common Language$_{ij}$		−0.331
		(0.281)
Contiguity$_{ij}$		0.353
		(0.419)
Observations	3,733	
RESET test (p-value)	0.337	0.009

Notes: Standard errors are clustered at the country-pair level in parentheses; The estimation in column (1) includes exporter, importer-time and country-pair fixed effects; The estimation in column (2) includes exporter and importer-time fixed effects; *** p<0.01, ** p<0.05, * p<0.1; Intercepts included but not reported.

Table 2.3 shows parameter estimates from the PPML model specifications (see Equations 2.3 and 2.4). It allows us to answer our first research question: How do UTZ Certified cocoa beans affect cocoa beans exports? The results for model specification 2.3 are shown in column (1). The variables RTA_{ijt} and *Export procedures*$_{it}$ show the expected positive sign, although only the latter has a statistically significant effect. Bilateral export values increase when both trading partners are members of an RTA or the ease of trading across borders in the exporting country is high. Specifically, if the exporter's trading across borders score increases by one point, cocoa beans export values increase on average by 0.5%. We find that tariffs and agricultural value added have no statistically significant trade effect. To check whether these results remain once we also estimate the time-invariant part, we estimate model specification 2.4. Column (2) shows the results and reveals the expected trade-impeding effect of applied tariffs. The directional effects of the other variables remain the same. Nevertheless, column (1) is our preferred model specification and we will return to interpret these estimates in more detail because the model specification in column (2) does not pass the RESET test (p-value < 0.01). Another unexpected result is the negative but statistically insignificant effect of agricultural value added on cocoa beans export values, this suggests that this variable might not adequately reflect the supply-side capacity of cocoa beans.[20] Ideally, we would have used cocoa beans production quantity, but as we already use it to rescale our variable of interest (UTZ Certified cocoa beans) it would have caused multicollinearity issues and makes interpretation difficult.

Our variable of interest - *UTZ volume share*$_{it-1}$ - shows the expected trade-enhancing effect ($\beta_1 > 0$) and is statistically significant at the 1% level. Specifically, a one percentage point increase in the share of UTZ Certified cocoa beans among total cocoa beans production increases cocoa beans export values on average by 1.2%. This result confirms our first hypothesis, namely that a country's export value of cocoa beans increases if a higher volume share of cocoa beans among total cocoa beans is certified.

2-stage estimation results

Table 2.4: Two-stage estimation results

	(1)	(2)
Estimation method	ppml (1st stage)	OLS (2nd stage)
Dependent variable	Export value	Exporter-year fixed effects
UTZ volume share$_{it-1}$		−0.0003
		(0.0038)
Log Agricultural GDP$_{it}$		0.237
		(0.560)
Export procedures$_{it}$		−0.010
		(0.008)
RTA$_{ijt}$	0.219*	
	(0.119)	
Log (1+Tariff$_{ijt}$)	−0.084	
	(0.102)	
Observations	3,733	294

Notes: Standard errors in column (1) are clustered at the country-pair level and in column (2) at the country level in parentheses; The estimation in column (1) includes exporter-time, importer-time and country-pair fixed effects; The estimation in column (2) includes exporter-fixed effects; *** p<0.01, ** p<0.05, * p<0.1; Intercepts included but not reported.

[20] Other proxies of supply-side capacity - i.e. exporter's GDP or exporter's GDP per capita - showed the same pattern.

As discussed in Section 2.4.1, model specification 2.3 does not allow us to control for outward multilateral resistance, and therefore we apply a two-step procedure (see Equations 2.6 and 2.7). The results for the first stage are shown in column (1) of Table 2.4. The coefficients show the expected signs. The second-stage results shown in column (2) do not confirm the trade-enhancing effect of UTZ Certified cocoa beans.

2.5.2 Effects on cocoa-grinding exports

Table 2.5: The effect of voluntary sustainability standards on cocoa-grinding exports

	(1)	(2)
Estimation method	ppml	
Dependent variable	Export value	
UTZ volume share$_{it-1}$	0.006	0.020***
	(0.004)	(0.005)
Powder dummy$_k$*UTZ volume share$_{it-1}$		−0.018**
		(0.008)
Butter dummy$_k$*UTZ volume share$_{it-1}$		−0.024***
		(0.008)
Log Agricultural GDP$_{it}$	−0.067	−0.041
	(0.281)	(0.272)
Export procedures$_{it}$	0.006**	0.004*
	(0.003)	(0.003)
RTA$_{ijt}$	0.099	0.114
	(0.112)	(0.114)
Log (1+Tariff$_{ijkt}$)	−0.145	−0.189
	(0.167)	(0.167)
Observations	6,611	
RESET test (p-value)	0.052	0.929

Notes: Standard errors are clustered at the country-pair-product level in parentheses; All estimations include exporter-product, importer-product-time and country-pair-product fixed effects; *** p<0.01, ** p<0.05, * p<0.1; Intercepts included but not reported.

To answer our second research question - Can we observe spill-over effects of UTZ Certified cocoa beans along the value chain on cocoa grindings? - we estimate our model specifications 2.3 and 2.5 with cocoa grinding (paste, powder and butter) export values as the dependent variable, product-specific tariffs, exporter-product fixed effects, country-pair-product and importer-product fixed effects. The results are shown in Table 2.5. Column (1) presents our results from the baseline model including country-pair-product fixed effects. The ease of trading across borders also plays a significant role in the case of cocoa grindings. A one unit increase in the trading across borders score increases exports of cocoa grindings on average by 0.6%. All other control variables do not have a statistically significant effect, but RTA_{ijt} and $Tariff_{ijkt}$ show the expected positive and negative signs, respectively. The insignificance of the estimated coefficient for tariffs is unsurprising. As already argued above, the inclusion of country-pair-product fixed effects absorbs most of the variation in tariffs. Not controlling for country-pair-product fixed effects yields significant coefficients for tariffs and increases their magnitude (see Appendix Table 2.A.3).

The positive coefficient of *UTZ volume share*$_{it-1}$ in column (1) confirms our second hypothesis, namely that a country's export value of cocoa grindings increases if a higher volume share of cocoa beans among total cocoa beans is certified, but it is not statistically significant at any conventional level. To check for product heterogeneity of this effect, we interact the variable with product dummies for cocoa powder and butter. The results are shown in column (2). We use cocoa paste as the base category because it is the product obtained from the first cocoa-grinding step.[21] Model specification 2.5 reveals the statistically significant heterogeneous product effect of *UTZ volume share*$_{it-1}$ on cocoa-grinding exports. Specifically, a one percentage point increase of the share of UTZ Certified cocoa beans among total cocoa beans production increases the export value of cocoa paste on average by 2%. However, this trade-enhancing effect reduces to 0.2% ($\hat{\beta}_1 + \hat{\beta}_2 *$ Powder dummy$_k$) in the case of cocoa powder and even turns negative (-0.4%) for cocoa butter. To check the robustness of our results, we split the sample by product group and use the one-product model specifications 2.3 and 2.4 to estimate the effect of *UTZ volume share*$_{it-1}$ for each cocoa-grinding product separately (see Table 2.A.4 in the Appendix). The results confirm the positive effect of UTZ Certified cocoa beans on cocoa paste exports. Moreover, the coefficient estimates for cocoa powder and butter show the same signs as in Table 2.5 column (2), but are insignificant.

2.5.3 Discussion

The results shown in Table 2.3 confirm the expected positive trade effect of UTZ Certified cocoa beans. However, applying the two-step procedure (see Equations 2.6 and 2.7) no longer yields any positive significant effect. One possible reason might be that we lose our bilateral data structure and are only able to estimate the effect on the exporters' market access, assuming that it is equal for all trading partners. As discussed in Section 2.3, the trade effect of UTZ certification is not only determined by the supply side but also by import demand. Kinzius et al. (2019) highlight that including all importers as treated leads to an underestimation of the treatment effect. Furthermore, the second-stage results only show how UTZ Certified cocoa beans affect outward multilateral resistance. We argue that in the case of cocoa beans trade, this type of multilateral resistance only plays a minor role because the production of cocoa is concentrated in the Global South and these exporters face low trade costs in most import regions. A trade policy change for a bilateral country-pair might have a low impact on all other exporters.

Turning to our results shown in Table 2.5, the stronger positive effect of UTZ certification on cocoa paste exports than cocoa powder and butter is unsurprising. Cocoa paste accounts for by far the largest share of certified cocoa grindings, ranging from 50% to 85%, followed by cocoa

[21] Cocoa butter - as well as cocoa cake - is extracted through the hydraulic pressing of cocoa paste. Cocoa powder is produced as a by-product during this second grinding step.

butter (11% - 46%) and cocoa powder (4% - 24%). As shown in Table 2.1, among the five largest cocoa-grinding exporters are countries with a relatively low UTZ Certified cocoa beans production share (<13.5%) specialised in exports of cocoa butter, while large UTZ Certified countries like Ivory Coast and Ghana mainly export cocoa paste (>50% of grinding exports).
Product-specific characteristics may explain these differences. Cocoa paste is the first grinding step and it can be either directly sold to a chocolate manufacturer or further processed into cocoa butter and powder (ITC, 2001). The quality of cocoa paste is an important purchase criterion for chocolate manufacturers and the potential quality-improving effect of certification - as discussed in Section 2.3.1 - could therefore enhance cocoa paste exports. Local processing plants might specialise in the production of cocoa paste only, e.g. FINMAC in Costa Rica (Haynes et al., 2012), because it is less sophisticated and less capital-intensive than the production of cocoa butter (ITC, 2001). Certification can increase the chance of local firms with low export experience to enter export markets (see Section 2.3.2).
Furthermore, chocolate manufacturers are the largest buyers of certified cocoa products and they mostly demand cocoa paste and butter, whereas the demand for certified cocoa powder - which is mainly used to produce drinking chocolates or bakery products - is rather low. Another factor that might explain the results is the transport requirements. Cocoa butter is usually transported in liquid form and very costly over a long distance. Therefore, for long distances, cocoa butter is shipped as a solid substance and requires an additional processing step once it arrives at the chocolate manufacturer's factory. The potential price premium for certified cocoa butter might be undone by these additional costs. Besides, the quality of cocoa butter depends less on the quality of the cocoa beans than cocoa paste or powder, which might reduce chocolate manufacturers' willingness to pay a price premium for quality (Fold, 2001). Besides chocolate manufacturers, the pharmaceutical and cosmetic industry is another large buyer of cocoa butter, which barely demands certified products.
Other time-varying country-specific trade characteristics might reinforce the negative effect of UTZ Certified cocoa beans on cocoa butter exports. Indonesia and Brazil - two of the five largest cocoa-grinding exporters that specialised in cocoa butter (see Table 2.1) - export most cocoa butter to the EU and Northern America but also a large share to countries in Latin America and Asia[22] that do not demand UTZ certification (UN Comtrade, 2017).

2.5.4 Limitations

We face three main limitations concerning the data used. First, given that we do not have data on certified trade flows, we use total cocoa trade flows (which include certified and uncertified cocoa products). This might lead to an upward bias of our results, if countries with a high share of certified cocoa beans in reality export only few certified cocoa products to their major trading partners, and vice versa. At present, the exact data of UTZ Certified export flows is not available.

[22]Data on importers of UTZ Certified products was provided by Phan Ha, Data analyst, Rainforest Alliance, Amsterdam, The Netherlands.

Second, we do not have country-specific data on the overall production quantity of cocoa paste, powder and butter. We are unable to calculate the share of certified cocoa grindings among total cocoa grinding production. Thus, we use the share of certified cocoa beans and assume that certified cocoa beans are processed to the same extent as uncertified cocoa beans. In reality, cocoa farmers are sometimes unable to sell their cocoa beans as certified, which results in a lower share of certified cocoa beans being processed into certified cocoa grindings. In the case of UTZ Certified, on average only 41% of certified cocoa beans production quantity during the study period (2011-2016) was sold as certified (UTZ, 2016). This might lead to an upward bias in our results.

Third, we do not have data on multiple certifications, so we cannot control for additional effects caused by other certification schemes. In 2015, 13% of cocoa certificates were multiply certified, of which 58% were a combination of UTZ Certified and Rainforest Alliance Certified. The highest concentration of multiple certified cocoa certificates was found in Peru (43%), while all other countries showed a concentration rate of multiple certifications lower than 20% (ISEAL Alliance, 2018). Since UTZ and Rainforest Alliance require similar certification criteria and Peru neither belongs among the five largest cocoa beans exporters nor cocoa-grinding exporters, we only expect a low bias from double certification in our dataset.

2.6 Conclusion

With growing global demand for ethically- and sustainably-produced cocoa products by consumers and chocolate manufacturers, VSSs are becoming increasingly important. Nonetheless, their effect on international trade flows - especially on processed goods - remains unclear. This chapter has analysed the trade effect of one of the leading certification schemes in the cocoa sector, UTZ Certified. We not only studied the effect on raw cocoa beans but also on the different cocoa grindings, namely cocoa paste, cocoa powder and cocoa butter to find possible spill-over effects along the supply chain.

Our results show that UTZ certification enhances the export values of cocoa beans and paste. This confirms our first hypothesis, namely that a country's export value of cocoa beans increases if a higher volume share of cocoa beans among total cocoa beans is certified. Our second hypothesis that a country's export value of cocoa grindings increases if a higher volume share of cocoa beans among total cocoa beans is certified is only confirmed for first-stage grindings, i.e. cocoa paste. We find mixed and negative trade effects for second-stage cocoa grindings, cocoa powder and cocoa butter, respectively, which can be partially explained due to product- and country-specific characteristics.

This emphasises the need for further support for certified origin grinding - especially for second-stage grinding - to enable value-chain upgrading in the country of origin. As previously discussed, only eight out of twenty countries that produce UTZ Certified cocoa beans also host certified cocoa grinders. If there is no certified grinder in the country, the production of certified grindings is impossible. A first step could be to create incentives for Foreign Direct Investment (FDI) by certified grinders in the cocoa-producing countries, e.g. by providing tax incentives to companies with certification. Similar strategies have been successfully applied by Nigeria and Ghana to attract FDI in the area of cocoa processing, albeit without differentiating between certified and uncertified investors (Langan and Price, 2020). However, this strategy may suppress domestic firms. Second, importing regions could set a demand-side incentive by lowering the tariff rate for certified cocoa grindings. A similar procedure is described by Marx (2018), who proposes that certified imports receive a lower tariff compared with non-certified imports under the EU GSP scheme. A stricter procedure is already in place under the EU Forest Law Enforcement Governance and Trade (FLEGT) action plan, which only allows timber products that are proven to be legally produced - e.g. by a VSS - to enter the EU market (Overdevest and Zeitlin, 2014). Third, the standard-setting organisation could require a price premium that has to be paid by the chocolate manufacturer to the certified cocoa grinder. Accordingly, cocoa grinders could compensate for the extra costs that they incur due to audit costs and the UTZ programme fee that they have to pay per metric tonne of UTZ Certified cocoa beans (UTZ, 2019).

Our macroeconomic model has a pure focus on trade at the country level and we are unable to identify which supply chain actors gain from certification. In addition, we face several data limitations as discussed in Section 2.5.4 which should be overcome in future analyses. Moreover, empirical studies focusing on other food products and other VSSs are needed to provide more general conclusions on the trade effects of VSSs along the supply chain. These results are especially important for policy-makers for decisions regarding the further support or regulation of VSSs.

2.A Appendix

Table 2.A.1: Exporting countries

UTZ Certified exporter	Non-UTZ Certified exporter	
Brazil	Belize	Sao Tome and Principe[1]
Cameroon	Bolivia	Sri Lanka
Colombia	Congo	Thailand
Costa Rica	Dominica	Trinidad and Tobago
Dominican Republic	El Salvador	
Ecuador	Equatorial Guinea	
Ghana	Fiji	
Indonesia	Gabon	
Ivory Coast	Grenada	
Liberia[2]	Guatemala	
Mexico	Guinea	
Nicaragua	Haiti	
Nigeria	Honduras	
Panama	India	
Papua New Guinea[4]	Jamaica	
Peru	Madagascar	
Tanzania, United Rep. of	Philippines	
Togo[3]	Saint Lucia[2]	
Uganda	Samoa[4]	

Notes: UTZ Certified exporter refers to a country that at least had one farmer certified during the whole study period from 2011 to 2016. Countries in italics produced UTZ Certified cocoa grindings at least once between 2011 and 2016. All countries also export all kinds of cocoa grindings, unless they are marked with a number referring to the type of grindings that a country exports: (1) only paste, (2) only powder, (3) no paste, (4) no butter.

Table 2.A.2: Importing countries

UTZ importer	Non-UTZ importer		
Argentina	Algeria	El Salvador	New Zealand
Australia	Armenia	Guatemala	Nigeria
EU27	Belarus	India	Norway
Japan	Bosnia and Herzegovina	Indonesia	Peru
Malaysia	Brazil	Iran	Russian Federation
Singapore	Canada	Israel	Sri Lanka
South Africa	China	Kazakhstan	Tunisia
Switzerland	Colombia	Korea	Turkey
Thailand	Costa Rica	Mexico	Ukraine
United States of America	Croatia		

Notes: UTZ importer refers to countries that imported at least one UTZ Certified cocoa product during the 2011 to 2016 period. All countries listed also imported all type of processed cocoa products.

Table 2.A.3: Robustness check: The effect of UTZ Certified on cocoa-grinding exports without country-pair fixed effects

	(1)	(2)
Estimation method	ppml	
Dependent variable	Export value	
UTZ volume share$_{it-1}$	0.001	0.021***
	(0.004)	(0.005)
Powder dummy$_k$*UTZ volume share$_{it-1}$		−0.023***
		(0.009)
Butter dummy$_k$*UTZ volume share$_{it-1}$		−0.033***
		(0.008)
Log Agricultural GDP$_{it}$	−0.198	−0.147
	(0.290)	(0.270)
Export procedures$_{it}$	0.006*	0.004
	(0.003)	(0.003)
RTA$_{ijt}$	0.156	0.188
	(0.143)	(0.146)
Log (1+Tariff$_{ijkt}$)	−0.722***	−0.741***
	(0.131)	(0.132)
Log Distance$_{ij}$	−0.988***	−0.976***
	(0.158)	(0.156)
Common Language$_{ij}$	0.185	0.173
	(0.247)	(0.244)
Contiguity$_{ij}$	1.314***	1.305***
	(0.383)	(0.381)
Observations	6,611	
RESET test (p-value)	0.197	0.225

Notes: Standard errors are clustered at the country-pair-product level in parentheses; All estimations include exporter-product and importer-product-time fixed effects; *** p<0.01, ** p<0.05, * p<0.1; Intercepts included but not reported.

Table 2.A.4: Robustness check: Trade effect of UTZ Certified on each cocoa-grinding product

	(1)	(2)	(3)	(4)	(5)	(6)
Estimation method	ppml					
Dependent variable	Export value					
	Cocoa paste		Cocoa powder		Cocoa butter	
UTZ volume share$_{it-1}$	0.021***	0.018***	0.006	0.002	−0.005	−0.014**
	(0.004)	(0.005)	(0.006)	(0.007)	(0.006)	(0.007)
Log Agricultural GDP$_{it}$	−0.078	−0.065	0.118	0.051	−0.131	−0.541
	(0.340)	(0.354)	(0.308)	(0.298)	(0.472)	(0.437)
Export procedures$_{it}$	0.002	0.004	−0.013**	−0.012**	0.010**	0.007
	(0.003)	(0.003)	(0.006)	(0.006)	(0.004)	(0.006)
RTA$_{ijt}$	0.392***	0.242	0.032	0.235	−0.043	−0.146
	(0.145)	(0.311)	(0.287)	(0.269)	(0.104)	(0.180)
Log (1+Tariff$_{ijt}$)	−0.094	−0.653***	−0.440**	−0.390	−0.317*	−1.688***
	(0.238)	(0.150)	(0.179)	(0.246)	(0.178)	(0.358)
Log Distance$_{ij}$		−0.402		−1.459***		−1.525***
		(0.271)		(0.253)		(0.260)
Common Language$_{ij}$		−0.116		0.377		0.163
		(0.368)		(0.238)		(0.330)
Contiguity$_{ij}$		3.074***		0.457		0.123
		(0.454)		(0.600)		(0.772)
Observations	1,926		2,671		2,014	
RESET test (p-value)	0.690	0.768	0.744	0.004	0.009	0.0001

Notes: Standard errors are clustered at the country-pair level in parentheses; The estimations in columns (1), (3) and (5) include exporter, importer-time and country-pair fixed effects; The estimations in columns (2), (4) and (6) include exporter and importer-time fixed effects; *** p<0.01, ** p<0.05, * p<0.1; Intercepts included but not reported.

Chapter 3

Do private standards carry the (cocoa and coffee) can for meeting public standards?

Abstract

The empirical evidence that private food standards have a positive effect on bilateral trade is robust. However, the trade effect of private standards in the presence of stringent public standards remains unclear. In this study, we apply a relative restrictiveness index to measure the regulatory heterogeneity in maximum residue limits between trading partners. We use a unique dataset that contains the Rainforest Alliance Certified land area of cocoa and coffee producers in 52 countries from 2008 to 2016. We estimate a structural gravity model to examine how the adoption of private voluntary sustainability standards interacts with the effect of regulatory heterogeneity. Our results show that while increasing regulatory heterogeneity hinders bilateral trade, certification according to a private voluntary sustainability standard can partially moderate the trade-inhibiting effect of public standards. This effect is only significant at the intensive margin of certification but not at the extensive margin of certification.

This chapter is joint work with Bernhard Brümmer. Nina Grassnick and Bernhard Brümmer contributed to the development of the research question and research design. Nina Grassnick is the corresponding author and responsible for the empirical and conceptual framework, data management, empirical estimation, and writing of the manuscript. Bernhard Brümmer revised the chapter.
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3.1 Introduction

While tariff barriers are decreasing over time and across countries, non-tariff barriers such as food safety and quality standards are increasing in number and stringency. One prominent example - also frequently discussed in the trade literature - is MRLs, which are set by public entities and regulate the maximum amount of residual pesticide components allowed in a food product. They are regulated at the international level by Codex Alimentarius (hereafter named Codex) but they can also be regulated differently at the national level. Most countries that deviate from Codex are located in the Global North - i.e. the EU, the USA, Japan - and these countries tend to set stricter MRLs than suggested by Codex, and often they add regulations on further pesticides without existing Codex MRLs.

This trend can harm producers from countries in the Global South where MRLs are non-existent or only as strict as recommended by Codex, because their products are rejected at the borders of importing countries with stricter MRLs. This especially affects producers of export commodities such as coffee or cocoa that depend on sales outside of their home country. For instance, 133 cases of hazardous pesticide residues were notified at the EU border for the product category of "cocoa and cocoa preparations, coffee and tea" from 2008 to 2016 (European Commission, 2020). Most of these commodities are grown in the Global South due to favourable climatic conditions for planting. However, the strongest demand comes from the USA, Russia, the EU and Japan. Additionally, cocoa and coffee are both crops that are mostly imported by countries that do not produce the same good.[23] This offers a suitable case to study trade policies aimed at discriminating against unsound imports regarding environmental, health or social concerns but not protecting domestic industries against imports per se.

Since many exporting countries do not have the institutional capacity to tighten their MRLs, one possible solution to overcome this trade barrier could involve adopting a private VSS[24] such as Rainforest Alliance Certified. This VSS is a good example because it prohibits the use of 99 pesticides,[25] of which 81 are relevant for the production of coffee and/or cocoa and regulated by national MRLs (Sustainable Agriculture Network, 2011). Rainforest Alliance Certified can have a twofold effect: first, it substitutes missing public standards in the exporting country; and second, it harmonises standards between the trade partners, because its list of prohibited pesticides refers to most importing countries regulations. Therefore, exporting countries with relatively lax MRLs but a high share of Rainforest Alliance Certified farmers might be able to export more cocoa and coffee than exporting countries with similar MRLs but no Rainforest Alliance Certified farmers. If this is the case, the negative trade effect caused by strict MRLs set by importers could be partially/fully compensated by the presence of Rainforest Alliance Certified in the exporting country.

[23] Only about 29% and 21% of coffee and cocoa importers in our dataset, respectively, also have domestic production and only 21% of those producers produce above average. In other words, only 9% and 4% of all coffee and cocoa importers, respectively, also show above-average production of these crops.

[24] In the following, we will refer to private voluntary sustainability standards when using the term voluntary sustainability standards.

[25] This number refers to the Rainforest Alliance list of prohibited pesticides from 2011 (Sustainable Agriculture Network, 2011), because our dataset ends in 2016. This list was updated in 2017 (see Sustainable Agriculture Network (2017b)).

This chapter adds to the current literature in disentangling such interactions between private and public standards. Furthermore, our study differs in two aspects from other product-specific trade analyses: first, we not only focus on one specific exporter or importer, but include all exporters and importers; and second, we not only study MRL for few pesticides but consider all MRLs regulated by Codex for both products. Such a comprehensive perspective is an essential precondition for disentangling the interplay between private and public standards.
The next section outlines our conceptual framework by discussing the possible pathways through which regulatory heterogeneity in MRL regulations can affect coffee and cocoa exports, as well as how they potentially interact with VSSs. In Section 3.3, we introduce the data, in particular the restrictiveness index, and the specification of the gravity model. The results are shown and discussed in Section 3.4, before Section 3.5 concludes the chapter.

3.2 Conceptual framework

We want two answer two research questions in our empirical setting: How do heterogeneous public food standards (here measured by MRLs) affect coffee and cocoa exports (RQ1)? Are VSSs (here Rainforest Alliance Certified serves as an example) a means to overcome this trade barrier (RQ2)? Here, we will take a closer look at the role of VSSs in the situation of regulatory heterogeneity at the extensive (RQ2.1) (at least one farmer is certified) and intensive margin (RQ2.2) (intensity of certification). In this section, we conceptualise different pathways that may moderate the effects.

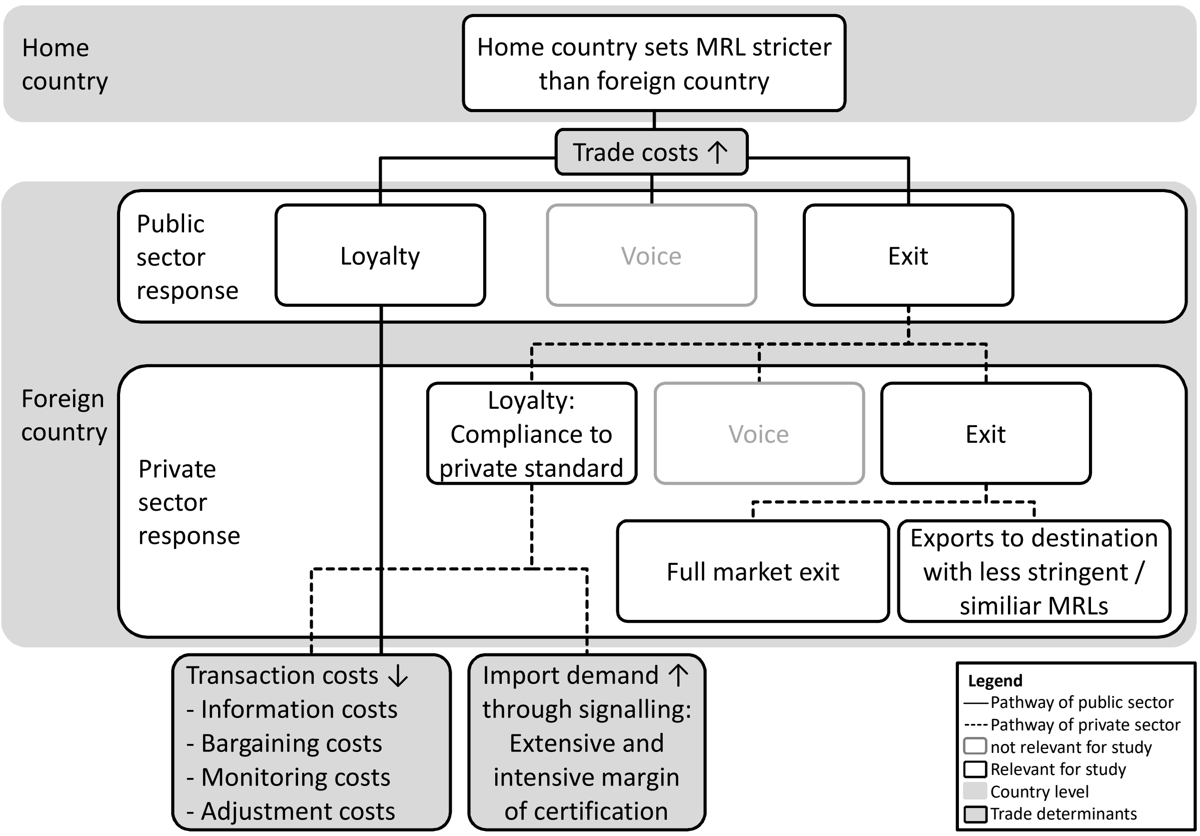
3.2.1 Regulatory heterogeneity and agricultural trade

Several scholars (e.g. Fischer and Serra, 2000; Swinnen and Vandemoortele, 2011; Beghin et al., 2012) have conceptualised the trade and welfare effects resulting from heterogeneous food standards set by trading partners. They all focus on the potential import protectionism through a standard. However, in our study we do not consider this strand of the debate, because we are studying import goods that are not produced (or barely produced) in the home market. Furthermore, we study a public standard that aims to protect the health of the consumers in the home market in the presence of imperfect information. The standard discriminates against imports that were produced under unsound conditions in the foreign country, but welcomes sound imports.[26] We argue that MRLs belong to this category because they apply to products that were produced in a foreign country using a technology that results in a potential health risk for consumers in the home country (consumption pollution). At the same time, it allows sound imports that do not harm consumers health. In the case of MRLs, we study a corner solution where unsound imports are banned, i.e. products not meeting the MRLs are rejected at the

[26] For a more detailed discussion on the optimal trade policy in the presence of imperfect information for an importing country that discriminates against unsound imports that are not produced domestically, see Engel (2004).

border. We focus on the regulatory distance between exporting and importing countries, specifically importers setting relatively more stringent public standards than the exporting country. In our case, all exporters are developing countries (following the country classification of the United Nations). Therefore, we refer to the conceptual work of Henson and Jaffee (2008) to explain the different options that developing countries have to respond to the strict standards set by developed countries. We extend this with the definition of transaction costs from Richter and Furubotn (2010). For an overview, see Figure 3.1.

Figure 3.1: Conceptual framework



Own elaboration based on Henson and Jaffee (2008) and Richter and Furubotn (2010)

Trade policy options of the exporting country

According to Henson and Jaffee (2008), governments and exporters have three strategies to respond to an importer that tightens its public standards: (1) loyalty, (2) exit and (3) voice. A more detailed discussion on the exporters' (private sector) response follows in Section 3.2.2. Here, we will focus on the public sector response strategies. In the first case, the exporting country would adjust its MRL regulation to the importers. A prominent example is the Ghana-Japan cocoa case. Following the implementation of a stricter legislation on MRLs by the Japanese government in 2006, Ghana adapted the Japanese standard and started to control whether cocoa beans destined for export to Japan - one of Ghana's major cocoa export destination - meet Japanese regulations (Jonfia-Essien, 2012). The second strategy would lead to exiting the market, i.e. the government does not adjust its domestic public standard to the new standard of its trading partner. This can have different reasons. For instance, given that the process of setting up a new or changing an existing public standard is usually time-consuming, it can result in a short-term "exit", but long-term "loyalty" (McCluskey and Winfree, 2009). In the case of a low-income country, the lack of institutional capacity and/or financial resources might make it infeasible to perform the necessary monitoring activities associated with setting stricter standards/additional standards (Henson and Jaffee, 2006). Additionally, the government could also consciously decide to exit when only a low export market share goes to the stricter importer or use the resources for investment in areas that yield relatively higher national welfare effects (Henson and Jaffee, 2008). Finally, a country can also complain ("voice") when stricter standards are applied, e.g. by raising a STC at the WTO. For instance, Ecuador used this instrument in 2008 to complain about the EU default limit of 0.01 mg per kg applied to all unregulated pesticides. Specifically, it asked to increase the MRL for Diuron, Melathion, Difenoconozol and Tribufos applied to cocoa beans. Otherwise, Ecuador would have had difficulties sustaining trade relations with the EU (WTO, 2008). In the following, we will focus on the relevant scenario for our study, which is the government's choice to "exit" - i.e. public standards of the exporting and importing country are not harmonised - and the related implications for trade.

Trade effects in the presence of regulatory heterogeneity

In recent years, several scholars have empirically analysed the effect of regulatory heterogeneity in MRL regulation between countries on agricultural trade (for an overview see Table 3.A.5). The evidence remains mixed: while some studies find the expected negative and statistically significant effect on trade (Winchester et al., 2012; DeMaria and Drogue, 2016; Vural and Akgüngör, 2019),[27] Drogué and DeMaria (2012) as well as Ferro et al. (2015) find positive effects. However, the positive effect of the latter study only remains for exports from high- to low-income countries, while for all other cases it proves to have no effect. Mixed results are also shown by studies focusing only on the relative stringency of importers. Xiong and Beghin (2014) confirm the trade-inhibiting effect of stricter standards, while Curzi et al. (2018) find this only for EU imports from non-OECD exporters but not for OECD exporters or the EU exporting to OECD/non-OECD countries. Moreover, Ferro et al. (2015) find no effect for relative strict importers. The only study explicitly analysing the effect of a stricter export standard (compared with Codex) is Curzi et al. (2018), who find a trade-enhancing effect for exports from non-OECD countries to the EU, as well as for EU exports to all countries. These mixed results can be explained by two counteractive effects resulting from more stringent standards, namely an increase in (1) trade costs and (2) import demand (Xiong and Beghin, 2014). Depending on which of the two effects is stronger, the effect of regulatory heterogeneity proves to be positive (import demand > trade costs), negative (import demand < trade costs) or has no effect (import demand = trade costs).

Here, trade costs are mainly caused by higher transaction costs, which can be split into four

[27] DeMaria and Drogue (2016) find positive effects when using the PPML estimator.

sub-groups: (1) information costs, (2) bargaining costs, (3) monitoring costs and (4) adjustment costs (Richter and Furubotn, 2010). First, as described above, several countries set their own MRL regulations, which differ from the Codex and they also frequently update their limits or add new/remove pesticides from/to the list of regulations. Therefore, an exporter has to continuously gather information about new regulations. Second, the buyer cannot see how much pesticide residues the product contains and finds oneself in a situation of asymmetric information, which can lead to more complex contract structures to safeguard both parties against potential fraud, thus increasing bargaining costs. Third, the farmer/exporter has to frequently monitor its production to ensure that it meets the importer's requirements. Additionally, border inspections are usually intensified for products originating from countries where previous cases of non-compliance were identified (Handford et al., 2015). Fourth, if an importer reduces its MRL, the exporter has to adjust its production technique to continue its trade relations with a buyer in that specific country.
Following the above-discussed conceptual framework, we define our first hypothesis:

> *H1:* A country exports less cocoa and/or coffee when MRL regulations between the two trading partners are not harmonised.

Here, becoming certified by a VSS could be helpful to reduce trade costs caused by differing trade regulations. The channels will be explained in the following section.

3.2.2 The interplay of voluntary sustainability standards and maximum residue levels

Strategic responses of the private sector

Following Henson and Jaffee (2008), private actors also have the three options discussed in Section 3.2.1 to respond to a stricter public standard in the export destination. They can either act before (proactive) or after (reactive) the government of the exporting country has made its decision. Here, we will specifically focus on the response options of exporters after the government has decided to "exit", i.e. not adjust its standards. The exporter could follow the government's decision and also exit the market. It can either completely exit this specific product market and switch to the production of another product with lower requirements or try to find another export destination with less demanding requirements for the same product. For instance, Henson and Jaffee (2008) describe the case of Indian fish processors who decided to export to less demanding destinations like China, the Middle East and Singapore after the EU banned all fish and fishery products from India in 1997, because most facilities did not meet EU hygiene requirements. Moreover, Kenya was subject to EU inspections in 1997, which led to tighter food safety regulations for Kenyan fish processors. Consequently, some processors exited the sector because they did not have the financial capacity to upgrade their production technique or they were small enterprises that would have had higher costs of upgrading than the benefits derived. Another possibility is to negotiate ("voice") food safety requirements with the buyer. This especially works in highly vertical integrated supply chains where asymmetric information and monitoring costs are low. Furthermore, the supply chain actors often have a long-term contract and a strong interest in upholding the trade relationship. Finally, the firm can decide to be "loyal" and adapt to the new standards. The certification by a suitable VSS could be a means to reach this aim.

Trade-cost reducing effect of Rainforest Alliance Certified

Organisations setting VSSs - such as Rainforest Alliance - are aware of the strict MRL requirements by major export destinations and therefore they have adapted their requirements on pesticide use accordingly. These requirements help to reduce higher transactions costs due to regulatory heterogeneity in different ways. First, they prohibit the use of 99 pesticides[28] (Sustainable Agriculture Network, 2011). This list includes - among others - pesticides that are banned or severely restricted in the USA and the EU, two major export destinations for cocoa and coffee. Second, for the remaining pesticides, they implement an integrated pest management plan to define criteria for the correct use and reduction of pesticides (Sustainable Agriculture Network, 2017a). These two requirements especially help to reduce adjustment costs resulting from stricter import food safety requirements. Asfaw et al. (2009) confirm that producers adopting GlobalGAP - a private food safety standard that also sets criteria for the correct use of pesticides - shift from using extremely hazardous pesticides to slightly hazardous pesticides.[29] In our case, seven pesticides relevant for coffee and/or cocoa are regulated by Codex and fall into the category of highly or extremely hazardous pesticides[30], of which three pesticides are prohibited by Rainforest Alliance (see Appendix Table 3.A.4). Most top importers set stricter MRLs on these highly hazardous pesticides than the Codex. Rainforest Alliance additionally provides training on importers requirements - among others on MRLs - and attracts cocoa/coffee processors to set up facilities in the producing countries (CoC certification). These two factors reduce information costs and simultaneously reduce the risk of border rejections. The stronger vertical integration and frequent audits required by Rainforest Alliance reduce monitoring costs. Finally, product certification reduces informational asymmetries and thus bargaining costs. Therefore, the following hypothesis can be derived:

> *H2.1:* In the presence of a negative trade effect resulting from relative more stringent MRLs in the importing country, certification of farmers in the exporting country by Rainforest Alliance can moderate this effect.

[28] We refer to the list of prohibited pesticides from 2011.

[29] However, GlobalGAP producers in this study do not necessarily reduce the overall use of pesticides. Moreover, studies show mixed results regarding the effect of VSSs on pesticide use. For instance, Rueda and Lambin (2013) do not find significant differences between certified and non-certified coffee farmers regarding the use of chlorpyrifos, glyphosate and synthetic fertiliser. In the case of chlorpyrifos and glyphosate, the result might be driven by the general low use of these pesticides in the study region.

[30] We refer to the WHO hazard classification 2009 (WHO, 2010).

At the same time, the label creates trust between the contracting parties and signals product quality. In addition to the trade-cost reducing effect, the signalling can have a demand-enhancing effect in the importing country.

Demand-enhancing "signalling" effect of Rainforest Alliance Certified

The signalling effect of a private certification scheme is mainly based on the *extensive margin of certification* (the overall existence of a certification scheme in a country or not) and can be maintained at the *intensive margin of certification* (share of certified land area within the exporting country). The signalling effect through the extensive margin may be stronger due to the following reasons. The existence of a certification scheme in one country signals that although public standards are lax, some farmers have the capacities to comply with the strict food safety requirements of the export destination. This is important especially in the case of cocoa and coffee, because the buyer market is highly concentrated. The large cocoa and coffee processors require a guaranteed supply of large quantities (see Section 2.3.2). Producers also deliberately use the private certification to signal the higher quality of their product by differentiating themselves from farmers that produce lower quality products (Arora and Gangopadhyay, 1995). Furthermore, the presence of certified farmers attracts certification bodies to establish an office in the prevailing country that can carry out effective food safety controls. This increases the likelihood of trading partners sourcing from this country (Henson and Jaffee, 2006). In order to satisfy the high demand for certified produce by a single buyer, as described above, a sufficient number of farms have to be certified. However, having too many certified farms bears the risk of oversupply and increasing the risk of fraud, because auditors are unable to check all producers (Swinnen et al., 2015). Based on these considerations, the following hypothesis can be proposed:

> *H2.2:* In the presence of regulatory heterogeneity, the extensive margin of certification plays a stronger role than the intensive margin of certification.

3.3 Data and model specification

3.3.1 Data

The MRL data that we use was purchased from Agrobase-Logigram's Homologa and covers 2008 to 2016 for 38 of the countries[31] included in this study (for an overview, see Tables 3.A.2 and 3.A.3) and the Codex. These 38 countries set their own national MRLs. For all other countries included in our dataset, we assume the Codex values, because they are all Codex member

[31] We count the EU27 countries as one country, because they harmonised their MRLs in 2009.

countries. For this time period, we identified 37 pesticides regulated by Codex relevant for coffee and six for cocoa, of which eight are prohibited by Rainforest Alliance (see Table 3.A.4).[32]
The dataset provided by Rainforest Alliance includes certified land area in ha by product and country. To calculate the certified area share in total harvest area, we merge it with data on cocoa and coffee area harvested from FAOstat. Data for cocoa and coffee production in tonnes was also retrieved from FAOstat. We include bilateral imports in current US Dollars and tonnes (to calculate consumption) of "coffee, whether or not roasted or decaffeinated; husks and skins; coffee substitutes containing coffee in any proportion" (HS 0901) and "cocoa beans; whole or broken, raw or roasted" (HS 1801) retrieved from the UN Comtrade database. We include 52 exporters that produce cocoa as well as coffee and 129 importers. See Tables 3.A.2 and 3.A.3 in the appendix for an overview of all importing and exporting countries considered in this chapter. The time-invariant bilateral standard gravity covariates - distance, common border, common language and colonial relationship - were obtained from CEPII website (Head et al., 2010; Head and Mayer, 2014). Furthermore, data on RTAs was obtained from Mario Larch's Regional Trade Agreements Database (Egger and Larch, 2008). Tariff data was downloaded from the UNCTAD TRAINS. See Table 3.1 for descriptive statistics of the data used.

Table 3.1: Descriptive statistics

Variable	Mean	Standard deviation	Minimum	Maximum
Trade value (Mio. USD)	1.83	40.38	0	4,354.73
Restrictiveness index	0.02	0.12	−1	0.57
Production (tonnes)	107,825.59	337,387.66	1	3,037,534.00
Consumption (tonnes)	51,733.77	242,662.31	0	2,940,204.11
Rainforest Alliance Certified area share	0.02	0.09	0	1
Rainforest Alliance Certified dummy	0.29		0	1
Distance (km)	9,011.54	4,759.37	94.27	19,650.13
Tariff (%)	11.31	13.75	0	100.60
Colony	0.01		0	1
Contiguity	0.02		0	1
Common language	0.22		0	1
RTA	0.19		0	1
Observations		106,256		

Notes: The standard deviation for dummy variables is not reported since it is one-to-one mapping of the mean.

3.3.2 Relative restrictiveness index

With increasing interest in studying the trade effects of MRL regulations in the literature, different indices have been proposed to measure the MRL stringency of countries for better

[32] Two active components - i.e. Saflufenacil (2012) and Cyantraniliprole (2014) - were only added to Codex later. However, we assume that they were already relevant in earlier years, because Codex negotiation processes usually take several years, but member countries might consider the potential stricter MRLs already before the final Codex decision.

comparison. For our study, we decided to use the relative restrictiveness index developed by Ferro et al. (2015), which varies between the values -1 (exporter sets the most stringent MRLs compared with an importer that sets the most lax MRLs) and 1 (importer sets the most stringent MRLs compared with an exporter that sets the most lax MRLs), based on the following reasons. As already discussed in Section 3.2.1, we are not only interested in measuring the dissimilarity of regulations between trading partners, but we are explicitly interested in whether and to what extent the exporter or importer is more stringent. We find it important to also focus on the exporter side, because our dataset includes eight exporters that set their own national MRL regulations.[33] Furthermore, we assume a positive trade effect for the case of an exporter being more stringent and a negative effect for the case of an importer being more stringent, which is depicted by Ferro et al.'s (2015) index. The index developed by Li and Beghin (2014) - which ranges from 0 to 2.72 - does not account for this. Another positive feature of the Ferro et al. (2015) index is that it is easy to interpret.[34] The index looks as follows:

$$\text{Index}_{ijkt} = \frac{1}{N(p)} \sum_{n(p)=1}^{N(p)} \frac{MRL_{ikpt} - MRL_{jkpt}}{MAX_{kpt} - MIN_{kpt}} \tag{3.1}$$

where MRL_{ikpt} is the MRL of exporter i, for product k and pesticide p in year t. MRL_{jkpt} is the MRL set by the importer j for the same product, year and pesticide. $N(p)$ is the total number of pesticides applied to product k. Averaging the sum of the index by the total number of pesticides makes the index invariant to the regulation intensity. MAX_{kpt} and MIN_{kpt} is the most lax MRL or most strict MRL set by any country for pesticide p on product k in year t, respectively. In the case the importers' MRLs equal on average the exporters' MRLs, the index takes a value of 0.

Following Li and Beghin (2014), we only include pesticides that were ever regulated by Codex within the 2008-2016 period for cocoa and coffee, assuming that these components are also the most relevant.[35] Nevertheless, we have missing values in our dataset because countries either do not set a national value for this substance or a default limit applies. Therefore, we follow Drogué and DeMaria (2012) and replace missing values with (1) default values if a country sets a default value, (2) the remaining missing values are replaced by Codex values since all countries in the dataset are Codex members, and (3) if the specific pesticide is not regulated by Codex in that year and no default value applies, we replace the missing value with the maximum value found in the data, i.e. 70 mg/kg.

Figures 3.2 and 3.3 both show the development from 2008 to 2016 of the relative restrictiveness index for the largest coffee and cocoa exporters and importers in our dataset. In the case of coffee, we observe more heterogeneous regulations in the earlier years (index $\neq 0$) and more similar MRL regulations between exporter and importers in later years. This trend can be partially explained due to the wider range of pesticides regulated by Codex in the later years,

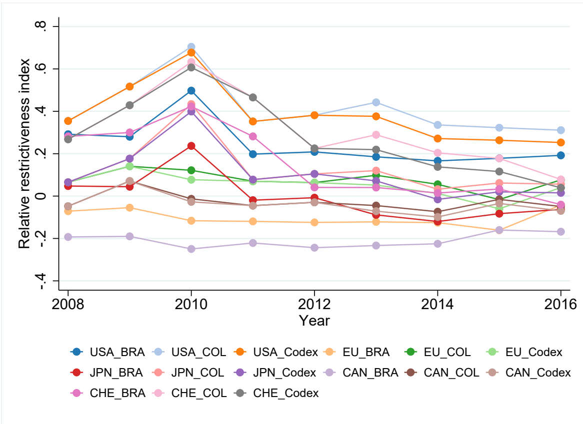
[33] Those exporters are Brazil, Colombia, India, Indonesia, Malaysia, Mexico, Philippines and Thailand.

[34] Nevertheless, a drawback of Ferro et al.'s (2015) index compared with Li and Beghin's (2014) index is that it does not place more weight on the MRLs that are relatively more stringent. This has to be taken into consideration when interpreting the results.

[35] Although we have the data for all pesticides ever regulated by any country, we do not use the list of all pesticides to avoid a left-censored index.

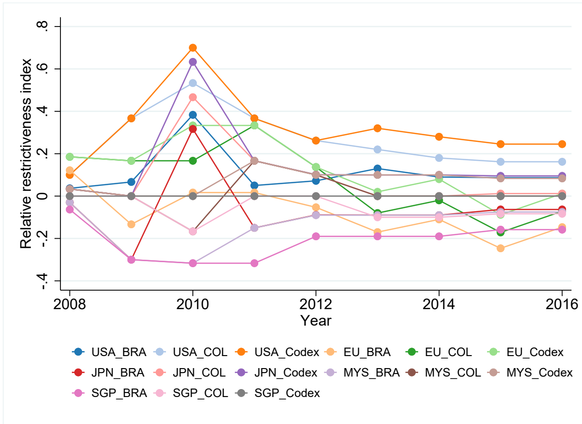
which has a harmonising effect because countries that did not set national regulations nor default values now apply the new Codex value. However, the EU also adjusted its MRL for Phorate to the stricter Codex value. Thus, most large importers are still relatively stricter than their corresponding export partner (index > 0), while few of the large exporters set relatively stricter MRL than importers (index < 0). In the case of cocoa, we observe the opposite development: in 2008 most trading pairs show an index close to zero (harmonisation), but in 2016 their MRL regulations seem to more strongly differ. However, this heterogeneity is partially caused by exporters that became relatively more stringent. For instance, the EU implemented a less stringent MRL than recommend by Codex for Methyl-Bromide in cocoa products.

Figure 3.2: Restrictiveness index for largest coffee exporters and importers, 2008-2016



Source: Homologa database, own graph

Figure 3.3: Restrictiveness index for largest cocoa exporters and importers, 2008-2016



Source: Homologa database, own graph

3.3.3 Gravity model

An extended gravity model is used to test our hypotheses. In recent decades, the gravity model of trade has become the most popular model to ex-post analyse trade policy effects. It was first introduced by Tinbergen (1962), who interpreted Newton's Law of Gravitation in such a way that it could be used to explain trade flows between two trading partners (X_{ij}) by the size of their economies (Y_i and E_j) and the distance or trade costs (T_{ij}^{θ}) between them (Yotov et al., 2016):

$$\mathrm{X}_{ij} = \widetilde{G}\frac{\mathrm{Y}_i\mathrm{E}_j}{T_{ij}^{\theta}} \tag{3.2}$$

where $\mathrm{T}_{ij}^{\theta} = (\mathrm{t}_{ij}/(\Pi_i\mathrm{P}_j))^{\sigma-1}$. Π_i and P_j are the multilateral resistance terms, which control for remoteness of the trading partners. Controlling for multilateral resistance is crucial because not only distance to trading partners matters but also distance to all other potential trading partners. Thus, trade flows are not only affected by absolute but also relative trade barriers. However, the multilateral resistance terms are not observable. A common approach to account for the multilateral resistance terms in a panel dataset is to use exporter-time and importer-time

fixed effects (Olivero and Yotov, 2012). As our analysis is at the product level, exporter-product-time and importer-product-time fixed effects should be included. However, the variation of our variables of interest $RAshare_{ikt-1}$ and $RAdummy_{ikt-1}$ would be absorbed by the exporter-product-time fixed effect. Moreover, our index variable $Index_{ijkt-1}$ shows low variation at the country-pair level and would be absorbed by the importer-product-time fixed effect. Therefore, we adopted a compromise strategy and use exporter-time and importer-time fixed effects. We argue that not fully accounting for multilateral resistance only leads to a small bias in our results, because only few country pairs in our dataset have a two-way trade relationship, i.e. most exporters never import and most importers never export the specific product.
The log-linearised gravity equation to answer our first research question is given by:

$$\begin{aligned} lnX_{ijkt} =&\pi_{it} + \eta_{jt} + \kappa_{kt} + \beta_0 + \beta_1\text{Index}_{ijkt-1} + \beta_2\text{RAshare}_{ikt-1} + \beta_3\text{RAdummy}_{ikt-1} \\ &+ \beta_4\text{lnProduction}_{ikt} + \beta_5\text{ln(1+Consumption)}_{jkt} + \beta_6\text{ln(1+tariff)}_{ijkt} + \beta_7\text{RTA}_{ijt} \\ &+ \beta_8\text{lnD}_{ij} + \sum_{n=9}^{11}\beta_n\Omega_{ij} \end{aligned} \tag{3.3}$$

By adding interaction terms, we can answer our second research question:

$$\begin{aligned} lnX_{ijkt} =&\pi_{it} + \eta_{jt} + \kappa_{kt} + \beta_0 + \beta_1\text{Index}_{ijkt-1} + \beta_2\text{RAshare}_{ikt-1} + \beta_3\text{RAdummy}_{ikt-1} \\ &+ \beta_4\text{Index}_{ijkt-1} * \text{RAshare}_{ikt-1} + \beta_5\text{Index}_{ijkt-1} * \text{RAdummy}_{ikt-1} \\ &+ \beta_6\text{lnProduction}_{ikt} + \beta_7\text{ln(1+Consumption)}_{jkt} + \beta_8\text{ln(1+tariff)}_{ijkt} + \beta_9\text{RTA}_{ijt} \\ &+ \beta_{10}\text{lnD}_{ij} + \sum_{n=11}^{13}\beta_n\Omega_{ij} \end{aligned} \tag{3.4}$$

This dataset contains 89.4% zero trade flows. Furthermore, trade data suffers from heteroskedasticity due to Jensen's inequality. To account for both, we use the PPML estimator[36] to estimate our baseline and interaction specification of the following augmented gravity model:

$$\begin{aligned} X_{ijkt} =&\exp(\pi_{it} + \eta_{jt} + \kappa_{kt} + \beta_0 + \beta_1\text{Index}_{ijkt-1} + \beta_2\text{RAshare}_{ikt-1} + \beta_3\text{RAdummy}_{ikt-1} \\ &+ \beta_4\text{lnProduction}_{ikt} + \beta_5\text{ln(1+Consumption)}_{jkt} + \beta_6\text{ln(1+tariff)}_{ijkt} + \beta_7\text{RTA}_{ijt} \\ &+ \beta_8\text{lnD}_{ij} + \sum_{n=9}^{11}\beta_n\Omega_{ij})\epsilon_{ijkt} \end{aligned} \tag{3.5}$$

$$\begin{aligned} X_{ijkt} =&\exp(\pi_{it} + \eta_{jt} + \kappa_{kt} + \beta_0 + \beta_1\text{Index}_{ijkt-1} + \beta_2\text{RAshare}_{ikt-1} + \beta_3\text{RAdummy}_{ikt-1} \\ &+ \beta_4\text{Index}_{ijkt-1} * \text{RAshare}_{ikt-1} + \beta_5\text{Index}_{ijkt-1} * \text{RAdummy}_{ikt-1} \\ &+ \beta_6\text{lnProduction}_{ikt} + \beta_7\text{ln(1+Consumption)}_{jkt} + \beta_8\text{ln(1+tariff)}_{ijkt} + \beta_9\text{RTA}_{ijt} \\ &+ \beta_{10}\text{lnD}_{ij} + \sum_{n=11}^{13}\beta_n\Omega_{ij})\epsilon_{ijkt} \end{aligned} \tag{3.6}$$

where π_{it} denotes exporter-time fixed effects, η_{jt} importer-time fixed effects, κ_{kt} product-time fixed effects and ϵ_{ijkt} are robust standard errors clustered at the exporter-importer-product level. The importer-time and exporter-time fixed effects capture other non-tariff measures imposed by the importing or exporting country. Note that all continuous covariates are z-transformed for normalisation purposes. This facilitates model conversion and allows for easier comparability

[36] For a detailed discussion of the advantages and disadvantages of the PPML estimator, see Santos Silva and Tenreyro (2006).

of the estimated coefficients. To avoid estimation problems arising from reverse causality, some variables are lagged by one year in the regressions. This has the downside of losing one estimation year, leaving us with data for the time period from 2009 to 2016.

X_{ijkt} denotes export values from country i to country j in year t for product k. To account for the intensive margin of certification, we include the variable $RAshare_{ikt-1}$[37] which measures the share of land area certified of total land area in exporter country i of product k in year $t-1$. $RAdummy_{ikt-1}$ is included to measure the extensive margin of certification and it is a dummy variable equalling 1 if at least one farmer has Rainforest Alliance certification in country i for product k, and 0 otherwise. We include the variable $Index_{ijkt-1}$ to measure the relative restrictiveness of importer $j's$ MRL regulations compared with exporter i for product k in year $t-1$. To overcome endogeneity due to reverse causality, a one-year lag of the private and public standard variables is used in the model specification. To test our hypothesis whether a VSS helps to overcome the negative effect of a public standard, we include the interaction terms $Index_{ijkt-1} * RAshare_{ikt-1}$ (for the intensive margin of certification) and $Index_{ijkt-1} * RAdummy_{ikt-1}$ (for the extensive margin of certification). $Production_{ikt}$ is the exporters' production (in tonnes) of product k in year t and it expresses country i's supply potential. We calculate importers' consumption (in tonnes), $Consumption_{jkt}$, as production-exports+imports of product k in year t, which captures country j's demand.[38] The variables $ln(1+Tariff_{ijkt})$ and RTA_{ijt} are included to proxy bilateral trade costs by the product-specific ad *valorem* tariff[39] and a binary variable that takes the value of one if both countries are members of the same RTA, respectively. D_{ij} measures the population-weighted distance[40] between country i and country j. Further time-invariant trade-cost variables are included in the vector Ω_{ij}, such as having a common border, common language and past colonial relationship.

Ideally we would have included importer-exporter-fixed effects μ_{ij} to control for all time-invariant trade costs, but 67% of our country pairs both never set national regulations and therefore show the index value 0 for all years, i.e. these observations would be dropped due to multicollinearity. As a robustness check, we also show the results including importer-exporter-fixed effects (see Table 3.3).

[37] For 2013-2015 Tanzania shows values >1. We replaced them with the value 1.

[38] We have 43 importers that had negative consumption values in some years (7996 observations). We replaced them with the value 0. Additionally, we have 36,450 observations with value 0 that would be dropped when we take the log of consumption. Therefore, we add +1 to all consumption values.

[39] Simple average applied tariffs are used for country pairs for each product and year available. We interpolate observations to fill in missing years. For cases where applied tariff data is not available for a given importer-exporter-product-time combination, we replace the missing values with MFN tariffs of the corresponding importer-product-time combination or with preferential tariffs of the given importer-exporter-product-time combination if they have a preferential tariff agreement.

[40] This variable is time-invariant because the CEPII dataset uses population data from 2004 to weight bilateral distances and applies it to all following years.

3.4 Results and discussion

3.4.1 Main results

Table 3.2 shows parameter estimates from our gravity model using the OLS estimator (see Equations 3.3 and 3.4) and PPML estimator (see Equations 3.5 and 3.6) for cocoa and coffee trade flows.[41]

Table 3.2: Effect of private and public food standards on cocoa and coffee exports

	(1)	(2)	(3)	(4)
Estimation method	OLS		ppml	
Dependent variable	ln Exports		Exports	
RAdummy_{ikt-1}	0.840***	0.697***	0.135	0.073
	(0.226)	(0.227)	(0.197)	(0.248)
RAshare_{ikt-1}	0.175***	0.177***	0.167***	0.105
	(0.051)	(0.052)	(0.046)	(0.065)
Index_{ijkt-1}	−2.042***	−2.718***	−0.515***	−0.555***
	(0.267)	(0.282)	(0.106)	(0.131)
RAdummy_{ikt-1}*Index_{ijkt-1}		0.871***		0.026
		(0.097)		(0.063)
RAshare_{ikt-1}*Index_{ijkt-1}		0.083		0.064**
		(0.054)		(0.031)
Log Production_{ikt}	2.003***	2.033***	3.755***	3.755***
	(0.133)	(0.131)	(0.327)	(0.321)
Log (1 + Consumption_{jkt})	1.318***	1.296***	0.639***	0.636***
	(0.143)	(0.142)	(0.106)	(0.107)
Log (1 + Tariff_{ijkt})	−0.457***	−0.463***	0.015	0.017
	(0.093)	(0.092)	(0.104)	(0.104)
RTA_{ijt}	0.223	0.209	−0.116	−0.118
	(0.163)	(0.159)	(0.119)	(0.120)
Log Distance_{ij}	−0.989***	−0.937***	−0.780***	−0.781***
	(0.094)	(0.093)	(0.102)	(0.102)
Contiguity_{ij}	0.032	0.125	0.441*	0.447*
	(0.319)	(0.315)	(0.268)	(0.268)
Common Language_{ij}	−0.050	0.021	−0.079	−0.080
	(0.187)	(0.181)	(0.194)	(0.193)
Colony_{ij}	0.548	0.474	0.373	0.379
	(0.593)	(0.554)	(0.790)	(0.792)
Observations	11,051		87,822	

Notes: Standard errors are clustered at exporter-importer-product level in parentheses; All estimations include exporter-time, importer-time and product-time fixed effects; All continuous covariates are z-transformed; *** p<0.01, ** p<0.05, * p<0.1; Intercepts included but not reported.

[41] We computed the regression coefficients using the statistical software StataSE 15 and the user-written commands reghdfe version 5.6.8 03mar2018 (Correia et al., 2019) and ppmlhdfe version 2.0.1 05mar2019 (Correia, 2019).

Columns (1) and (3) show regression results for the baseline specification without interaction terms and columns (2) and (4) include interaction terms to analyse the interplay of public and private food standards. All continuous covariates were z-transformed before the estimation for easier interpretation of the coefficients. Please find the regression results with non-standardised coefficients in Appendix Table 3.A.1. In support of our first hypothesis, the coefficient estimates of the restrictiveness index, $Index_{ijkt-1}$, are negative and statistically significant at the 1% level in all model specifications. Thus, increasing heterogeneity of MRL regulations between trading partners reduces bilateral trade. The coefficient estimates of our variables measuring the extensive and intensive margin of Rainforest Alliance certification, $RAdummy_{ikt-1}$ and $RAshare_{ikt-1}$, show the expected positive signs but are only both statistical significant in the OLS specifications. When using the PPML estimator, the effect only remains for the intensive margin of certification in the baseline specification (column 3) and vanishes for the extensive margin. A nine percentage point (= one standard deviation) increase in certified land area increases the expected trade value on average by 16.7% (column 3). Taking a closer look at the average marginal effects of different standardised values of $RAshare_{ikt-1}$ in column (4) (see Figure 3.4), we also find a significant effect at the 5% level for $RAshare_{ikt-1}$ on the predicted mean of exports until the value of 5.18 (which translates into a Rainforest Alliance Certified area share of about 0.46). Figure 3.4 also shows that the positive effect on the predicted mean of exports is rather low in the beginning, but increases exponentially with higher shares of Rainforest Alliance Certified land area. This could also explain why we do not find a significant signalling effect, because only a sufficient amount of certified land area translates into a trade promoting effect.

Figure 3.4: Average Marginal Effects of standardised RAshare$_{ikt-1}$ with 95% CIs

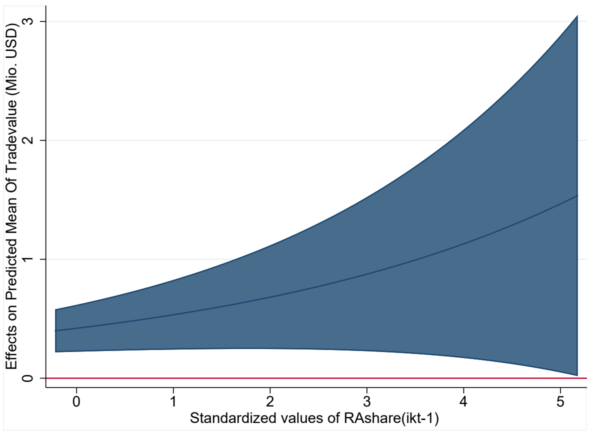
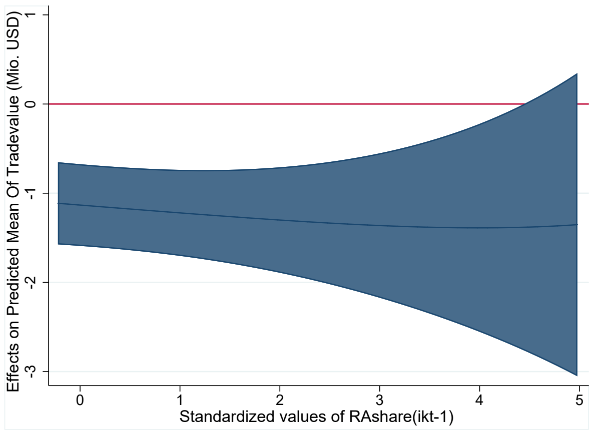


Figure 3.5: Average Marginal Effects of standardised Index$_{ijkt-1}$ at different RAshare values with 95% CIs



To test hypotheses 2.1 and 2.2 - private certification moderates the trade-inhibiting effect of a strict public standard, and this effect is stronger at the extensive margin of certification - we include the interaction terms $Index_{ijkt-1} *$ RAshare$_{ikt-1}$ and $Index_{ijkt-1} *$ RAdummy$_{ikt-1}$ in our model (columns 2 and 4). As expected, the interaction terms are positive. Hence, the more strictly that the importer sets its MRLs compared to the exporter, the more effective the use of Rainforest Alliance certification. However, this effect is only statistically significant for the extensive margin using the OLS estimator and for the intensive margin using the PPML estimator. Specifically, when considering only country pairs that show positive trade values (column

2) the signalling effect can reduce the trade-inhibiting effect for a country pair with an index value of 0.033 (mean value before z-transformation) by about one-third on average.[42]

While taking into account zero trade flows (column 4), a one standard deviation increase in the relative restrictiveness index (= 0.151) reduces exports of countries with 1.9% (= mean value before z-transformation) certified land area by 55.5% on average. This trade-inhibiting effect on average reduces to 49.1% (i.e. $\beta_1 + \beta_4$RAshare$_{ikt-1}$ = -0.491) when the share of certified land increases by one standard deviation (= 0.086). Figure 3.5 shows that we only find a significant interaction effect at the 5% level for the lower values of Rainforest Alliance Certified area share until 4.379 (= real Rainforest Alliance Certified area share value is 0.393). Furthermore, we find that on average the negative marginal effect of a one standard deviation increase of $Index_{ijkt-1}$ on the predicted mean of exports first increases as a function of the corresponding Rainforest Alliance Certified area share value, but decreases after the Rainforest Alliance Certified area share equals 3.979 (= real Rainforest Alliance Certified area share value is 0.36). In other words, the reduction of exports that a country experiences when its trading partner - with which it shared an index value of 0.033 - tighten its MRLs so that their index increases by 0.151 points will be partially compensated for exporters that have between 36% and 39% of their land area certified. Specifically, the exports of a country with an area share of 36% are expected to decrease by 1.388 Mio. USD if the index value increases by one standard deviation, while the exports of a country with an area share of 39% are expected to decrease by 1.383 Mio. USD if the index value increases by one standard deviation.

Our result that signalling only has an interaction effect at the intensive margin of trade (Exports>0) is in line with Berliner and Prakash (2014), who find that especially export-oriented firms - i.e. firms that already participate in the export market - located in countries with weak regulatory institutions are likely to seek private certification to differentiate themselves from other non-certified firms and thereby signal regulatory conformity. Additionally, Berliner and Prakash (2013) show that adoption of private standards is more beneficial for firms in countries with weak regulatory institutions when their buyers in the export destination value this private standard. This could be another factor driving our results, especially because 31% of the trade relationships in the intensive margin of trade model include importers that care about sustainability certification[43], but only 10% in our model including zero trade flows. This implies that Rainforest Alliance Certified can partly reduce the higher transaction costs that cocoa and coffee producers face due to stricter MRLs set by importers but it does by far not outweigh the negative effect.

The remaining statistically significant variables show the expected sign and magnitude, except for $Log\ Production_{ikt}$, whose magnitude exceeds 1 by far. Thus, exports of coffee and cocoa increase with stronger demand by the importer ($Log(1 + Consumption_{jkt})$), higher supply by the exporter ($Log\ Production_{ikt}$) and when the trading partners share a common border ($Contiguity_{ij}$) (only significant in our PPML specifications). Furthermore, exports decrease with increasing distance between the trading partners. We also find the expected positive effect

[42] 0.871 / 2.718 = 0.320

[43] Here proxied by UTZ Certified, which we assume to be similar valued as Rainforest Alliance Certified in importing countries and it is the only data that we can access. The following eleven countries imported UTZ Certified products over the 2011-2016 period: Argentina, Australia, EU27, Japan, Malaysia, Mauritius, Singapore, South Africa, Switzerland, Thailand and the USA. The data was provided to us by Phan Ha, Data analyst, Rainforest Alliance, Amsterdam, Netherlands.

of a former colonial relationship, but it is not statistically significant. Surprisingly, in our PPML specification, higher tariffs have a positive insignificant effect on exports and being a member of the same RTA as well as speaking a common language have negative insignificant effects on exports. However, these variables show the expected significant effect in our OLS specifications.

3.4.2 Robustness checks

Table 3.3: Robustness check: Only positive trade flows and inclusion of country-pair fixed effects

	(1)	(2)	(3)	(4)
Estimation method	ppml		ppml	
Dependent variable	Exports>0		Exports≥0	
RAdummy_{ikt-1}	0.164	−0.204	0.141	−0.180
	(0.210)	(0.234)	(0.132)	(0.196)
RAshare_{ikt-1}	0.167***	0.151***	0.186***	0.138**
	(0.047)	(0.052)	(0.052)	(0.069)
Index_{ijkt-1}	−0.586***	−0.895***	−0.654***	−0.887***
	(0.165)	(0.198)	(0.131)	(0.180)
RAdummy_{ikt-1}*Index_{ijkt-1}		0.320***		0.234**
		(0.095)		(0.097)
RAshare_{ikt-1}*Index_{ijkt-1}		0.062		0.101**
		(0.040)		(0.046)
Log Production_{ikt}	2.665***	2.705***	3.258***	3.294***
	(0.259)	(0.258)	(0.256)	(0.245)
Log (1 + Consumption_{jkt})	0.778***	0.769***	0.772***	0.784***
	(0.111)	(0.111)	(0.178)	(0.175)
Log (1 + Tariff_{ijkt})	0.107	0.105	0.651***	0.652***
	(0.108)	(0.108)	(0.228)	(0.216)
RTA_{ijt}	−0.141	−0.143	0.027	0.053
	(0.117)	(0.116)	(0.075)	(0.075)
Log Distance_{ij}	−0.855***	−0.857***		
	(0.113)	(0.112)		
Contiguity_{ij}	0.305	0.309		
	(0.243)	(0.244)		
Common Language_{ij}	−0.148	−0.157		
	(0.197)	(0.196)		
Colony_{ij}	0.692	0.717		
	(0.560)	(0.556)		
Observations	11,051		29,776	

Notes: Standard errors are clustered at the exporter-importer-product level in parentheses; All estimations include exporter-time, importer-time and product-time fixed effects; Estimations in columns (3) and (4) additionally include country-pair fixed effects; All continuous covariates are z-transformed; *** p<0.01, ** p<0.05, * p<0.1; Intercepts included but not reported.

The differences in the coefficient estimates in the OLS and PPML specification could be explained by including zero trade flows that are added to the reference group when using the PPML es-

timator (Anderson and Yotov, 2016). Therefore, we re-estimate the model using the PPML estimator and exclude all zero trade flows as a robustness check (see Table 3.3 columns (1) and (2)). The results in column (1) of Table 3.3 show that for our baseline estimation the direction of the effect and the significance level are not biased by adding zero trade flows to the reference group, but the strength of the effect for some variables is overestimated (i.e. Log Production$_{ikt}$ and Contiguity$_{ij}$) or underestimated (i.e. Index$_{ijkt-1}$ and Log (1+Consumption$_{ikt}$)). However, the results for our model specification including interaction terms (column (2)) differ for RAshare$_{ikt-1}$ and Index$_{ijkt-1}$*RAdummy$_{ikt-1}$, both of which prove to be significant and much stronger in magnitude. Furthermore, the partial effect of the extensive margin of certification, RAdummy$_{ikt-1}$, switches its sign but remains insignificant. This might be explained by the fact that 65% of our observations in the non-zero trade sample are certified countries, while in the sample including zeros only for 30% of our observations the RAdummy$_{ikt-1}$ equals 1. This has to be taken into consideration when interpreting the results.
We perform another robustness check to account for all time-invariant bilateral trade costs by including importer-exporter-fixed effects (see columns (3) and (4) in Table 3.3). As expected, all observations where the index value does not change over time are dropped. The results show that excluding importer-exporter-fixed effects leads to a slight underestimation of all of our variables of interest in the baseline model as well as for $Log(1 + Consumption_{jkt})$. Surprisingly, the coefficient of $ln(1 + Tariff_{ijkt})$ increases in magnitude and turns highly significant. This could be explained by the much higher share of zero tariffs in the robustness check sample (58%) than in our main results (36%). Since all dropped observations are zero trade flows, we observe the same pattern for the remaining variables as described above for column (2) in Table 3.3. Nevertheless, our result that a relative increase of certified land area in the exporting country partially helps to overcome the trade barrier of relatively stricter public standards in the importing country remains.

3.5 Conclusion

The number and stringency of MRLs set by importers for cocoa and coffee has increased over the last decade. There is evidence that this has trade-impeding effects for country- or pesticide-specific cases. We apply an augmented gravity model to our nine-year panel data (2008-2016) to test this in the case of cocoa and coffee exports. By including all countries that export and/or import both products and all MRLs for pesticides regulated by Codex, we are able to draw more general conclusions. Furthermore, to the best of our knowledge, we are the first to empirically test the interplay of certification according to a VSS - Rainforest Alliance Certified - in exporting countries and the relative restrictiveness of public MRLs set by importing countries. Our results confirm our first two hypotheses: first, regulatory heterogeneity in MRL regulations has a negative effect on coffee and cocoa exports; and second, being certified to Rainforest Alliance Certified partially mitigates the trade loss but does not fully compensate it. However, when considering zero trade flows, this effect is only significant at the intensive margin of certification.

This means our third hypothesis - in the presence of regulatory heterogeneity, the extensive margin of certification plays a stronger role than the intensive margin of certification - is not confirmed. One possible explanation is a certain amount of certified products is needed to find a buyer. Therefore, the pure signalling effect (extensive margin of certification) only has a moderating effect on already-existing trade relationships (intensive margin of trade). Our results show that it is important to not only consider the pure trade effect of a private certification scheme but also its interplay with existing public standards in the exporting as well as importing country.

The following policy implications can be drawn from our results. Coffee and cocoa producers located in countries with relatively lax MRL regulations compared with their export destination can not only benefit from the commonly-known demand-enhancing effect of Rainforest Alliance Certified, but also from its trade-cost reducing effect. For instance, prohibition of the use of specific pesticides, training on an integrated pest management and information about export market requirements provided by Rainforest Alliance can reduce farmers' transaction costs, although this effect only occurs when a sufficient amount of land area is certified. At the same time, the label signals product quality and therefore enhances demand, especially for products from countries that already have established trade relationships. Nevertheless, seeking certification under a VSS cannot be seen as a means to entirely overcome the trade barrier incurred by MRLs. Here, a frequent update of the list of prohibited pesticides provided by the certification scheme is needed, as well as their criteria for the correct use of product-specific pesticides. These up-to-date private requirements with international changes in MRL regulations provide the best support to certified farmers. Rainforest Alliance already took a step in this direction by updating their list of prohibited pesticides in 2017. In the long term, the harmonisation of exporters' and importers' public MRLs is probably the more effective solution. Future research should examine a broader set of private standards and products to improve the external validity of our results.

3.A Appendix

Table 3.A.1: Gravity estimation results with non-standardised coefficients

	(1)	(2)	(3)	(4)
Estimation method	OLS		ppml	
Dependent variable	ln Exports		Exports	
RAdummy_{ikt-1}	0.840***	0.305	0.135	0.068
	(0.226)	(0.232)	(0.197)	(0.257)
RAshare_{ikt-1}	2.084***	1.661***	1.954***	1.062
	(0.605)	(0.602)	(0.535)	(0.822)
Index_{ijkt-1}	−8.807***	−11.862***	−3.420***	−3.778***
	(1.152)	(1.217)	(0.705)	(0.883)
$\text{RAdummy}_{ikt-1}*\text{Index}_{ijkt-1}$		3.756***		0.171
		(0.417)		(0.417)
$\text{RAshare}_{ikt-1}*\text{Index}_{ijkt-1}$		4.273		4.931**
		(2.783)		(2.438)
Log Production_{ikt}	0.864***	0.877***	1.221***	1.221***
	(0.057)	(0.057)	(0.106)	(0.104)
Log (1 + Consumption_{jkt})	0.279***	0.275***	0.136***	0.135***
	(0.030)	(0.030)	(0.023)	(0.023)
Log (1 + Tariff_{ijkt})	−0.343***	−0.347***	0.012	0.013
	(0.070)	(0.069)	(0.080)	(0.080)
RTA_{ijt}	0.223	0.209	−0.116	−0.118
	(0.163)	(0.159)	(0.119)	(0.120)
Log Distance_{ij}	−1.163***	−1.102***	−1.048***	−1.050***
	(0.110)	(0.109)	(0.138)	(0.138)
Contiguity_{ij}	0.032	0.125	0.441*	0.447*
	(0.319)	(0.315)	(0.268)	(0.268)
Common Language_{ij}	−0.050	0.021	−0.079	−0.080
	(0.187)	(0.181)	(0.194)	(0.193)
Colony_{ij}	0.548	0.474	0.373	0.379
	(0.593)	(0.554)	(0.790)	(0.792)
Observations	11,051		87,822	

Notes: Standard errors are clustered at the exporter-importer-product level in parentheses; All estimations include exporter-time, importer-time and product-time fixed effects; Intercepts included but not reported; *** p<0.01, ** p<0.05, * p<0.1.

Table 3.A.2: Exporting countries

Angola	Gabon	Papua New Guinea
Belize	Ghana	Peru
Bolivia	Guatemala	Philippines*
Brazil*	Guinea	Saint Vincent and the Grenadines
Cameroon	Guyana	Samoa
Central African Republic	Haiti	Sao Tome and Principe
Colombia*	Honduras	Sierra Leone
Comoros	India*	Sri Lanka
Congo	Indonesia*	Suriname
Congo (Democratic Republic of the)	Ivory Coast	Tanzania, United Rep. of
Costa Rica	Jamaica	Thailand*
Cuba	Liberia	Togo
Dominica	Madagascar	Trinidad and Tobago
Dominican Republic	Malaysia*	Uganda
Ecuador	Mexico*	Vanuatu
El Salvador	Nicaragua	Venezuela
Equatorial Guinea	Nigeria	
Fiji	Panama	

Notes: * denotes whether a country sets its own MRL regulations.

Table 3.A.3: Importing countries

Albania	Ghana	Norway*
Algeria	Guatemala	Oman*
Angola	Guinea	Pakistan
Antigua and Barbuda	Guyana	Panama
Argentina*	Honduras	Papua New Guinea
Armenia	Hong Kong*	Paraguay
Australia*	Iceland	Peru
Bahamas	India*	Qatar*
Bahrain*	Indonesia*	Russian Federation*
Bangladesh	Iran	Rwanda
Belarus	Israel	Saint Kitts and Nevis
Belize	Ivory Coast	Saint Lucia
Benin	Jamaica	Saint Vincent and the Grenadines
Bhutan	Japan*	Samoa
Bolivia	Jordan	Saudi Arabia*
Bosnia and Herzegovina	Kazakhstan	Senegal
Botswana	Kenya	Seychelles
Brazil*	Kiribati	Sierra Leone
Brunei Darussalam*	Korea*	Singapore*
Burkina Faso	Kuwait*	Solomon Islands
Burma*	Kyrgyzstan	South Africa*
Burundi	Lao People's Democratic Republic*	Sri Lanka
Cambodia*	Lebanon	Sudan
Cameroon	Lesotho	Suriname
Canada*	Macedonia	Swaziland
Cape Verde	Madagascar	Switzerland*
Central African Republic	Malawi	Syrian Arab Republic
Chile*	Malaysia*	Tanzania, United Rep. of
China*	Maldives	Thailand*
Colombia*	Mali	Togo
Congo	Mauritania	Tonga
Costa Rica	Mauritius	Trinidad and Tobago
Croatia	Mexico*	Tunisia
Dominica	Moldova, Rep.of	Turkey*
Dominican Republic	Mongolia	Uganda
Ecuador	Morocco	Ukraine*
Egypt*	Mozambique	United Arab Emirates*
El Salvador	Namibia	United States of America*
Ethiopia	Nepal	Uruguay
European Union*	New Zealand*	Viet Nam*
Fiji	Nicaragua	Yemen
Gambia	Niger	Zambia
Georgia	Nigeria	Zimbabwe

Notes: * denotes whether a country sets its own MRL regulations.

Table 3.A.4: Number of country pairs where importer sets stricter MRLs for pesticides regulated by Codex relevant for cocoa and coffee (2008-2016)

Pesticide residual component		2008	2009	2010	2011	2012	2013	2014	2015	2016
Cocoa										
Clothianidin		692	692	692	692	162	162	162	108	162
Endosulfan*	2	805	320	581	580	580	728	675	673	724
Metalaxyl	2	616	378	432	378	378	432	432	432	486
Methyl-Bromide	FM	744	797	692	850	850	904	851	432	432
Phosphine	FM	304	54	108	54	54	0	0	0	0
Thiamethoxam		745	745	692	745	216	162	162	108	162
Coffee										
Aldicarb*	1a	464	216	270	216	216	216	162	108	162
Alpha-Cypermethrin	2	732	732	372	372	372	426	426	267	214
Azoxystrobin	U	792	792	740	791	790	280	280	174	228
Benomyl*	U	1,050	270	270	1,010	1,010	1,140	1,140	1,188	1,182
Boscalid	U	741	741	740	734	734	878	929	0	54
Buprofezin	3	692	692	692	744	744	850	850	540	594
Carbendazim	U	464	216	270	270	270	270	216	162	162
Carbofuran*	1b	720	535	430	535	536	590	590	590	590
Chlorantraniliprole	U	692	744	741	791	791	895	377	376	376
Chlorpyrifos	2	412	738	336	162	108	228	227	173	173
Clothianidin		692	692	692	692	162	162	162	108	162
Cyantraniliprole		692	692	692	692	692	745	378	319	478
Cyhalothrin*	2	692	692	692	692	692	745	798	798	108
Cypermethrin	2	516	846	390	216	162	282	281	227	227
Cyproconazole	2	738	738	740	736	736	788	340	286	338
Diquat	2	740	740	741	739	739	791	282	228	283
Disulfoton	1a	669	429	484	429	429	483	483	537	537
Endosulfan*	2	813	323	585	534	534	773	721	717	767
Fenpropathrin	2	744	744	744	744	744	797	850	605	605
Flutriafol	2	741	741	741	740	739	480	479	160	160
Glufosinate-Ammonium	2	746	746	739	743	743	322	268	214	160
Haloxyfop	2	692	692	324	270	216	216	216	162	216
Imidacloprid	2	739	739	430	428	374	374	320	266	320
Permethrin*	2	513	795	491	214	161	281	280	279	331
Phorate	1a	516	270	324	270	270	270	216	216	216
Propiconazole	2	567	323	561	282	282	515	512	458	464
Pyraclostrobin		791	552	552	446	446	500	340	287	182
Saflufenacil		692	692	692	692	740	54	54	54	172
Spirodiclofen		741	741	324	270	216	162	162	108	162
Tebuconazole	2	743	741	446	285	285	285	284	231	231
Terbufos	1a	516	482	497	324	324	498	444	444	444
Thiamethoxam		738	738	741	737	426	323	215	161	215
Thiophanate-Methyl	U	745	745	377	743	741	793	795	847	845
Triadimefon	2	636	760	1,000	898	892	1,028	1,028	1,021	1,040
Triadimenol	2	638	393	948	858	853	984	978	972	990
Triazophos*	1b	615	901	1,152	1,108	1,108	1,301	1,301	1,301	1,301
Zeta-Cypermethrin	1b	739	740	378	324	324	378	378	216	162

Notes: * refers to pesticides prohibited by Rainforest Alliance in 2011 (Sustainable Agriculture Network, 2011); Numbers after residue names refer to WHO Hazard Categories 2009 (WHO, 2010): 1a = Extremely hazardous, 1b = Highly hazardous, 2 = Moderately hazardous, 3 = Slightly hazardous, U = Unlikely to present acute hazard, FM = Fumigant, not classified, a blank means information was not reported; We count the EU27 as one country.

Table 3.A.5: Selected empirical studies analysing the trade effect of regulatory heterogeneity

Authors	Products	Years	Exporter	Importer	Measurement of standard	Type of standard	Main findings
Drogué and DeMaria (2012)	2: pears and apples	Panel: 2000-2009	38 countries	40 countries	Similarity index is Pearson's distance; scale: 0-2; 0=similarity, 2=highest dissimilarity; compare importer and exporter	MRL (749 pesticides)	ZINB: + AUS, CAN, CHN, NZL and the EU: + ARG, BRA, CHL, KOR and ZAF: / USA and JAP: –
Winchester et al. (2012)	11 : animal products, fruits & vegetables, cereals, oil seeds	Cross-section: 2009	1: EU (treated as one entity)	9: ARG, AUS, BRA, CAN, CHN, JAP, NZL, RUS and USA	Dissimilarity index; scale: 0-1, 0= exporter equally or stricter than importer (truncated), >0=importer stricter than exporter	Among others MRL (610 pesticides)	Intensive margin of trade: – Extensive margin of trade: /
Xiong and Beghin (2014)	109 products: e.g. Live trees and other plants, vegetables, fruits, cereals, oil seeds	Cross-section: 2008 and 2012	61	20 high-income OECD countries	Stringency index; scale: 0-2.72; 1=importer as strict as Codex, >1 importer stricter than Codex, <1 Importer laxer Codex	MRL (all Homologa pesticides)	Intensive margin of trade: – Extensive margin of trade: /
Ferro et al. (2015)	66: fruits and vegetables, other spices, cereals, oil seed, asparagus preserved	Panel: 2006-2011	61 countries included in Homologa	61 countries included in Homologa	Restrictiveness index; scale: 0-1; 0=least restrictive importer, 1=most restrictive importer Relative restrictiveness index; scale: -1-1; 0=exporter equals importer, 1=importer most restrictive & exporter least restrictive, -1=exporter most restrictive & importer least restrictive	MRL (989 pesticides)	Restrictiveness index: • Extensive margin of trade: – • Intensive margin of trade: / Relative restrictiveness index: • Extensive margin of trade: – (low-high: –, high-low: +) • Intensive margin of trade: + (low-high: /, high-low: +)
DeMaria and Drogue (2016)	4 food classes : fruits, vegetables, cereals and meats	Panel: 2008-2010	20 EU countries and 47 other countries	20 EU countries	Severity index; scale: 0-2.72, 0=exporter equally or stricter than EU (truncated), >0=EU stricter than exporter	MRL (912 pesticides)	PPML: + Extensive margin of trade: + Intensive margin of trade: –
Kareem et al. (2016)	3: tomatoes, oranges, limes & lemons	Panel: 2008-2013	28 African countries	10 EU countries	Restrictiveness index; scale: 0.559-0.652; yearly average MRLs of all pesticides imposed by importer; lower index: importer stricter	MRL (468 pesticides)	Extensive margin of trade: –
Curzi et al. (2018)	698 products	Cross-section: 2014	EU (treated as one country) / 85 countries	EU (treated as one country) / 85 countries	Protectionism index; scale: 0-2.72, 1=importer/exporter=Codex, >1=importer/exporter stricter than Codex, <1=importer/exporter laxer Codex	MRL (359 pesticides)	EU as importer (PPML): • stricter EU standards: OECD: /, non-OECD: – • stricter exporter standards: OECD: /, non-OECD: + EU as exporter (PPML): • stricter EU standards: OECD: +, non-OECD: + • stricter importer standards: OECD: /, non-OECD: /
Kareem et al. (2018a)	3: tomatoes, oranges, limes & lemons	Panel: 2008-2013	34 African countries	5 EU countries: BEL, FRA, NDL, POR, ESP	Protectionism index; scale: 0-2.72, 1=Codex=EU, >1 EU stricter than Codex, <1 EU laxer Codex	MRL (all MRLs regulated by Codex (∼72))	Extensive margin of trade: Tomato: – Oranges, limes & lemons: +
Vural and Akgüngör (2019)	Dried fruits	Panel: 2002-2016	45	EU-28	Heterogeneity index; scale: 0-1, 0=exporter equally or stricter than importer (truncated), >0=Importer stricter than exporter	MRL (aflatoxin)	Extensive margin of trade: – Intensive margin of trade: –

Notes: + if positive trade effect, - if negative trade effect, / if no trade effect.

Chapter 4

The uneven spread of Global G.A.P. certification

Abstract

GlobalG.A.P. compliance has often become a key requirement for farmers to access high-value global markets. Nonetheless, the global spread of certification is highly uneven among countries. We assess the drivers and dynamics behind these unequal patterns, applying panel data regressions. The findings show that global agricultural trade networks and urbanisation remain relevant, but are no longer sufficient in explaining certification. Investing in transportation infrastructure gained in importance to drive the spread of certification. Fostering a favourable business environment - via providing secure land tenure and a functioning judicial system - as well as investing in information infrastructure may facilitate farmers' participation in certification schemes. The stringency of existing public regulations in non-EU countries is helpful for overcoming entry barriers.

This chapter is joint work with Insa Flachsbarth and Bernhard Brümmer, inspired by earlier work of Amjad Masood and Bernhard Brümmer. Nina Grassnick and Insa Flachsbarth contributed to the development of research question and research design, empirical and conceptual framework, data management and writing of the manuscript. Insa Flachsbarth is the corresponding author and responsible for empirical estimations. Bernhard Brümmer reviewed and edited the chapter.

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4.1 Introduction

Food quality and safety standards[44] have become an integral part of global and local agri-food value chains (Swinnen and Maertens, 2007). Supermarket chains and agri-food companies want to drive down transaction costs and secure a sufficient supply of high-quality food, demanded by an increasing number of discerning consumers worldwide (Reardon et al., 2012). Thus, large supermarket chains and agri-food companies - and increasingly also smaller retail chains - demand compliance with increasingly stringent standards from the entire value chain – including requirements for food quality and safety, as well as environmental sustainability and labour standards (Halabi and Lin, 2017).

According to the International Trade Centre Standards Map database, there exist about 236 private food standards worldwide (ITC, 2015). This study focuses on the GlobalG.A.P.[45] standard (hereafter named GlobalGAP), which is one of the most prominent global B2B private agri-food pre-farm-gate process standard (Henson et al., 2011). The number of GlobalGAP certified farmers increased by almost sixfold between the mid-1990s and 2011 (Swinnen, 2016) and by more than 50% between 2010 and 2015 (GlobalGAP, 2015). In 2018, more than 30 European and fifteen non-European retail chains - predominantly located in high-income countries - required proof of GlobalGAP certification (mostly of fruits and vegetables) from their suppliers (GlobalGAP, 2018b). Moreover, in developing countries, the retail sector has undergone a tremendous transformation from traditional retail systems to modern grocery stores with the associated demand for high-quality certified food (Weatherspoon and Reardon, 2003; Reardon et al., 2003, 2012). Thus, for farmers around the world to successfully access high-value modern retail markets, it is essential to comply with the private food quality standard and become certified (Fiankor et al., 2019). This is especially pertinent considering the continuing relevance of agriculture for livelihoods in rural areas of developing countries.[46]

However, the global spread of GlobalGAP – and other important certification schemes – is observed to be uneven. While some regions perform well in adjusting to the sector's transformation, other world regions lag behind and show low or zero certification rates of farmers. These unequal patterns of the global diffusion of food quality standards remain poorly understood, as the underlying macroeconomic determinants of standard adoption have not been thoroughly investigated. The existing literature mainly focuses on farm-level determinants of adoption decisions of standards in specific countries (see e.g. Kleinwechter and Grethe, 2006; Asfaw et al., 2009; Kersting and Wollni, 2012). The literature explaining global diffusion patterns at the macro level is scarce and relies on cross-sectional data only. For the agricultural sector, to the best of our knowledge, the only studies analysing the global scale of diffusion have been conducted by Herzfeld et al. (2011) and Mohammed and Zheng (2017). Herzfeld et al. (2011)

[44] Note that we use the terminology food quality standard and certification interchangeably in our study.

[45] GlobalG.A.P. stands for Global Good Agricultural Practices. For details on the private standard, see http://www.globalgap.org.

[46] In the development context, there is an ongoing scientific debate on whether standards are catalyst or barriers to trade. High certification costs and technical requirements for GlobalGAP certified farmers may act as market entry barriers for the poorest farmers. By contrast, the most productive farmers gain more market share (e.g. Handschuch et al., 2013). Since our study uses country-level data, we cannot shed light on these intra-country heterogeneities. Instead, we focus on the macro environment either hampering or fostering standard adoption.

mainly find that third-party certification for export purposes reinforces already-existing trade relations but potentially hampers new entrants. In addition, Mohammed and Zheng (2017) find that a large distance to Europe and the US impedes standard adoption rates. Both studies use cross-sectional data, and thus provide a snapshot of only one year and neglect the dynamics of standard diffusion.

This study attempts to close the knowledge gap that exists at the global macro scale. Specifically, we aim to answer the following RQs: (1) What are the factors explaining why some countries are left out of the GlobalGAP market, i.e. show zero certified farmers? (2) What factors drive high certification rates? Since GlobalGAP is no (longer) limited to certain products but continuously gaining relevance for many agricultural products, our analysis considers the aggregate scope 'crops' to capture all certified farmers globally. This allows us to make more general statements on the GlobalGAP diffusion process across countries.

We conceptualise these two RQs on the grounds of Rogers' (1995) model of the diffusion of innovations. The GlobalGAP standard can be viewed as an organisational innovation, because farmers choose to adapt standard-specific novel processes to comply with the strict requirements to become certified. Based on this, we derive our Data Generating Process (DGP) and develop specific hypotheses for an array of macro variables regarding their effect on the two RQs. Our empirical model uses a global panel dataset from 2008 to 2014, with the number of certified crop producers per country as the dependent variable. To the best of our knowledge, our study is the first macro study on the topic using panel data. This allows us to incorporate dynamics and minimise modelling problems arising from endogeneity. To answer the two RQs, we use two dependent variables: (1) a binary variable (adopting or non-adopting country); and (2) an integer non-negative number counting the certified farmers per country and year. In the former, we apply a logit model, while the latter requires a negative binomial model that deals with overdispersion appropriately. The time dimension in our data allows us to use a random effects model with an AR1 error structure to reduce problems related to temporal and spatial autocorrelation. Thus, the panel structure allows for superior econometric models compared with those used in the aforementioned cross-sectional studies.

The remainder of this chapter is organised as follows. Section 4.2 develops the conceptual framework and hypotheses, before Section 4.3 explains the empirical model and the underlying data. Section 4.4 presents and discusses the empirical results, before Section 4.5 concludes and offers policy recommendations. We also refer to the Appendix for a detailed background information on the evolution and meaning of the private food standard GlobalGAP (see Appendix section 4.A.1) and existing scientific literature regarding the adoption and diffusion process of private food standards (see Appendix section 4.A.2). Moreover, supporting information on methods and the descriptive results is provided in the Appendix sections 4.A.4 and 4.A.6 for the sake of brevity.

4.2 Conceptual framework and hypotheses

The DGP for analysing the spread of GlobalGAP certification is grounded on the concepts from the field of organisational innovations. In our context, we refer to innovations as "new firm practices", i.e. innovative production processes and technologies as defined by Nelson and Winter (1982). We understand the GlobalGAP standard as an innovation because it aims at the adoption of "safe and sustainable [production] practices" by agricultural producers worldwide (GlobalGAP, 2015, p.2). Within the field of organisational innovations, we are specifically interested in the underlying process of GlobalGAP diffusion across and within different countries. Here, we distinguish two definitions of diffusion: (1) those factors that make standard adoption generally (im)probable in a country (see RQ1 in introduction), and (2) those macro factors explaining a fast spread within a country (see RQ2). There is a sizeable theoretical literature aiming to explain the diffusion process of innovations, but with a great diversity in behavioural and informational assumptions. In our context, choosing among the vast number of theoretical models[47] for the DGP is difficult because we follow an explorative approach rather than concentrating on a specific variable. Thus, we consult different theories within the field of organisational innovations to appropriately derive all relevant variables and the corresponding hypotheses.

The well-established theoretical model by Rogers (1995) offers a useful starting point for studying the diffusion process of GlobalGAP as an innovation. Accordingly, the certification process comprises four phases. The main mechanisms in each phase are briefly described in the following paragraphs. For further explanation, see Table 4.1 and Appendix section 4.A.3.

During the information phase (1), the producer is - by chance - exposed to information about the existence of the private food standard and gains a first understanding of the requirements to comply. Awareness of the standard is necessary before making a certification decision. The information effect is often modelled by network or contagion theories, which is borrowed from the epidemiology literature (Young, 2009). Examples of such network models can be found in Bass (1969), Bass (1980), Easley and Kleinberg (2010), Valente et al. (2015) or Ferrier et al. (2016). These models consider social network structures relevant for initiating and accelerating the diffusion process. Networks compose 'nodes', which are the different agents within a social network, and 'links' connecting these agents. These links can be understood as channels of information required in the decision-making process of adoption, flowing quickly from one farmer to another. Thus, we use proxies for facilitated information flow at the macro level.

A notable limitation of contagion models is that they provide no clear reason why a producer would adopt an innovative practice. During the next phase – the persuasion phase (2) – the producer is in the process of bringing about an adoption decision based on a rational evaluation of the associated costs and benefits. Proxy variables at the macro level relate to aspects of market power, the degree of agricultural sector development, risk-taking behaviour and the home market effect.

After the two described phases, the producer has decided that adoption is generally benefi-

[47] For a literature review and comparison between determinants of adoption of technological or organisational innovations, see e.g. Alänge et al. (1998), Sunding and Zilberman (2001) and Young (2009).

cial, and thus the implementation phase (3) follows. Despite having perceived the standard as favourable, the cost of implementation can still vary across countries, which leads to comparative advantages of some countries over others.[48] Thereby, (a high rate of) adoption becomes more probable in some countries than in others. Variables that serve this context describe the macroeconomic conditions and the business environment in countries. Further infrastructure matters, as well as the (sectoral) policy setting.

The final confirmation phase (4) is characterised by maintaining the certification after successful adoption. Since GlobalGAP certification needs to be renewed annually, this phase holds particular importance for the spread of the standard, but it is not useful for explaining the extensive margin (RQ1). Relevant variables should proxy the financial capacity of farmers and financial support to farmers.

Table 4.1 provides an overview of all relevant variables that play a role in each of Rogers' (1995) phases in the specific GlobalGAP context and derives the corresponding hypotheses. For the sake of brevity, we refer to Appendix section 4.A.3 for a more complete description of the concrete pathways and the relevant variables in the GlobalGAP diffusion process.

Admittedly, there is a discrepancy between our scale of analysis at the country level and the scale of Rogers' (1995) model, which operates at the micro level. However, since adoption decisions take place precisely at the micro level, a theoretical micro-foundation seems appropriate. Instead of using micro-level data, we identify those (macro) factors that frame individual behaviour but are beyond the reach of individual producers.[49] This approach obviously obscures within-country heterogeneity. However, arguing similarly to Herzfeld et al. (2011), this simplification still yields important between-country variation in variables relevant for the diffusion process. Due to this scale problem, we apply the conceptual framework for both RQs in analogy. This means that some farmers of the same country will still be in phase (1) while others are already certified and in phase (4). The lack of farm-level data makes a-priori assumptions about which phase is allocated to RQ1[50] – the probability of non-adoption in some countries – or RQ2 – the intensification of certification – impossible.

[48] Since GlobalGAP certified produce is largely produced for export markets, the notion of comparative advantages of countries is of key relevance in modelling adoption decisions.

[49] Ideally we would need to use farm-level data for each country and combine it with macro data.

[50] The wording - e.g. 'increase in adoption probability' - or similar expressions equivalently refer to the reverse hypothesis of the likelihood of being in the group of 'zero certified farmers country' relevant for RQ1.

Table 4.1: Conceptual framework and hypotheses

Rogers' phases	Channel	Variable	Hypothesis	Ground
Information phase	Local network ties	Certification rate neighbours	+	Awareness about existence of standard is needed to consider adoption. Sharing experience reduces uncertainty about initial investment risks.
		Urbanisation rate	+	Agglomeration economies drive down costs and network effects facilitate information flow about the standard.
	Global network ties	Trade networks with EU	+	Awareness of the existence of the standard. Cohesion of organisational practices between markets.
		Colonial history with EU6	+	Common culture with most important GlobalGAP demanding countries and knowledge of 'binding' documentation language reduces transaction costs.
	Infrastructure	Transport (road density)	+	Better market access accelerates information flow.
		ICT	+	Better ICT eases information flow.
	Structure agricultural sector	Horticultural production share	+	Historical relevance of GlobalGAP in horticulture makes GlobalGAP more likely.
Persuasion phase	Market power	Trade with EU	+	EU retail chains (as largest world market) increasingly require GlobalGAP certification by suppliers.
	Sophistication in agriculture	Agricultural capital stock	+	Countries with high degree of input use and mechanisation have comparatively lower initial investment costs and higher productivity.
		Agricultural export share	+	Countries with traditionally well-established export sector have comparatively lower initial investment costs.
	Risk-taking behaviour	GDP per capita	+	Wealthier farmers (usually located in richer countries) usually show lower level of risk aversion and are more likely to take initial investment risk.
	Home market effect	Population size	+	If home demand is large, the produce can also be sold in home markets.
		Urbanisation	+	Domestic supermarkets located in urban centres will likely increase the demand for high-quality produce.
Implementation phase	Macroeconomic conditions	Inflation rate	-	High inflation reduces investment and thereby prevents adoption decisions.
		Exchange rate	-	An overvalued exchange rate reduces returns on investment in the tradables sector, e.g. GlobalGAP produce, and thereby can prevent adoption decisions.
	Business environment	Doing business indicators	+	High quality of business environment drives innovative action in countries, due to lower costs and makes certification more profitable.
		Conflict-related deaths	-	An insecure environment hampers (international) investment decisions.
	Infrastructure	Transport (road density)	+	Better infrastructure reduces trade costs and thereby increases competitiveness.
		Landlocked	-	Higher transportation costs.
		ICT	+	Lower costs of documentation and traceability.
	Agricultural sector policies	Public regulations (MRLs)	+	Existing public regulations in the food sector reduce initial investment costs.
		Development flows to agriculture	+	Developing countries' agricultural sector supported by donors are likely to have comparatively higher developed agricultural systems and smallholders are supported in paying certification fees.
		International Organization for Standardization (ISO) membership	+	Existing ISO certification in the food sector reduces initial investment costs.
Confirmation phase	Financial capacity	GDP per capita	+	Wealthier countries have likely more wealthy farmers that can bear the annual certification costs.
	Financial support	Development flow to agriculture	+	Recurrent certification fees are supported by donors.

Note: The conceptual framework serves as the DGP for both research questions. A positive sign in the "Hypothesis" column refers to: (RQ 1) either a higher probability of *NOT* being in the zero certification group of countries, or (RQ 2) a higher probability of an increasing number of certified farmers.

4.3 Empirical model and data

4.3.1 Empirical models

The DGP derived above holds for both RQs, but we need two different empirical models respectively. RQ1 requires a logit estimation due to its binary dependent variable. To account for unobserved country heterogeneity and spatial dependency, we apply a random effects[51] logit model. The conditional probability of the panel binary choice model is as follows:

$$Pr(y_{i,t} = 1|x_{i,t}, \alpha_i) = \mathbf{x}_{i,t}^{'}\beta + \alpha_i + \epsilon_{i,t}, \tag{4.1}$$

where $Pr(y_{i,t} = 1)$ is the probability of a positive certification rate due to farmers' decision to adopt GlobalGAP, i indexes country, t (t = 2009, ..., 2014) indexes year, α is the random intercept of country i, $\epsilon_{i,t}$ is the uncorrelated zero-mean residual, and $\mathbf{x_{i,t}}$ are explanatory variables (including a constant) with their corresponding coefficients β as defined below.
To empirically model RQ2, we apply a count data model, because the dependent variable is an integer non-negative number. Generally, Poisson models can deal with count data if the assumption of an underlying Poisson process is fulfilled (Winkelmann, 2008). However, this may be violated in our case, as the variance of our dependent variable exceeds its mean by far.[52] If equidispersion cannot be achieved by including relevant regressors in the Poisson specification, we need to specify a negative binomial model taking the form:

$$\begin{aligned} &Pr(Y_{i,} = y_{i,t}|x_{i,t}, u_i) = \frac{\Gamma(y_{i,t} + \theta)}{\Gamma(y_{i,t} + 1)\Gamma(\theta)} r_{i,t}^{\theta}(1 - r_{i,t}^{y_{i,t}}), \\ &r_{i,t} = \theta(\theta + exp(\sigma_i)\lambda_{i,t}), \\ &\lambda_{i,t} = exp(\alpha + \mathbf{x}_{i,t}^{'}\beta + \epsilon_{i,t}), \end{aligned} \tag{4.2}$$

where $y_{i,t}$ is the number of certified farmers producing any permanent or temporary crop per country and year (including zeros), u_i is the random effect over country i, which is incorporated to account for unobserved heterogeneity, and θ is the overdispersion parameter to be estimated and it serves as a more formal test of overdispersion (Greene, 2007). Following specification tests (see Appendix section 4.A.4), we consider temporal autocorrelation, which makes our error term $\epsilon_{i,t} = \rho\epsilon_{i,t-1} + \omega_{i,t}$, with $\mid \rho \mid < 1$ being the autocorrelation parameter and $\omega_{i,t}$ is the error term with $\omega_{i,t} \sim_{iid} N(0, \sigma^2)$.
Additionally, the high share of zeros in our dependent variable (45 percent) may add to the problem of overdispersion. Sometimes a zero-inflated count data model can appropriately deal with many zeros, but only if the zero counts belong to two different DGPs (Winkelmann, 2008). Herzfeld et al. (2011) precisely argue that there are heterogenous groups of countries in their

[51] The non-zero and statistically significant ρ is reported in the Appendix regression Table 4.A.3. It confirms that a random effects logit model is superior over the pooled model. Alternatively to a random effects specification of our model, we could use a fixed effects specification with less strict assumptions about exogeneity. Since this would entail the incidental parameter problem (Wooldridge, 2002), we stick to random effects.

[52] The mean of the dependent variable is 602 and its variance 6690634.

cross-country dataset. They assume that one group shows structural zeros in which standard adoption is infeasible or where GlobalGAP plays no economic role. The other group of countries may show zeros, but with the option to gain certification status at a later point in time. We question the assumption that the zero-certified countries in our panel dataset belong to two different DGPs for various reasons. First, the dependent variable is not a latent variable, since there is no interest in underreporting. Second, over the years GlobalGAP has evolved towards global market relevance, including because global retail chains are increasingly harmonising their standards. There are hardly any countries without any benefit or interest per se in GlobalGAP certification. Our data shows that even some small island states far away from the core GlobalGAP European market show positive certification numbers nowadays. This indicates that all 'zero-countries' are somehow structurally left out of the market, i.e. forming one group of zeros with the same DGP. Third, our panel data structure allows us to observe the adoption behaviour of farmers in different countries over several years. We find that non-adopting countries either show zeros in every year, or they switch from zero to a very low number of farmers, which should be driven by similar processes.[53]

To formally check for the preferred model specification, we start testing the Poisson assumption of equidispersion of the dependent variable. A rejection of equidispersion allows us to proceed with the negative binomial model. We compare a specification with and without random effects. Furthermore, we test whether zero-inflation remains a problem after having incorporated the dispersion parameter in the estimation. Model selection is based on the Akaike Information Criterion (AIC) and likelihood ratio tests. Further, we check the behaviour of the residuals of each model using the R package DHARMa (Gelman and Hill, 2006; Hartig, 2019). After selecting an appropriate model type, we refine the specification towards a more parsimonious model. For this purpose, we omit those variables with z-values$<$1 in the full models. Finally, we compare the full model (Equation 4.3 below) with the parsimonious models (Equations 4.4 and 4.5 below) by a likelihood ratio test. For details of model selection, see Appendix section 4.A.4. The results in Section 4.4 only present the final parsimonious models.

4.3.2 Model specification and data

Our global panel dataset contains information on the number of certified farms per country and year for a time period between 2008 and 2014. Corresponding to the conceptual framework, we define the regressors with the corresponding parameters to be estimated in both (full) models

[53] We additionally specify a panel zero-inflated negative binomial model to test the above-described assumption. However, specification tests are ambiguous (see Appendix section 4.A.2) and the model in its panel version is still somewhat underdeveloped, leading to high instability of the model. Therefore, we highly question the results' reliability. Our estimation results in stage one provided unrealistically high coefficients and model conversion was problematic. The results can be obtained from authors upon request.

as follows:

$$
\begin{aligned}
\mathbf{x}_{i,t}^{'}\beta = & \beta_0 + \beta_1 \text{GGAPN}_{i,t-1} + \beta_2 \text{Urban}_{i,t} + \beta_3 \text{ExEU}_{i,t-1} + \beta_4 \text{Colony}_i + \beta_5 \text{Road}_{i,t} \\
& + \beta_6 \text{www}_{i,t} + \beta_7 \text{FV}_{i,t-1} + \beta_8 \text{Agcap}_{i,t-1} + \beta_9 \text{ExCrop}_{i,t-1} + \beta_{10} \text{GDPpc}_{i,t} \\
& + \beta_{11} \text{GDPpc}^2_{i,t} + \beta_{12} \text{Pop}_{i,t} + \beta_{13} \text{I}_{i,t} + \beta_{14} \text{XR}_{i,t} + \beta_{15} \text{DB}_{i,t} + \beta_{16} \text{Conflict}_{i,t} \\
& + \beta_{17} \text{lock}_i + \beta_{18} \text{MRL}_{i,t} + \beta_{19} \text{DevAg}_{i,t} + \beta_{20} \text{ISO}_{i,t}
\end{aligned}
\tag{4.3}
$$

The preferred and more parsimonious logit equation is as follows:

$$
\begin{aligned}
\mathbf{x}_{i,t}^{'}\beta = & \beta_0 + \beta_1 \text{GGAPN}_{i,t-1} + \beta_2 \text{Urban}_{i,t} + \beta_3 \text{Colony}_i + \beta_4 \text{www}_{i,t} + \beta_5 \text{FV}_{i,t-1} \\
& + \beta_6 \text{ExCrop}_{i,t-1} + \beta_7 \text{GDPpc}_{i,t} + \beta_8 \text{DB}_{i,t} + \beta_9 \text{MRL}_{i,t} + \beta_{10} \text{ISO}_{i,t}
\end{aligned}
\tag{4.4}
$$

The preferred and more parsimonious negative binomial equation is as follows:

$$
\begin{aligned}
\mathbf{x}_{i,t}^{'}\beta = & \beta_0 + \beta_1 \text{GGAPN}_{i,t-1} + \beta_2 \text{Urban}_{i,t} + \beta_3 \text{ExEU}_{i,t-1} + \beta_4 \text{Colony}_i + \beta_5 \text{Road}_{i,t} \\
& + \beta_6 \text{www}_{i,t} + \beta_7 \text{ExCrop}_{i,t-1} + \beta_8 \text{DB}_{i,t} + \beta_9 \text{Conflict}_{i,t} + \beta_{10} \text{DevAg}_{i,t} \\
& + \beta_{11} \text{ISO}_{i,t}
\end{aligned}
\tag{4.5}
$$

Note that all continuous covariates are z-transformed for normalisation purposes. This facilitates model conversion and allows for easier comparability of the estimated coefficients. To avoid estimation problems arising from reverse causality, some variables are lagged by one year in the regressions. This has the downside of losing one estimation year, leaving us with data for the time period from 2009 through to 2014. As a size control, we also include cropland in hectares in the logit model. In the negative binomial model, we apply cropland as an offset variable, so the interpretation of estimated coefficients refers to the 'number of certified producers per hectare cropland'. In the following, we describe the covariates that are relevant for our model specifications in its parsimonious form (Eqs. 4.4 and 4.5).

The covariate $GGAPN_{i,t-1}$ serves as a proxy for local network ties (information phase) and measures the sum of the number of neighbouring countries' certified crop producers in the previous year. Local network ties are also proxied by the percentage of the urban population among the total population ($Urban_{i,t}$). At the same time, the urbanisation rate proxies the home market effect (persuasion phase). Global network ties to the EU are represented by two variables: first, the binary variable $Colony_i$ (information phase), equalling one if the country has a colonial relationship with one of the top GlobalGAP consumer markets – the EU6 countries, namely Belgium, France, Germany, Italy, the Netherlands, or Spain; and second, $ExEU_{i,t-1}$ gives the one-year lag of the crop export share to EU27 in world crop exports (information phase). Existing trade networks with the EU ($ExEU_{i,t-1}$) not only proxy facilitated information flow, but simultaneously proxy the market power behaviour of EU retailers over farmers worldwide (persuasion phase). The horticultural production share (over total crop production) within countries (information phase) is given by the lagged variable $FV_{i,t-1}$.

As infrastructure variables (information phase and implementation phase), we include road density per km² ($Road_{i,t}$) and the share of population with a fixed broadband subscription ($www_{i,t}$).

The one-year lagged variable of country i's total crops export share in total exports $ExCrop_{i,t-1}$ (persuasion phase) serves as a proxy for the degree of the sector's sophistication. $GDPpc_{i,t}$ is a proxy for the sector's aggregate risk-taking behaviour as well as the general financial capacity of the country's farmers (persuasion phase and confirmation phase).
The general business environment of a country is proxied by a Doing Business (DB) indicator ($DB_{i,t}$) (implementation phase). A principal component analysis is applied to generate one single variable ($DB_{i,t}$) that comprises information of four DB indicators (relevant for our purpose) released by the World Bank, namely registering property, obtaining credit, trading across borders and enforcing contracts. The principal component analysis reveals that this component explains around 68% of the variation. The investment climate is also influenced by a country's political stability (implementation phase), which is proxied by the number of conflict-related deaths normalised by the population size ($Conflict_{i,t}$).
We use three sector policies that we hypothesise to influence certification decisions. First, existing domestic public regulations in the food market are proxied by the MRLs of pesticides applied (implementation phase). Since pesticide regulations substantially vary across products and pesticides, we transform the absolute value of the MRL given in mg/kg and construct a strictness indicator that makes MRL regulations comparable across countries and products. We follow Ferro et al. (2015) and construct the index as follows:

$$R_{i,p,t} = \frac{1}{N(a)} \sum_{n(a)=1}^{N(a)} \frac{MAX_{p,a,t} - MRL_{i,p,a,t}}{MAX_{p,a,t} - MIN_{p,a,t}} \tag{4.6}$$

where $MAX_{p,a,t} = max_{i \in I}\{MRL_{i,p,a,t}\}$ is the maximum MRL (lease strict) for product p, pesticide a, and year t across all countries and $MIN_{p,a,t} = min_{i \in I}\{MRL_{i,p,a,t}\}$ is the corresponding minimum MRL (most strict). $MRL_{i,p,a,t}$ is the country i's specific MRL regulation for pesticide a, for product p in year t. This index is a normalisation of the product-specific pesticide regulation to values between zero (least strict) and one (most strict) countries, relative to the whole sample. Since we need one strictness index for all products produced in one country, we take the weighted mean over all products according to their production share within one country. This gives us the final index used in the regressions as mentioned in Eqs. 4.3 and 4.4:

$$MRL_{i,t} = \frac{\sum_{n(p)=1}^{N(p)} R_{i,p,t} * Q_{i,p,t}}{\sum_{n(p)=1}^{N(p)} Q_{i,p,t}} \tag{4.7}$$

where $Q_{i,p,t}$ is the quantity produced of product p, in country i in year t.
The second sector policy variable included is development flows to agriculture ($DevAg_{i,t}$) (implementation phase and confirmation phase), which is normalised by the country's agricultural GDP. Finally, a country's ISO membership status is included as a dummy variable ($ISO_{i,t}$) equalling one if country i is ISO member in year t (implementation phase).

Additionally, the following covariates are included in the full model specification (Eq. 4.3). We hypothesise that a country being landlocked plays a role in deciding for certification (implementation phase) and is measured by a dummy variable ($lock_i$) equalling one if country i is landlocked. As a proxy for agricultural productivity, we use the lag of agricultural capital

Table 4.2: Descriptives 2009-2016

	Non-certified producers				Certified producers					
Variable	**Mean**	**sd**	**min**	**max**	**Mean**	**sd**	**min**	**max**	**Difference**	**Source**
GlobalGAP producers (no.)	0	0	0	0	1166.60	3581.96	1	32550	-1166.60***	GlobalGAP
GlobalGAP producers neighbouring countries (sum)	922.34	2486.56	0	16328	3637.34	8063.13	0	65410	-2715.00***	GlobalGAP
Export share crops EU - world	0.31	0.31	0	1	0.44	0.3	0	0.99	-0.13***	UN Comtrade
Fruits and vegetables area share	0.21	0.23	0.01	0.99	0.17	0.22	0.01	1.63	0.05**	FAOSTAT
Net agricultural capital stock per agr. GDP	1.84	2.35	0.08	19.19	2.44	2.06	0.18	13.81	-0.60***	FAOSTAT, Worldbank
Export share crops - total exports	0.08	0.15	0	0.91	0.07	0.1	0	0.7	0.01	UN Comtrade
Inflation rate	0.05	0.07	-0.05	0.62	0.05	0.05	-0.08	0.39	0.01*	Worldbank
Exchange rate (LCU/USD)	732.48	2484.7	0	19068.42	673.96	2768.34	0	25941.66	58.52	Worldbank
Doing Business (principal component)	-0.55	1.31	-3.62	3.29	0.62	1.27	-3.72	3.19	-1.17***	Worldbank
Maximum Residue Limits (Index 0-1)	0.01	0.03	0	0.25	0.09	0.13	0	0.77	-0.08***	Homologa Database
Development flows to agr. per agr. GDP	0.01	0.02	0	0.18	0.01	0.02	0	0.13	0.01***	FAOSTAT, Worldbank
Conflict-related deaths per Mio. persons	8.83	58.55	0	709.39	4.22	29.76	0	521.73	4.61	UCDP, Worldbank
Urban population (population share)	47.8	23.93	8.55	100	62.42	20.85	14.19	97.82	-14.62***	Worldbank
Road density (per km2)	0.59	0.97	0.01	5.42	0.85	1.31	0.02	9.68	-0.26***	CIA, Worldbank
Fixed broadband subscriptions (population share)	0.05	0.09	0	0.37	0.13	0.14	0	1.05	-0.08***	Worldbank
GDP per capita ('000 current USD)	10275.72	18974.67	204.94	119225.38	16254.20	19718.03	341.31	103059.25	-5978.48***	Worldbank
Colonial history with EU6 (1=yes)	0.35	0.48	0	1	0.35	0.48	0	1	0.01	CEPII
ISO membership (1=yes)	0.31	0.46	0	1	0.8	0.4	0	1	-0.49***	ISO
Landlocked (1=yes)	0.25	0.43	0	1	0.17	0.38	0	1	0.08***	CEPII
Cropland (in million ha)	3.35	12.92	0	123.84	12.54	28.39	0	169.72	-9.19***	FAOSTAT

stock (normalised by agricultural GDP) $Agcap_{i,t-1}$ (persuasion phase). To control for the effect of macroeconomic conditions (implementation phase), the inflation rate ($I_{i,t}$) and the exchange rate ($XR_{i,t}$) are included. In the full model, we additionally include $GDPpc^2_{i,t}$ as a proxy for the sector's aggregate risk-taking behaviour as well as the general financial capacity of the country's farmers (persuasion phase and confirmation phase). The squared term is only included in the negative binomial regression to account for concavity. A size control variable that can also serve as a proxy for the home market effect is the number of inhabitants per country $Pop_{i,t}$ (persuasion phase). In the logit regression for RQ1, we exclude the squared term of the GDP variable ($GDPpc^2_{i,t}$), because there should not be concave behaviour when the dependent variable is binary. We further exclude $Pop_{i,t}$ in the logit model, because it behaves highly collinear with the cropland variable, which needs to be used as a size control (for details see above).

Our baseline sample includes 168 countries,[54] which are listed in Appendix Table 4.A.4. Since GlobalGAP is developed and quasi-mandatory in the EU, EU crop producers are more likely to comply with it. Thus, to ensure that our results are not solely driven by the EU, we re-estimate the baseline model (see column (1) in Tables 4.3 and 4.4) excluding all EU countries (see column (2) in Tables 4.3 and 4.4). Furthermore, we explore the dynamics of the diffusion process by interacting all variables with a dummy equalling one for 2012-2014 period (see column (3) in Tables 4.3 and 4.4). This shows if different drivers are relevant in later than in earlier years.

The descriptive statistics of all variables, their units measured, and the corresponding data sources are provided in Table 4.2. The sample is divided into countries showing at least one certified producer versus countries without any certificates. Assuming non-normal distributions of the dummied variables, we use Wilcoxon rank sum tests, while we use a t-test for all other variables to test for statistical significance of the differences in the means of the two country groups. We find them all to be statistically different, except for colonial history, conflict-related deaths, crop's export share to world among total exports and exchange rate.

4.4 Results and discussion

Our empirical modelling exercise sheds light on the underlying forces of some of the distributional and growth patterns of GlobalGAP certificates around the world. The Appendix section 4.A.6 illustrates the descriptive results. This section is confined to presenting the empirical modelling results only.

Table 4.3 shows the results of the logit model.[55] The model identifies those determinants that explain the probability of showing at least one certified farmer, we call this overcoming the *barriers to entry* the certification market. Here, odds ratios are reported with a value above one meaning an increase in the odds of entering the certification market if the covariate increases by one standard deviation. By contrast, a value below one means that the odds of certification decreases with a one standard deviation increase of the covariate. For the logit model, we

[54] We had to drop 27 countries due to missing data of important variables. However, most of these countries are small island states with only very limited agricultural production potential.

[55] The estimates are generated using the statistical software StataSE 15 and the command xtlogit.

limit the interpretation of the estimated odds ratios to a positive effect or negative effect and an increasing or decreasing effect (when looking at interaction terms). The reason for not interpreting it in percent changes is that the signs and general tendencies are robust across different model specifications, but the magnitudes vary.
The negative binomial model presented in Table 4.4 shows why some countries show higher certification rates compared with others, whereby we call this the *spread* of certification.[56] Here, incidence rate ratios are reported, which can be interpreted as a factor change of the dependent variable due to a one standard deviation increase in the independent variable. Again, values below one can be interpreted as a negative effect on certification rates, and values above one as a positive effect. The negative binomial estimations give us more confidence to also interpret the magnitude of estimates, because they are more stable across different model specifications and the magnitudes are more moderate than the logit estimations.[57] Only the dynamic changes via interaction terms are limited to a 'more/less than the first period' interpretation. Each variable in both Tables 4.3 and 4.4 is assigned to the corresponding Rogers' phases derived in Section 4.2. Additionally, the Appendix Table 4.A.3 shows the corresponding coefficients of the full and parsimonious model specification for the full sample.

4.4.1 Global results

Regarding RQ1 concerning what are the factors explaining why some countries are left out of the GlobalGAP market in the full sample (Table 4.3 column 1), we find positive and statistically significant effects for the variables *Sum of GlobalGAP producers in neighbour countries*, *Colonial history with EU6*, *Urbanisation*, *Share of fixed broadband subscription*, *Crop export share over total exports*, *Doing business*, and *ISO membership*. This means that variables from the first three of Rogers' stages can all pose relevant entry barriers to GlobalGAP at the macro level. The only negative covariate is *GDP per capita*, which is a surprising result at first sight. This effect is driven by high-income countries without a considerable amount of agricultural land.[58] In other words, close local and global network ties, adequate information infrastructure, a strong focus on agricultural trade, a favourable business environment and membership of an international standard-setting community increase the probability of initiating the certification process. The latter effect was also found by Herzfeld et al. (2011) in their cross-sectional analysis. Furthermore, the positive effect of urbanisation is expected as less urbanised countries are typically also among the poorer countries, where the supermarket revolution is still in its earlier stages of development (Reardon et al., 2003, 2012).

[56]The estimates are generated using the statistical software R version 4.0.4 and the package glmmTMB (Magnusson et al., 2020).
[57]Since RQ2 aims to find the drivers of changes in certification numbers, magnitudes seem more relevant here than for the logit model, where we have a binary dependent variable.
[58]If we run the regression omitting countries with very high GDP per capita and very low agricultural land – e.g. oil-exporting countries – the sign switches to be positive. The results can be obtained from authors upon request.

Table 4.3: Determinants of the probability of adopting GlobalGAP (RQ1)

VARIABLES	Standard deviation	Full sample (1) RQ1 Logit Odds ratios	Non-EU (2) RQ1 Logit Odds ratios	2nd period (3) RQ1 Logit Odds ratios	Roger's phases / Trend
GlobaGAP neighbouring countries (lag)	6079.966	9.023*	8.922	21.431**	I
		(11.66)	(13.44)	(28.714)	
Fruits and vegetables area share (lag)	0.228	0.291	0.208*	0.118***	I
		(0.223)	(0.169)	(0.075)	
Colonial history with EU6 (dummy)		14.96*	144.8***	13.156*	I
		(21.99)	(263.6)	(19.430)	
Urbanisation	23.309	4.032*	5.649*	15.111***	I, II
		(2.965)	(5.037)	(13.672)	
Fixed broadband subscriptions	0.130	13.10***	10.22**	9.919**	I, III
		(12.25)	(10.03)	(10.639)	
Crops export share (lag)	0.125	2.127*	2.002	7.814***	II
		(0.864)	(0.868)	(4.650)	
GDP per capita	19625.962	0.091***	0.260	0.041***	II, IV
		(0.065)	(0.282)	(0.039)	
Doing Business indicator	1.408	3.129*	2.548	4.636*	III
		(1.986)	(2.191)	(3.733)	
Maximum Residue Limits	0.109	11.16	65.17**	23.599**	III
		(17.21)	(119.3)	(36.519)	
ISO membership (dummy)		32.63***	10.11**	121.16***	III
		(34.75)	(11.09)	(162.890)	
Cropland	23.681	3.201	4.326*	3.006	
		(4.411)	(3.771)	(2.683)	
2nd period				0.336	
				(0.324)	
GlobaGAP neighbouring countries (lag)				0.972	
*2nd period				(1.351)	
Fruits and vegetables area share (lag)				3.052**	↑
*2nd period				(1.478)	
Colonial history with EU6 (dummy)				1.054	
*2nd period				(1.247)	
Urbanisation				0.251**	↓
*2nd period				(0.176)	
Fixed broadband subscriptions				1.176	
*2nd period				(1.271)	
Crops export share (lag)				0.077***	↓
*2nd period				(0.071)	
GDP per capita				1.312	
*2nd period				(1.181)	
Doing Business indicator				1.473	
*2nd period				(0.854)	
Maximum Residue Limits				0.306	
*2nd period				(0.441)	
ISO membership (dummy)				1.204	
*2nd period				(1.221)	
Constant		0.647	0.668	0.791	
		(0.702)	(0.852)	(0.948)	
Observations		985	826	985	
Random effects		YES	YES	YES	

Note: *** p<0.01, ** p<0.05, * p<0.1; I = Information phase, II = Persuasion phase, III = Implementation phase, IV = Confirmation phase; standard deviation of full sample; Odds ratio: to be interpreted as an increase in the odds if odds ratio is above one and decrease if odds ratio is below one; Cropland is included as a control variable; Trend in last column refers to the arrows after interaction terms only.

Table 4.4: Determinants of intensification of GlobalGAP certification (RQ2)

VARIABLES	Standard deviation	Full sample (1) NB IRR	Non-EU (2) NB IRR	2nd period (3) NB IRR	Roger's phases / Trend
GlobaGAP neighbouring countries (lag)	6079.966	1.13	1.28	1.2	I
		(0.17)	(0.431)	(0.188)	
Colonial history with EU6 (dummy)		2.55	3.52*	2.34	I
		(1.685)	(2.57)	(1.573)	
Export Share to EU (lag)	0.315	1.29*	1.35	1.43**	I, II
		(0.184)	(0.249)	(0.208)	
Urbanisation	23.309	1.89*	1.89	1.89*	I, II
		(0.674)	(0.754)	(0.688)	
Road density	1.191	2.73***	2.41*	2.15**	I, III
		(0.874)	(1.244)	(0.718)	
Fixed broadband subscriptions	0.130	1.69***	1.51	1.94***	I, III
		(0.338)	(0.501)	(0.436)	
Crops export share (lag)	0.125	1.45**	1.46**	1.62***	II
		(0.242)	(0.277)	(0.272)	
Doing Business indicator	1.408	2.27***	2.66***	2.05***	III
		(0.561)	(0.83)	(0.51)	
Conflict-related deaths	44.086	1.06	1.07	1.16**	III
		(0.061)	(0.071)	(0.074)	
ISO membership (dummy)		1.48	1.48	1.63	III
		(0.41)	(0.483)	(0.494)	
Development flows to agriculture	0.019	0.74***	0.75***	0.66***	III, IV
		(0.061)	(0.071)	(0.06)	
2nd period				1.31	
				(0.282)	
GlobaGAP neighbouring countries (lag)				0.99	
*2nd period				(0.065)	
Colonial history with EU6 (dummy)				1.12	
*2nd period				(0.207)	
Export Share to EU (lag)				0.79***	↓
*2nd period				(0.07)	
Urbanisation				1.03	
*2nd period				(0.125)	
Road density				1.37***	↑
*2nd period				(0.163)	
Fixed broadband subscriptions				0.88	
*2nd period				(0.083)	
Crops export share (lag)				0.75***	↓
*2nd period				(0.073)	
Doing Business indicator				1.12	
*2nd period				(0.134)	
Conflict-related deaths				0.68***	↓
*2nd period				(0.082)	
ISO membership (dummy)				0.71	
*2nd period				(0.163)	
Development flows to agriculture				1.37**	↑
*2nd period				(0.171)	
Observations		985	827	986	
Random effects		YES	YES	YES	

Note: *** p<0.01, ** p<0.05, * p<0.1; I = Information phase, II = Persuasion phase, III = Implementation phase, IV = Confirmation phase; standard deviation of full sample; IRR = Incidence rate ratio: to be interpreted as a factor increase if IRR value is above one and decrease if IRR value is below one; NB = Negative binomial; Cropland is included as an offset variable, thus interpretation of results should be 'number of certified farmers per hectare'; Trend in last column refers to the arrows after interaction terms only.

Regarding RQ2 (Table 4.4 column 1) concerning why some countries show higher certification rates, different variables of the Rogers' four phases play a role. This is unsurprising as our analysis considers the aggregate macro level, which means that some farmers might still be in the information or persuasion phase while others have already entered the implementation or confirmation phase. While all phases are relevant, our results indicate that Rogers' second and third phases are slightly more important than access to information networks during the first phase. Specifically, local network ties (i.e. GlobalGAP producers in neighbour countries) are not statistically significant. This hints at information about GlobalGAP certification from nearby peers becoming less relevant once a country has entered the certification market. On the other hand, the variables *Share of fixed broadband subscription* and *Road density* are highly significant and strong in magnitude. This hints at the internet as an important information source about GlobalGAP requirements. The positive effect of transportation infrastructure is likely explained by the fact that it is often perishable certified fruits and vegetables that need to be transported over long distances to markets.

Furthermore, ISO membership is insignificant when looking at the spread of GlobalGAP. This means that being involved in the standard-setting community enhances the chances of entering the certification market with at least one farmer, but for accelerating the spread factors more directly related to GlobalGAP are decisive.

The variables *Urbanisation*, *Crop export share over total exports* and *Doing business* are statistically significant and also have a positive effect on the intensity of GlobalGAP certification. Our results go hand in hand with results from Mohammed and Zheng (2017) on urbanisation, Masood and Brümmer (2014) on internet access and Neumayer and Perkins (2005) on regulatory burden. This means that factors such as access to credit, secure property rights, functioning contract enforcement, and efficient trading across borders hold strong relevance for pushing the certification process in countries. This is unsurprising for various reasons. First, credit is often needed to finance the entry costs. Second, secure property rights also reflect the land tenure situation in a country, which is found to be decisive in explaining farm investment decisions (Deininger and Jin, 2006). Third, GlobalGAP is in fact a contract between a farmer and a retailer or wholesaler, and thus reliable contract enforcement is a prerequisite for GlobalGAP. Finally, easy and cheap trading across borders can operate in favour of GlobalGAP certification rates, because most of the certified produce is traded internationally. As expected, the *Export share to EU* explains an increasing number of GlobalGAP certificates. Our findings regarding a countries trade pattern are in line with Herzfeld et al. (2011), who find that higher net agricultural exports and stronger trading relations with EU increase the number of GlobalGAP certificates.

Together with a favourable business environment, good transport infrastructure has the strongest effect (in magnitude) on the number of certified farmers in a country. This is expected since most certified produce is (still) not sold in local markets but rather distant locations. Each of these determinants more than doubles the number of farmers certified (ceteris paribus) when it increases by one standard deviation. Relating this information to concrete country examples, we find that certification doubles if the doing business indicator increased from e.g. Senegal's (or Egypt's) level to the level that Greece (or Austria) showed in 2009 (2014). Another way to show the relevance of the business environment is taken from the example of Peru: the country increased its doing business performance by 0.25 points between 2009 and 2014. Ceteris paribus, this is equivalent to a 22 percent increase, which translates into 279 more certified farms. Thus, good infrastructure is one key element for the further spread of certificates within a country, although there are others. Keeping the example of Peru, a higher focus on the agricultural sector – proxied by its *Crop export share over total exports* – increased total certification numbers by 15 percent (or 188 farmers) between 2009 and 2014, because the trade share had increased substantially.

Surprisingly, development flows to agriculture significantly reduce the number of certified GlobalGAP farmers. This result can be partially explained by the fact that development aid to agriculture is rather spent on emergency food assistance and agricultural and rural development strategies. On average, each of the aforementioned sectors account for 10 percent of aid for agriculture. By contrast, less than one percent of development aid to agriculture is spent on industrial crops or export crops during the 2008-2014 period (OECD, 2018).

4.4.2 Non-EU results

Column 2 in both Tables 4.3 and 4.4 shows the results for the non-EU sample. Our main results are not driven by EU countries with their high certification rates. All variables for the non-EU sample show the same sign and for RQ2 even very similar magnitudes. This is also the case for most variables that explain entry into the certification market (RQ1). Only *Colonial history with EU6* and *Maximum Residue Limits* show much higher coefficients. This is reasonable, because the EU countries are almost all certified, but naturally cannot have a colonial history with the EU. By contrast, the non-EU countries with strong historical ties to the EU are among the group of certified countries. Moreover, non-EU countries usually face laxer MRLs compared with stricter MRLs in the EU. Since GlobalGAP requirements are adapted to European MRLs, stricter MRLs in non-EU countries lower the initial investment costs to comply with GlobalGAP, making market entry more probable. The *ISO membership* coefficient is lower in the non-EU sample, which can be partially explained by the indirect harmonisation effect between ISO and GlobalGAP due to a large participation share of EU governments in the international standard-setting community. Nevertheless, the coefficient remains positive and significant, which is in line with Curzi et al. (2018), who state that the harmonisation effect is particularly relevant in low- and middle-income countries, which make up 84 percent of the non-EU sub-sample.

4.4.3 Dynamics

Considering the dynamics in explaining the probability of entering the certification market (see Table 4.3 column 3), *Urbanisation* and *Crops export share* remain relevant in time period 2 (2012-2014), but compared to time period 1 (2009-2011) the effects decrease (Ratio of odds $\text{ratios}_{Interaction} < 1$). During the first time period, the share of fruits and vegetables in total crop production significantly reduces the probability of entering the certification market. This result may be driven by some countries - e.g. United Arab Emirates, Bahrain and Saint Vincent and the Grenadines - that show above average share of fruits and vegetables production areas, but no certification during time period 1. In later years, the negative effect is less pronounced

Table 4.5: Main findings: Entry barriers to and spread of GlobalGAP

Entry barrier	**Driver of spread**	**Total effect**	**Dynamics**
Missing local and global network ties	Strong global network ties	• Nearby certified peers → Decreased uncertainty about GlobalGAP's profitability.* • Cultural ties to core GlobalGAP market → Facilitates information flow about GlobalGAP requirements.* • Existing trade network with EU → GlobalGAP quasi-mandatory EU trade.†	• Relevance of EU network ties for GlobalGAP spread reduces over time → Relevance of GlobalGAP also for non-EU retailers increases.†
Lacking information infrastructure	Functioning Infrastructure	• Internet access → Access to relevant information and essential for operability of documentation and traceability. • Transportation infrastructure → Better market access and reduced trade costs.†	• Unclear trend • Road infrastructure becomes increasingly important for GlobalGAP.†
Low focus on agricultural trade	High focus on agricultural trade	• High levels of export share of crops on total exports → Decisive for initial investment costs needed to enter export market.	• Relevance in agricultural trade decreases over time → Due to accelerated spread of GlobalGAP in(to) regions with relatively low economic focus on agricultural sector.
Rural society	Urban society	• More urban societies more likely to have a higher domestic demand for certified produce → Decisive for entering and spreading GlobalGAP certification.	• Urbanisation rate becomes less relevant → Supermarkets increasingly spread into rural areas.*
Unfavourable business environment	Favourable business environment	• Functioning business environment (proxied by easy access to credit, secure property rights, functioning contract enforcement and efficient trading across borders) → Decisive for transaction costs related to investment decisions and domestic and international trade (comparative disadvantage over other countries.)	• Unclear trend.
Lack of (agricultural) sector policies	Member of international standard setting community	• Strict MRL of pesticide regulations → Differences in domestic and international food quality requirements increase investment costs for farmers.* • Exclusion of international standard committee of ISO → Impedes harmonisation process of standards which equally fit domestic and international markets.	• Unclear trend • Unclear trend

Note: The *Entry barrier* and *Driver of spread* mentioned to the channels and/or variables as described in Table 4.1 of the conceptual framework. An asterix (*) denotes that the channel is only relevant for overcoming the *Entry barrier*, a cross (†) that the channel is only relevant for explaining the *Driver of spread*. If nothing is mentioned, the channel is relevant for both.

due to an ever-increasing number of countries with horticultural production entering the GlobalGAP market, although the effect cannot be completely reversed.
The dynamics in the intensification process of certification reveal (see Table 4.4 column 3) that a good transportation infrastructure becomes even more relevant over time. A denser road network of 1.2 km per squared km land increased the expected certification rate ratio by a factor of 2.15 during 2009 to 2011 and by a factor of 2.95 between 2012 and 2014. This increasing relevance in functioning roads can be explained by an increasing quantity of certified produce, which needs increasingly more buyers to be reached by road. *Development flows to agriculture* decrease the rate of certification, albeit less in later than in earlier years. As expected, *Conflict-related deaths* turn to have a statistically significant negative effect on certification during the later period. However, in earlier years conflicts had a positive effect, which could be partially explained by on average higher death rates by certified countries during the 2009-2011 period, e.g. driven by countries such as Ivory Coast and Colombia (due to the FARC conflict). The relevance of *Crop export shares over total exports* decreases over time. Moreover, trade relations with the EU play a less important role in later years, which illustrates the increasing global orientation of GlobalGAP. While Herzfeld et al. (2011) specifically emphasise the relevance of EU trade networks in explaining the global distribution of GlobalGAP, we show this more nuanced picture, which shows that EU trade remains relevant but becomes less pertinent.
To gain a quick grasp of the main determinants driving the spread of certification or explaining market access restrictions, Table 4.5 summarises the main elements, offering an interpretation of the total effect and the dynamics.

4.5 Conclusion

In response to a widening set of consumer concerns in many countries across the world, retailers increasingly demand compliance with stringent standards with requirements for food quality and safety, environmental sustainability and labour standards. The GlobalGAP standard is one of the most prominent global private agri-food pre-farm-gate process standards. Thus, many agricultural producers across the world are embracing GlobalGAP as an entry ticket to high-value (mostly) European and increasingly also other markets. However, the global spread of the GlobalGAP certification scheme is highly unequal: while some regions perform well in adjusting to the sector's transformation, other world regions lag behind and show low certification rates of farmers.
This study investigates the underlying forces behind these unequal patterns of the global diffusion of food quality standards. Our scale of analysis is the macro level, whereby we derive the set of potential macro-level drivers of adoption based on theoretical considerations at the micro level. We build on the theoretic framework of adoption of organisational innovations, which provides an appropriate base for answering two RQs: first, we investigate why some countries do not show any certified farmers despite the high global relevance of GlobalGAP, and second, we show why some regions adopt more intensively than others. Our panel data structure - covering

2009 to 2014 - allows us to include dynamic processes in our model.
Our findings show that similar factors drive the processes behind why countries enter the GlobalGAP market or why some countries show much higher certification rates than others. We want to highlight six main macro factors supporting the certification process. Existing network ties to the EU are crucial for the further spread of GlobalGAP and a strong focus on agricultural export sectors not only supports the spread but also increases the probability to enter the market, albeit with a decreasing relevance over time. This highlights that GlobalGAP certification has become relevant far beyond the already-debated export markets by Herzfeld et al. (2011), Masood and Brümmer (2014) and Mohammed and Zheng (2017). With the ongoing supermarket revolution in developing countries, domestic markets enter the scene for GlobalGAP produce. Accordingly, the third driver for both entering GlobalGAP markets for the first time and the further spread is urbanisation. More urban societies tend to shift their diets towards a westernised style, yet the supermarket revolution is underway to expand into more remote rural areas in every corner of the planet. Thus, we find the effect of urbanisation to be more moderate for entering the GlobalGAP market in later years. Fourth, our results point to the relevance of promoting a favourable business environment through good governance structures. Especially facilitating access to credit, lowering trade-related transaction costs, secure land tenure rights and good contract enforcement are found to be crucial. Fifth, another important channel is a good information and transportation infrastructure, whereas the latter is especially relevant for the further spread of GlobalGAP and gained in importance in later years. Some countries simply lag behind in the agricultural sector transformation due to a lack of information flow and because produce cannot be transported in time to important destination markets. Sixth, we find that existing strict public food regulations in non-EU countries facilitate the entry of private standards. This is because the additional initial investment costs to comply with the even stricter pesticide standards set by GlobalGAP are comparatively lower in those countries. Certification entails substantial benefits, such as better working conditions for farmers and workers, an increase in productivity levels and access to high-value (export) markets with their inherent positive effects for farm income, as well as environmental protection. This is especially crucial for countries in which agriculture plays a major role for many livelihoods. In addition, consumers worldwide benefit from increasing food safety and quality. Considering the diverse opportunities of private food standards, promoting the further expansion of GlobalGAP can be desirable from a local as well as global perspective.
Our findings provide important policy recommendations in this sense. First, governments should foster a favourable business environment by guaranteeing land tenure and functioning land and credit markets. Developing judicial and executive power can support contract enforcement, which is a prerequisite for GlobalGAP to come into force. Second, connecting rural production areas to urban centres and harbours through infrastructure investments makes certification a beneficial investment for farmers. Third, the expansion of reliable internet in remote areas enables information flow and compliance with the strict requirements of traceability and GlobalGAP documentation. Finally, governments should engage in developing public standards of good agricultural practices. This gives farmers the need to invest in higher production standards, making GlobalGAP certification an easy-to-reach target.

One caveat of this study is posed by the inability to capture heterogeneities within countries. The general debate about whether private food standards and certification is beneficial for farmers usually revolves around the most vulnerable part of the rural population and how to include them in high-value markets. Our scale of analysis fails to capture these within-country differences, as high certification rates do not necessarily lead to an inclusion of all population segments. Despite this shortcoming, we still believe that our study provides valuable insights into how to create the enabling macroeconomic conditions to cope with the inevitable agricultural sector transformation. Country-specific case studies should in turn provide insights into how to design more inclusive policies to be accompanied by the mentioned macro policies.

4.A Appendix

4.A.1 GlobalGAP background

Nowadays, GlobalGAP is one of the most important international B2B standards.[59] Thus, unlike B2C, B2B standards are imposed by retailers or food companies upon agricultural producers to ensure traceability along the entire supply chain and reduce transaction costs (Fulponi, 2006). Hence, they are neither visible to the consumer nor used for product differentiation. GlobalGAP was rather developed to protect the retail sector from potential harm through food safety scandals and secure sufficient supply of high-quality produce in times of increasingly stringent public food safety regulations (Webb, 2015). While GlobalGAP is a complex system of sub-standards,[60] this study focuses on the core of the GlobalGAP standards, namely the IFA standard. It covers good agricultural practices for agriculture, aquaculture, livestock and horticulture production and is designed for primary products on farms. To obtain the IFA certificate, producers have to meet certain compliance criteria categorised into *major must*, *minor must* and *recommendation*, which are controlled annually (Dannenberg, 2012). Most requirements are related to product quality, environmental effects and labour practices/human rights. For instance, GlobalGAP requests the implementation of an integrated pest management, conservation of biodiversity, waste management, safe practices at work and a food safety system in place (GlobalGAP, 2017). Hence, the spread of GlobalGAP compliance (with its strict criteria) has the potential to reduce the use of hazardous pesticides (Asfaw et al., 2009), improve farmers health (Asfaw et al., 2010a), and improve on-farm working conditions (Colen et al., 2012) at a global scale. On the other hand, it is the farmers who normally fully defray the compliance costs.[61] However, sometimes technical assistance programmes are in place, or export companies partially or fully cover certification costs (Asfaw et al., 2010b; Henson et al., 2011).

GlobalGAP was formerly called 'EurepGAP' and it was founded in 1997 by European retailers mainly located in Great Britain. Over recent decades, the number of retailers requiring standard compliance by their suppliers has grown to 45, with the majority among them still located in Europe, but also increasingly outside of the EU borders. As a reaction, many agricultural producers worldwide adopted the standard, eliciting a rebrand to GlobalGAP in 2007 (GlobalGAP, 2018a). In 2016, 174,316 suppliers worldwide were certified under GlobalGAP, of which 61.8% are located in Europe, which reflects the European origin of the standard. The second highest proportion of GlobalGAP certificates is located in Africa (17.2%), followed by South America (10.8%) and Asia (8%), while North America and Oceania comprise the remaining 2.2%. As

[59]Note that there are also other globally-relevant private standards in food supply chains, such as BRC, SQF, GFSI and IFS. However, there is an increasing tendency towards global standard harmonisation. In our context, this means that zero-certified countries are also likely lacking certification to other private standards.

[60]GlobalGAP offers several standards designed for different scopes, such as the Integrated Farm Assurance Standard (IFA), the Chain of Custody Standard (CoC), the Crops for Processing Standard (CfP), the Harmonized Produce Safety Standard (HPSS), the Livestock Transport Standard and the Compound Feed Manufacturing Standard (CFS). The latter target processing steps of agricultural produce or specific aspects of the livestock sector.

[61]To date, there is only limited empirical evidence on the effects of private standards in different realms.

a pre-farm-gate standard, GlobalGAP focuses on the production processes of livestock, fruits and vegetables, aquaculture, flowers and ornamentals, combinable crops, tea and coffee. With 168,060 certified producers in 2016, the fruits and vegetables sector is by far the most important under GlobalGAP (GlobalGAP, 2016).

Given that large global players such as Aldi, Edeka, Lidl, Rewe Group and Tesco have all become GlobalGAP members, farmers' compliance is today de facto mandatory to enter the EU market – and increasingly also non-EU markets. This trend is further reinforced by the 'bottleneck' structure of global food supply chains (Dannenberg, 2012, p.106), whereby the market is characterised by a few large (European) retail chains established in oligopolistic market structures. By contrast, there are many farmers operating in highly competitive environments at the bottom of the value chain. The market power enables retail chains to set strict standards to be fulfilled by their suppliers to remain in or enter the market (Lee et al., 2012). As a reaction, WTO members have already raised concerns about private food standards acting as trade barriers, because some countries might be systematically excluded from markets due to high costs. However, due to the strict private nature of the standard without any participation of public bodies in the standard-setting process, GlobalGAP does not fall under the WTO SPS agreement (Webb, 2015).

In summary, GlobalGAP farm-gate certification has spread globally despite its associated costs. It entails potential advantages such as increasing food safety and quality for consumers, better working conditions for farmers and workers, an increase in productivity levels with its inherent positive effects for farm income, as well as environmental protection. Given that usually the poorest countries are those with the strongest focus on agriculture in their economies, reaping the aforementioned advantages and guaranteeing market access to high-value chains can hold strong relevance for their development path. However, especially farmers located in poor developing countries sometimes face difficulties in complying with the high requirements needed for GlobalGAP certification. Thus, understanding what macro environment facilitates the successful implementation of such food standards can deliver the base for designing more effective policies.

4.A.2 Literature review on the adoption and diffusion of private food standards

An increasing number of scientific publications have focused on the realm of food standards with their different ramifications along the agricultural supply chain. However, most studies focus on analysing public standards such as SPS and TBT measures set by the WTO or EU food safety standards (see e.g. Disdier et al., 2008; Kareem et al., 2018b). Less attention has been given to private food quality standards, mostly due to a lack of data. Furthermore, empirical studies in this field are mostly conducted at the micro level and focus on one specific product and/or country. The most relevant micro studies exploring adoption determinants of the private standard GlobalGAP are Kleinwechter and Grethe (2006), Souza Monteiro and Caswell (2009), Asfaw et al. (2010b) and Kersting and Wollni (2012).

Souza Monteiro and Caswell (2009), Asfaw et al. (2010b) and Kersting and Wollni (2012) agree

Table 4.A.1: Summary of scientific literature explaining food standards adoption and diffusion, 2005-2017

Authors	**Data**	**Standard**	**Model**	**Determinants of standards diffusion**
Kleinwechter and Grethe (2006)	Micro; cross-section	GlobalGAP	qualitative / descriptive analysis; t-test / Chi^2-test / correlation analysis	*Positive effect - information stage:* vertical integration, producer organisation, cosmopolitanism, telephone / internet access, farm size *Positive effect - decision stage:* vertical integration, age *Positive effect - implementation stage:* starting point, target level, buyers support
Souza Monteiro and Caswell (2009)	Micro; cross-section	GlobalGAP	Discrete choice models	*Positive effect:* sales to UK, producer organisation, education
Asfaw et al. (2010b)	Micro; cross-section	GlobalGAP	2-stage standard treatment effect model	*Positive effect:* female household members, intrahousehold literacy, agricultural training, radio, group membership, formal contract *Negative effect:* land size, export experience *No effect:* public extension services, mobile phone
Kersting and Wollni (2012)	Micro; cross-section	GlobalGAP	Bivariate Probit model	*Positive effect:* education, export experience, female household members, farming technology, extension service, mobile phone, farm size (only small effect) *Negative effect:* group membership, distance to capital
Neumayer and Perkins (2005)	Macro; panel	ISO 9000	OLS	*Positive effect:* lagged ISO 9000, GDP, export share to EU 15, telephone access, colony, education *Negative effect:* regulatory burden
Herzfeld et al. (2011)	Macro; cross-section	BRC, GlobalGAP	Negative binomial count data model	*GlobalGAP - positive effect:* population, domestic auditor, ISO membership, trade share to standard holder, F&V production, GDP per capita, institutional quality *GlobalGAP - negative effect:* colonial ties with Germany/Netherlands/UK
Masood and Brümmer (2014)	Macro, panel	GlobalGAP	Heckman two-stage model	*Positive effect:* common language, domestic auditor, export share to EU, F&V production, internet access *No effect:* GDP per capita, regularity quality
Mohammed and Zheng (2017)	Macro; cross-section	BRC, FSSC 22000, GlobalGAP, ISO 22000, Primus-GFS, SQF	Negative binomial count data model	*Positive effect:* Number of certification bodies, total food exports, GDP per capita, F&V production, urbanisation, agricultural land, common border *Negative effect:* distance to standard holder, landlocked *No effect:* food exports to Europe, common language, colonial ties

that farmers with higher educational levels are more likely to adopt the standard, because GlobalGAP requires sophisticated record-keeping and the implementation of a quality management system. Another supporting factor is an already-high level of farming technology, which helps to comply with GlobalGAP production process requirements (Kleinwechter and Grethe, 2006; Asfaw et al., 2010b; Kersting and Wollni, 2012). Furthermore, in the specific case of Kenyan and Thai horticultural farmers, Asfaw et al. (2010b) and Kersting and Wollni (2012) show that access to female family labour promotes the adoption of GlobalGAP, because horticultural farming includes many labour-intensive work that are tasks usually taken over by women. In addition, Kleinwechter and Grethe (2006) and Kersting and Wollni (2012) agree that proximity to cities increases the diffusion of GlobalGAP certificates.

The micro literature is inconclusive regarding the effects of agricultural households' access to Information and Communications Technology (ICT), farm size and access to export networks or services. While Kleinwechter and Grethe (2006) and Kersting and Wollni (2012) find clearly positive effects of access to ICT on the adoption decision, Asfaw et al. (2010b) estimate no effect of mobile phone use. Other ambiguous results regard the effect of farms size and export experience. While Asfaw et al. (2010b) find negative effects on the adoption of private food standards in Kenya, Kleinwechter and Grethe (2006) and Kersting and Wollni (2012) find a positive effect of these two variables. The former can be explained by region-specific characteristics such as Kenyan large-scale farmers specialising in the production of traditional cash crops, rather than the production of typical GlobalGAP crops such as fruits and vegetables. As expected, all studies - except for Kersting and Wollni (2012) - find that membership in a producer organisation increases GlobalGAP adoption, which can be explained by the option to obtain group certification offered by GlobalGAP. However, Kersting and Wollni (2012) is the only study confirming that access to public extension services has a positive effect. In the case of Kenyan horticulture farmers, public extension services have no effect because they are replaced by technical services provided by the private sector (Asfaw et al., 2010b). The same holds for Peruvian mango producers who are more likely to adopt GlobalGAP when they receive buyers' support (Kleinwechter and Grethe, 2006).

While the aforementioned case studies provide valuable insights into standard adoption, the results are case-specific and overarching macro factors are mostly ignored. To the best of our knowledge, only four studies (Neumayer and Perkins, 2005; Herzfeld et al., 2011; Masood and Brümmer, 2014; Mohammed and Zheng, 2017) have analysed the determinants of standard adoption at the macro level. In line with the micro-level studies mentioned above, some macro-level studies also highlight the positive effect of urbanisation (Mohammed and Zheng, 2017) and confirm higher numbers of certificates through better education and access to phones (Neumayer and Perkins, 2005). All four agree on positive relations between standard adoption and the export share to Europe, although Mohammed and Zheng (2017) find positive but insignificant results. This is likely driven by the fact that the authors calculate the aggregate effect of six different standards, among them standards of stronger importance for retailers located in the USA rather than in Europe. In addition, there is consensus about the positive effects of the economic size and aggregate wealth status of a country – measured in GDP or GDP per capita. Herzfeld et al. (2011) estimate an inverse U-shaped relationship between GDP per capita and

the adoption rate of GlobalGAP.
Herzfeld et al. (2011) and Masood and Brümmer (2014) find a higher degree of certification in countries that are specialised in the production of fruits and vegetables. This is driven by the fact that initially GlobalGAP started with certifying only fruits and vegetables. Furthermore, certification rates are found to increase with population size and the probability of non-certification is significantly higher for less-populated countries (Herzfeld et al., 2011). Other factors that positively influence the spread of standards are institutional quality (Neumayer and Perkins, 2005; Herzfeld et al., 2011) and access to the standards' infrastructure through domestic certification bodies or auditors (Herzfeld et al., 2011; Masood and Brümmer, 2014; Mohammed and Zheng, 2017). In addition, Herzfeld et al. (2011), Masood and Brümmer (2014) and Mohammed and Zheng (2017) expect a historical colonial relationship and a common language with the standard setter to reduce transaction costs and thereby increase certification rates, although the empirical results are ambiguous.
Table 4.A.1 summarises the main findings of all mentioned micro-[62] and macro-level studies.

4.A.3 Conceptual framework

This section picks up on the general explanation of the conceptual framework described in Section 4.2. In the following subsections, we adapt Rogers' (1995) concept directly to the context of the GlobalGAP diffusion process and derive all relevant variables.

Information phase

In this phase (1), gaining awareness and information flow matters. For the purpose of studying the global spread of GlobalGAP, the agents within a network are neighbouring certified farmers. At the macro level, this can be proxied by the average number of certificates in neighbouring countries. In this case, geographic proximity acts as the connecting link between farms. These networks allow for faster information flow and the producer can consider past experiences of near-peers before taking an adoption decision. Thus, it is hypothesised that countries surrounded by countries with high certification rates are more likely to (further) transform their agri-food system towards (more) certification. Likewise, well-developed transportation infrastructure as well as access to ICT increase the likelihood of interaction between potential adopters (Hägerstrand, 1967). Furthermore, geographical proximity and existing trade relationships with Europe - the main GlobalGAP market - enhance information flow and thereby the chances of a country's adoption rate. Generally, trade networks with modern retail chains increase information flows and induce cohesion of organisational practices, which reduces transaction costs (Eichengreen and Irwin, 1998).[63]

[62] Since the standard diffusion at the macro level is shaped by aggregate micro-level behaviour, we think it is essential to also highlight the main findings of relevant micro-level studies.

[63] Another channel through which information flow is facilitated is frequent FDI or vertical integration in the food sector. However, lacking global data on agricultural-specific FDI does not allow us to consider this aspect.

Johansson (2014, p. 404) argues that "new product cycles are frequently initiated in metropolitan regions with rich knowledge sources, intense knowledge flows and competent and demanding customers side by side with alert input suppliers". Similarly, Krugman (1996) developed the theory of agglomeration economies to explain spill-over effects from learning processes and thereby the spread of innovations. Thus, highly-urbanised countries are hypothesised to initiate GlobalGAP certification, including because supermarket chains (with GlobalGAP membership) are mostly located in urban centres.
Moreover, eligibility for certification requires the implementation of numerous processes prescribed in documentations usually written in English, Dutch or German in their binding versions, and frequently translated to French, Spanish and Italian. Thus, knowledge of one of the six European languages - proxied by historical colonial status - is hypothesised to favour information flow and thereby the spread of the standard. Finally, GlobalGAP - formerly called EurepGAP - started with good agricultural practices for producers of fresh fruits and vegetables, and only later extended the portfolio of standards to other agricultural sectors. Due to this history, farmers in countries with a higher share of horticultural production were likely exposed earlier to information about GlobalGAP, which enhances the likelihood of early adoption and finding more certified producers here.

Persuasion phase

During this phase (2), the producer evaluates the direct costs and benefits of GlobalGAP. These costs include the payment of a yearly certification fee and payments for external auditing. Thus, the presence of nearby auditing facilities may be decisive for the spread of the standard, because it reduces its costs. Unfortunately, we only have information on existing auditing facilities for one time period, making its inclusion in the panel dataset imprecise. Furthermore, the variable suffers from endogeneity due to reverse causality with the outcome variable. Hence, we abstain from including this direct cost information. To become certified, ex-ante investments are needed, e.g. the construction of grading and sanitation facilities or training of employees, as well as changes in the production process, e.g. documentation and water testing. These costs are expected to be comparatively lower for producers located in countries with a traditionally well-developed agricultural sector. Hence, countries with high degree of sophistication in agriculture - proxied by agricultural capital stock - are hypothesised to have (more) certified farms. Countries with a high share of agricultural exports over total exports might display a higher number of certified farms as a larger share of farms located in these countries usually have already paid the sunk cost required to enter high-value markets. This argument is supported by scientific evidence analysing smallholder certification adoption. Here, certification increases with support from exporting firms in financing compliance costs and providing technical support (Holzapfel and Wollni, 2014).
Besides cost considerations, the distribution of market power determines the certification decision. With the EU being the single most important market on aggregate and EU retailers showing a high concentration, GlobalGAP has become a quasi-mandatory standard for farmers

to either enter high-value markets or avoid market exit. Existing trade relationships with the EU can proxy this market power. Moreover, the level of risk aversion influences certification decisions because adoption always involves a certain degree of uncertainty due to the payment of the mentioned sunk cost (Abadi Ghadim and Pannell, 1999; Easley and Kleinberg, 2010). At the global macro level, it is very difficult to find appropriate risk aversion proxies. In part, the wealth status reflects attitudes towards risk, mainly because poorer farmers have fewer opportunities to insure their consumption against exogenous shocks. External circumstances such as low incomes, little or no insurance, limited access to credit, and thin labour markets limit farmers to low-risk, low-return activities (Yesuf and Bluffstone, 2009). GDP per capita can serve as a rough proxy for wealth, but comes with limitations.[64] Moreover, Krugman (1980) shows that countries with a large home market - proxied by population size and urbanisation[65] - are more inclined to show innovative action. The reason is that the producer likely faces a lower risk of malinvestment if the home demand for certified produce is high as there is less dependence on export markets.

Implementation phase

While the persuasion phase was influenced by costs directly related to the standard, the implementation phase (3) considers more general country-specific costs affecting successful implementation of the standard. First of all, general macroeconomic conditions can determine investment decisions (Bleaney, 1996; Ghura and Goodwin, 2000) and thereby the number of certified farms. Stability is typically influenced by decent inflation rates, and exchange rates. High inflation reduces capital accumulation and productivity growth and thereby prevents investment decisions (Fischer, 1993). An overvaluation of the exchange rate reduces the returns to investment in the tradables sector (Bleaney and Greenaway, 2001) and thereby shapes adoption decisions.
Furthermore, according to Tinguely (2013) - who builds on the work of Porter (1990) - the quality of the business environment in a country drives innovative activity in different industries. The 'Doing Business' indicators[66] provide objective measures of business regulations and their enforcement across 190 economies (World Bank, 2018). For the purpose of studying agricultural value chains, we specifically include the following indicators as they seem relevant for the adoption process: registering property, access to credit, trading across borders, and enforcing contracts. A lack in access to credit markets as well as insufficient land tenure rights can hamper agricultural transformation (see e.g. Barrett et al., 2010). Given that GlobalGAP produce is often traded internationally, the time and cost associated with the logistical process of trading goods matter for the implementation of the standard. Moreover, a country's general efficacy and efficiency in enforcing contracts might reduce reluctance concerning GlobalGAP certifica-

[64] Some countries may show a high GDP per capita, e.g. due to abundance of natural resources, but the peasants and the majority of the population can be very poor.

[65] We would have liked to include more precise variables such as modern grocery distribution (MGD) by PlanetRetail.com, but unfortunately the global data coverage is too low.

[66] Alternatively, one could use governance indicators that are presumed to contribute to a well-functioning business environment in a country. Since the 'World Governance Indicators' are highly correlated to the mentioned 'Doing Business' indicators, we abstain from additionally using them in this study.

tion (which in principle is a contract between a buyer and supplier). In many world regions, ongoing conflicts inhibit economic activity. We assume that an increase in conflict-related deaths reduces certification and especially increases the likelihood of being completely left out of the GlobalGAP market.
Country-specific transaction costs are also affected by infrastructure conditions. Production for distant (domestic and international) markets requires the provision of good transport infrastructure and logistic services. Poorly developed roads reduce a country's competitiveness due to delayed procedures, causing higher costs. Accordingly, producers are hypothesised to have lower incentives to adopt standards if adequate infrastructure conditions are absent. The geographic location also determines market access costs, whereby landlocked countries are hypothesised to show a lower probability of certification. Additionally, advanced administrative systems facilitate proper documentation and plot-level traceability. A high degree of a country's ICT can thus support these processes and thereby lead to more certification (Neumayer and Perkins, 2005).
Finally, there are agricultural-specific sector policies that can help transformation towards high-value certified production. Existing public food standards - proxied by MRL regulations - facilitate meeting private standard requirements, which reduces initial investment costs. Thus, strong agricultural sector policies are hypothesised to increase the implementation of private food standards. In addition, farmers in countries with ISO membership face lower compliance costs, because some GlobalGAP requirements are based on ISO standards such as ISO 17025 or ISO 7002 (GlobalGAP, 2017). Furthermore, in some developing countries, donor support can be decisive to overcome high certification fees, which helps to initiate the adoption process.[67]

Confirmation phase

After the implementation phase, the confirmation phase (4) follows, during which there are recurring costs associated to the annual certificate renewal. At the macro level, we cannot identify new variables being specific to this process, but it is likely that richer farmers or those that are externally supported[68] can more easily conquer these high recurring costs. Thus, GDP per capita as well as bilateral financial flows to agriculture help to maintain and reinforce certification rates.

4.A.4 Model selection

As briefly described in Section 4.3.1, we conducted various specification tests to find the preferred model for the binary and count model specification, respectively. To start with, we compare a pooled model over a model with random effects in the logit specification. The error terms within countries with observations over six years are likely correlated, in which case the random

[67] Trade policies, and the level of sectoral support by governments, such as consumer support estimates and especially producer support estimates likely also play a role in shaping the general agricultural business environment. Due to missing data for many countries and/or years, we cannot consider these factors in our analysis.

[68] However, some producers might as well drop out again if producer support ends and certification-induced productivity improvements were insufficient to stay in the market (Kersting and Wollni, 2012).

effects specification is superior to a pooled model. The estimated ρ turns out to be close to one, which suggests that there might be substantial residual outcome variation at the country-ID level. The post-estimation likelihood ratio test rejects the null hypothesis of $\rho = zero$ with a value of $\chi^2(1) = 391.80, p = 0.000^{***}$. Hence, we choose a random effects logit specification for RQ1. Furthermore, according to AIC test statistics, the random effects model (AIC=494.48) is superior to the pooled logit model (AIC=884.28).

Table 4.A.2: Specification tests of count models

	Poisson		**Poisson with RE**		**NB with RE**		**NB with RE and AR(1)**	
	Test	p-value	Test	p-value	Test	p-value	Test	p-value
Overdispersion	0.546	0.000	0.182	0.000	0.045	0.037	0.046	0.030
Zero-inflation test	3.827	0.000	0.616	0.000	0.979	0.766	0.977	0.716
Spatial autocorrelation	0.003	0.162	0.003	0.424	0.002	0.676	0.003	0.395
Temporal autocorrelation	2.073	0.249	1.957	0.500	2.026	0.680	1.953	0.457
AIC	820,065		36,327		7,098		7,037	

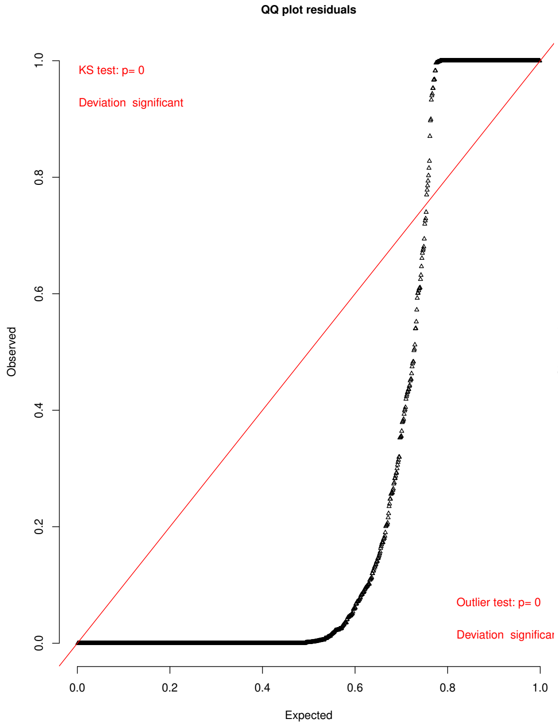
Note: RE = random effects; AR(1) = temporally correlated error structure; Overdispersion test: Kolmogorov-Smirnov test with H0 = equidispersion under fitted model; Zero-inflation test: ratio of true and expected zeros with H0 = no zero-inflation under fitted model; Moran's I test for spatial autocorrelation with H0 = no spatial autocorrelation under fitted model; Temporal autocorrelation: Durbin-Watson test with H0 = no temporal autocorrelation under fitted model.

We also conduct various specification tests of the (full) count data model following Gelman and Hill (2006) and using the DHARMa package in the statistical software R (Hartig, 2019). Results are displayed in Table 4.A.2. We proceed step by step, starting with a Poisson specification with and without random effects. We test for overdispersion, zero-inflation being a special case of overdispersion, as well as spatial and temporal autocorrelation. The statistical tests are underpinned by a graphical inspection of the behaviour of the residuals which can be found in Figures 4.A.1, 4.A.2, 4.A.3 and 4.A.4 below.

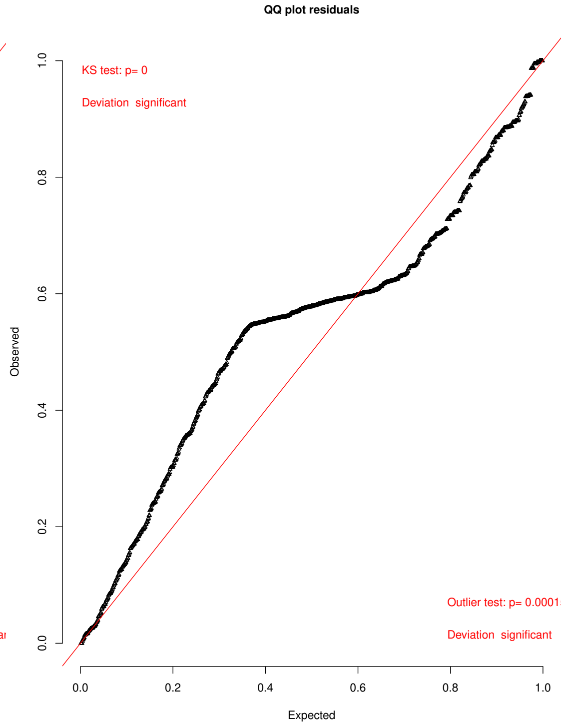
Here, we simulate scaled (standardised) model residuals, which are then plotted against fitted values, and against time and space. In the QQ-plot (see Figure 4.A.1), the model is deemed valid if the plot comes close to a straight line, which is the case only for the two negative binomial regressions. In Figures 4.A.3 and 4.A.4, residuals are plotted against time and in two-dimensional space. There should be no clear trends or clusters if the model has valid model specifications.

Figure 4.A.1: Specification test of overdispersion

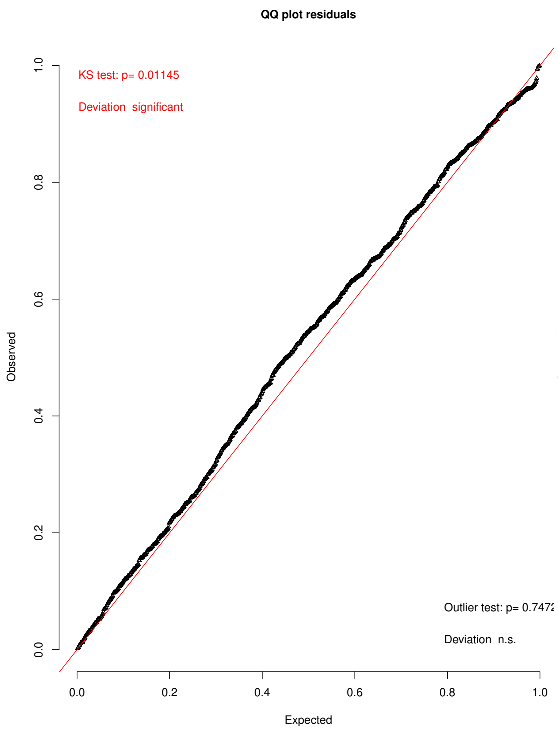
(a) Pooled Poisson



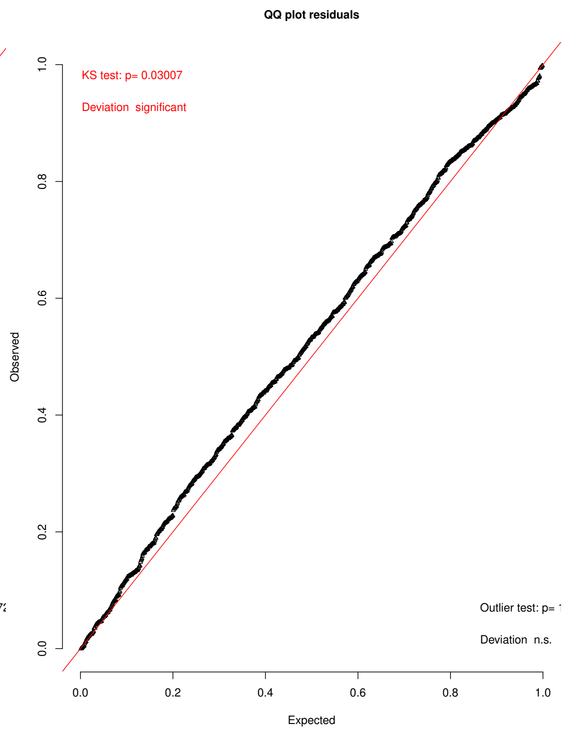
(b) Poisson random effects



(c) Negative binomial random effects



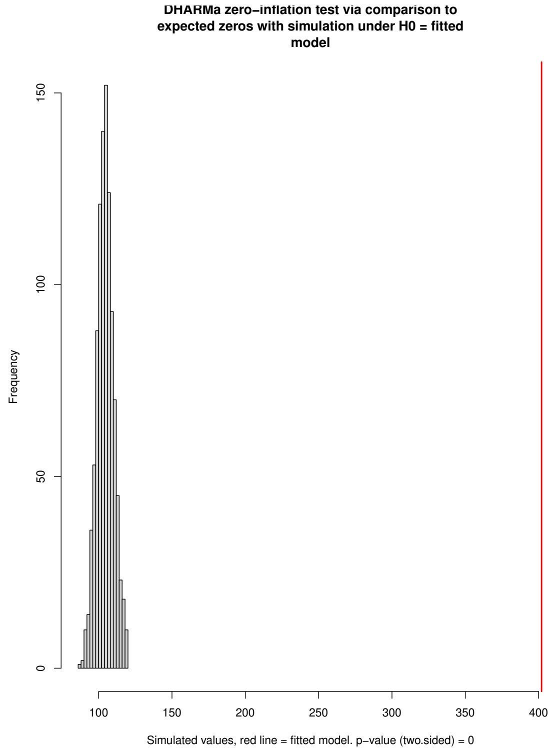
(d) Negative binomial random effects with AR(1)



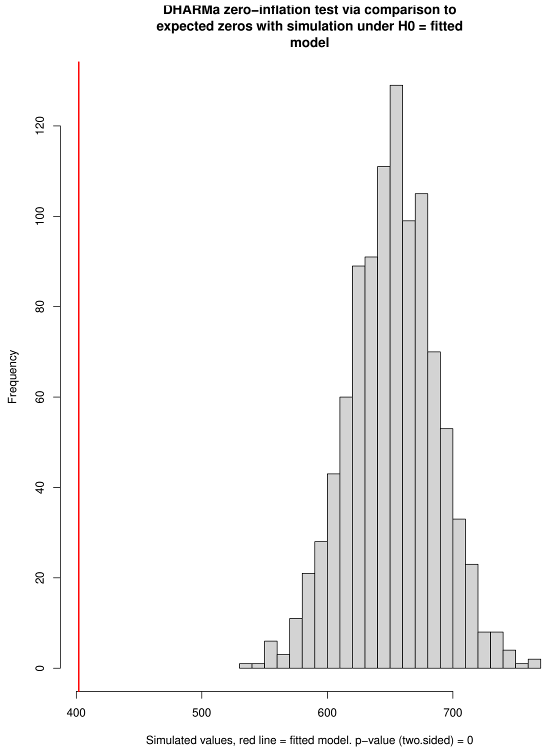
Source: Own elaboration based on DHARMa package in R (Hartig, 2019)

Figure 4.A.2: Specification test of zero-inflation

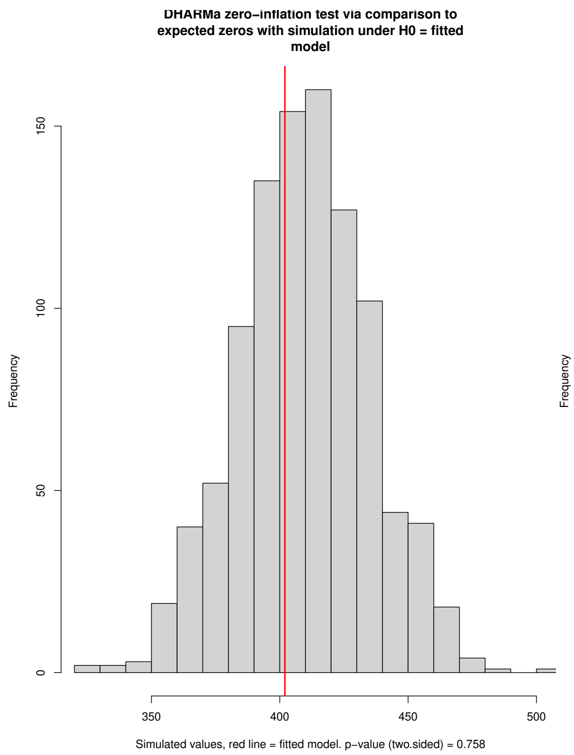
(a) Pooled Poisson



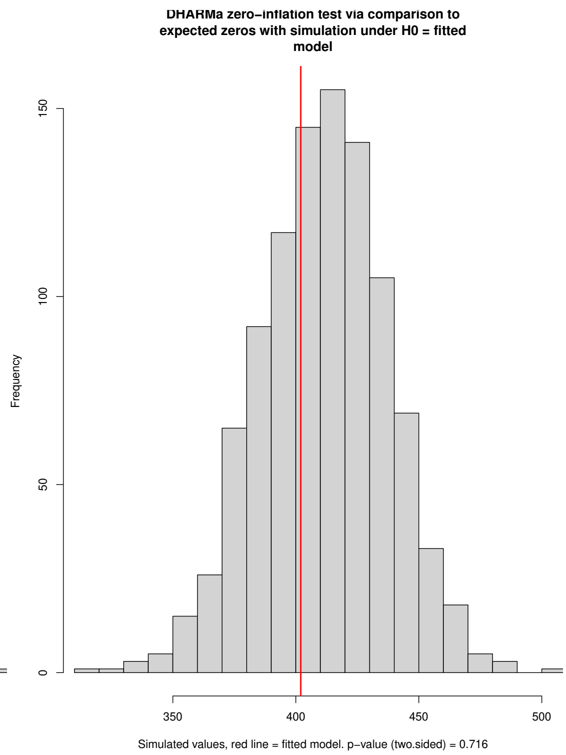
(b) Poisson random effects



(c) Negative binomial random effects



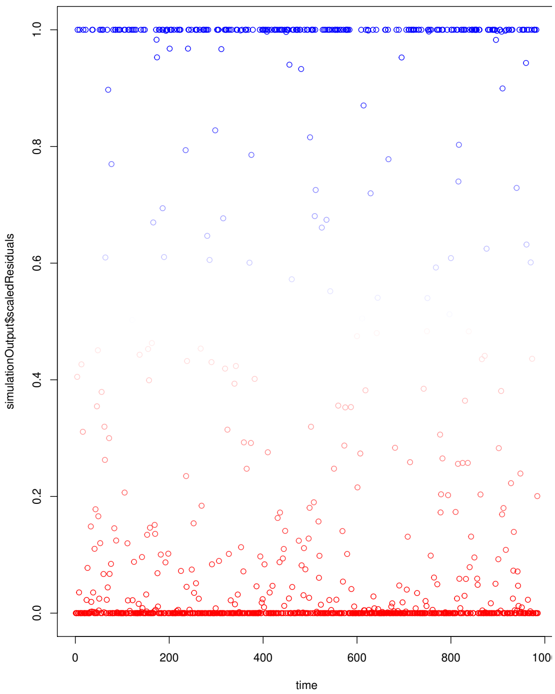
(d) Negative binomial random effects with AR(1)



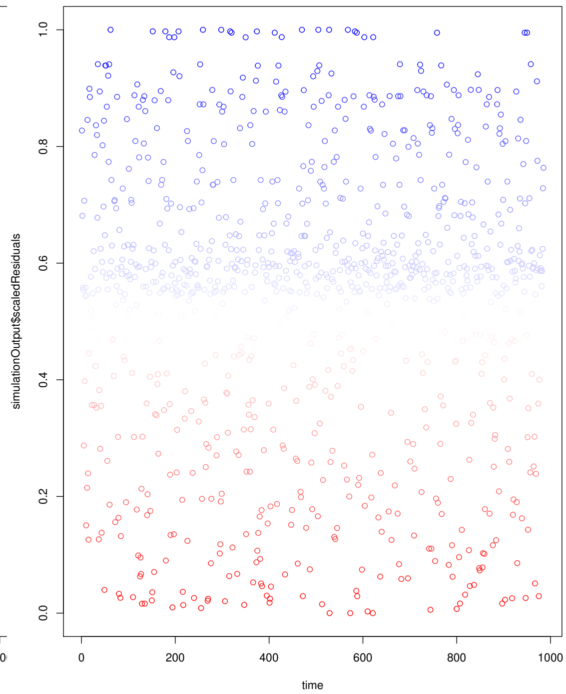
Source: Own elaboration based on DHARMa package in R (Hartig, 2019)

Figure 4.A.3: Specification test of temporal autocorrelation (Moran I test)

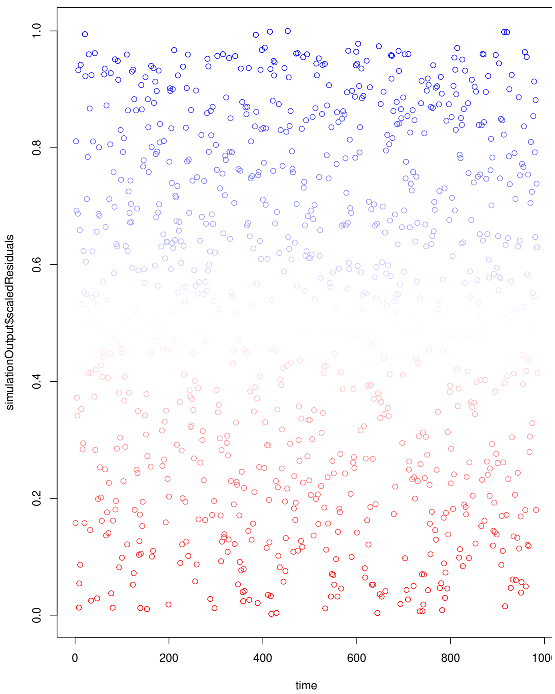
(a) Pooled Poisson



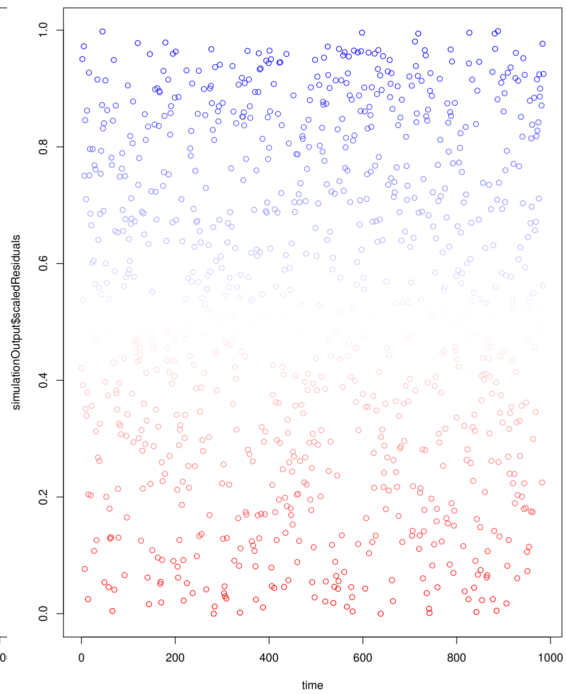
(b) Poisson random effects



(c) Negative binomial random effects



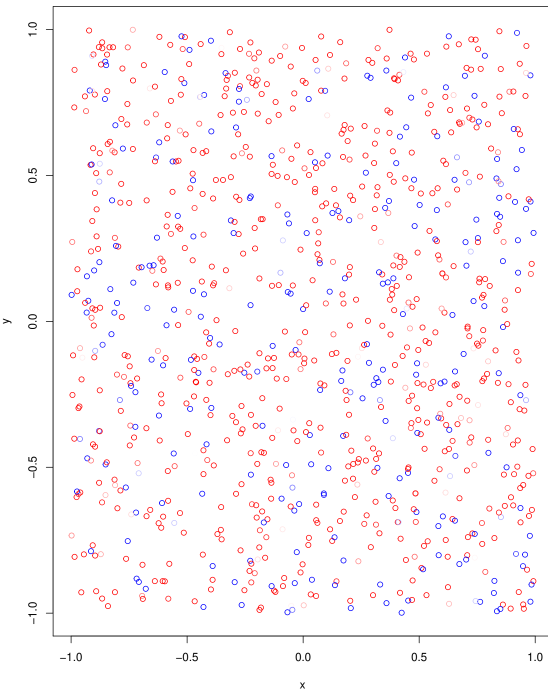
(d) Negative binomial random effects with AR(1)



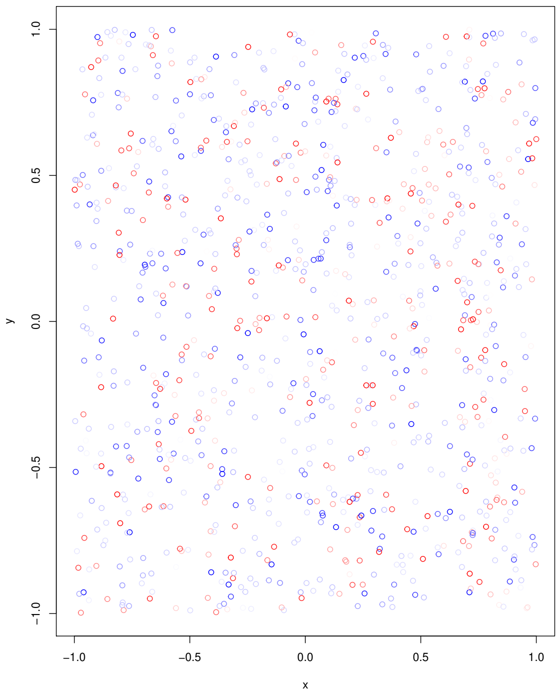
Source: Own elaboration based on DHARMa package in R (Hartig, 2019)

Figure 4.A.4: Specification test of spatial autocorrelation

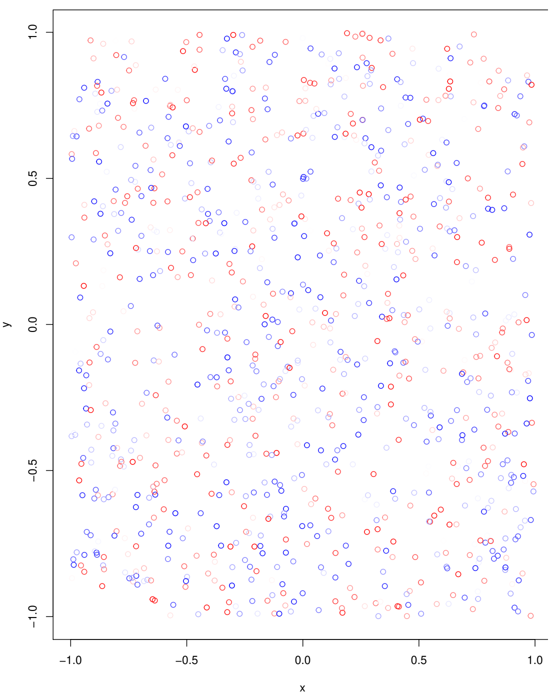
(a) Pooled Poisson



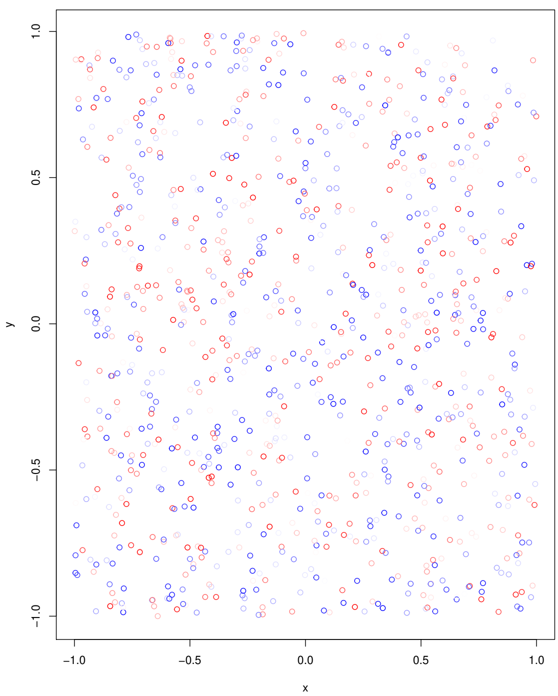
(b) Poisson random effects



(c) Negative binomial random effects



(d) Negative binomial random effects with AR(1)



Source: Own elaboration based on DHARMa package in R (Hartig, 2019)

Given that both Poisson specifications suffer from overdispersion, we move to the negative binomial specification with random effects. According to the Kolmogorov- Smirnov test statistics, including the dispersion parameter in the regression improves the model but does not entirely solve overdispersion.

As Figure 4.A.1 shows, the negative binomial model with random effects improves the model in this respect. The negative binomial model also performs much better with respect to zero-inflation, which can be understood as a special case of overdispersion. While the Poisson estimator indicates zero-inflation, the negative binomial estimator does not (see Table 4.A.2 and Figure 4.A.2). This confirms our hypothesis stated in Section 4.3.1 that all zeros are 'true' zeros, and hence the absence of two different DGPs for observed zero certificates.

Table 4.A.3: Coefficient estimates of the final full and parsimonious model

	Full model		Parsimonious model	
	(1)	(2)	(3)	(4)
VARIABLES	RQ1, Logit	RQ2, NB	RQ1, Logit	RQ2, NB
GlobaGAP neighbouring countries (lag)	2.314*	0.177	2.200*	0.126
	(1.328)	(0.154)	(1.292)	(0.150)
Export Share to EU (lag)	0.363	0.286*		0.254*
	(0.403)	(0.146)		(0.143)
Fruits and vegetables area share (lag)	-1.075	0.06	-1.234	
	(0.779)	(0.279)	(0.764)	
Agricultural capital stock (lag)	-0.551	-0.047		
	(0.696)	(0.205)		
Crops export share (lag)	0.806*	0.381**	0.755*	0.372**
	(0.445)	(0.168)	(0.406)	(0.167)
Inflation rate	-0.249	0.021		
	(0.288)	(0.09)		
Exchange rate	0.185	0.077		
	(0.381)	(0.161)		
Population		0.18		
		(0.271)		
Doing Business indicator	1.163*	0.796***	1.141*	0.821***
	(0.654)	(0.25)	(0.635)	(0.247)
Maximum Residue Limits	2.526*	0.041	2.412	
	(1.416)	(0.108)	(1.543)	
Development flows to agriculture	-0.138	-0.299***		-0.302***
	(0.194)	(0.083)		(0.082)
Conflict-related deaths	-0.401	0.063		0.062
	(0.444)	(0.058)		(0.057)
Urbanisation	1.259*	0.515	1.394*	0.635*
	(0.718)	(0.405)	(0.735)	(0.357)
Road density	-0.307	0.952***		1.005***
	(0.643)	(0.329)		(0.320)
Fixed broadband subscriptions	2.502**	0.519**	2.572***	0.524***
	(1.005)	(0.21)	(0.935)	(0.200)
GDP per capita	-2.141***	0.568	-2.398***	
	(0.758)	(0.67)	(0.712)	
GDP per capita^2		-0.608		
		(0.473)		
Colonial history with EU6 (dummy)	2.399*	1.016	2.705*	0.937
	(1.302)	(0.672)	(1.470)	(0.660)
ISO membership (dummy)	3.564***	0.398	3.485***	0.395
	(1.005)	(0.278)	(1.065)	(0.276)
landlocked (dummy)	-0.190	-0.233		
	(1.742)	(0.794)		
Observations	985	985	985	985
Overdispersion parameter		6.23		6.3
ρ		0.932***		0.933***

Note: *** p<0.01, ** p<0.05, * p<0.1; Standard errors given in parentheses; All models include random effects; RQ = Research question; All covariates are z-transformed for normalisation purposes; Parsimonious models omit those variables with z-values<1 in the corresponding full models; Logit model includes cropland as control variable; NB = negative binomial models include Cropland as an offset variable in logarithm, thus interpretation of results should be 'number of certified farmers per hectare'; population variable omitted in full logit model due to high collinearity with cropland control.

Finally, we estimate a negative binomial specification with an AR(1) error structure to account for temporal autocorrelation. According to statistical specification test results, neither of the four models presented suffer from spatial nor temporal autocorrelation. Nevertheless, we choose a negative binomial specification with random effects and AR(1) error structure as our preferred model due to various factors. First, plotting residuals against time and space (see Figure 4.A.3) points towards temporarily-correlated residuals in the Poisson specification. Second, it shows the lowest AIC test statistic. Finally, a likelihood ratio test suggests that the model with random effects and AR(1) error structure is superior over the nested negative binomial model with solely random effects: $\chi^2(2) = 64.079, p = 0.000^{***}$.[69]

After selecting an appropriate model type, we refine the specification towards a more parsimonious model. For this purpose, we omit those variables with z-values<1 in the full models of both the logit and negative binomial models. For both models, the null hypothesis of the likelihood ratio tests cannot be rejected. This confirms that for both RQs the respective parsimonious model is appropriate. The test statistic for the logit model is $\chi^2(8) = 3.51, p = 0.899$. The test statistic for the negative binomial model is $\chi^2(9) = 3.60, p = 0.936$. The results of the final full and final parsimonious model are presented in Table 4.A.3.

[69] Equivalently all other nested models were tested. The results can be obtained from the authors upon request.

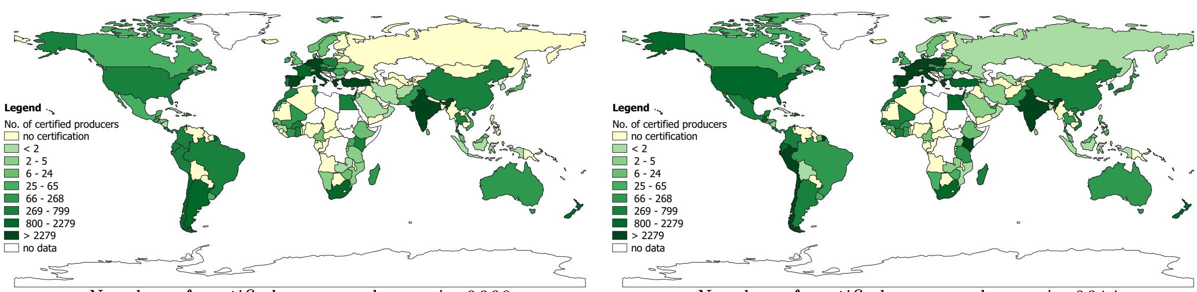
4.A.5 Countries

Table 4.A.4: List of countries included in analysis

Afghanistan	Denmark	Kyrgyzstan	Saint Kitts and Nevis
Albania	Djibouti	Lao People's Dem. Rep.	Saint Lucia
Algeria	Dominica	Latvia	St. Vincent and the Grenadines
Angola	Dominican Republic	Lebanon	Samoa
Antigua and Barbuda	Ecuador	Lesotho	Sao Tome and Principe
Argentina	Egypt	Liberia	Saudi Arabia
Armenia	El Salvador	Lithuania	Senegal
Australia	Equatorial Guinea	Luxembourg	Seychelles
Austria	Estonia	Madagascar	Sierra Leone
Azerbaijan	Ethiopia	Malawi	Singapore
Bahamas	Fiji	Malaysia	Slovakia
Bahrain	Finland	Maldives	Solomon Islands
Bangladesh	France	Mali	South Africa
Barbados	Gabon	Malta	Spain
Belarus	Gambia	Mauritania	Sri Lanka
Belgium	Georgia	Mauritius	Suriname
Belize	Germany	Mexico	Swaziland
Benin	Ghana	Micronesia (Fed. States of)	Sweden
Bhutan	Greece	Moldova, Rep.of	Switzerland
Bolivia	Grenada	Mongolia	Tajikistan
Botswana	Guatemala	Morocco	Tanzania, United Rep. of
Brazil	Guinea	Mozambique	Thailand
Brunei Darussalam	Guinea-Bissau	Namibia	Togo
Bulgaria	Guyana	Nepal	Tonga
Burkina Faso	Haiti	Netherlands	Trinidad and Tobago
Burma	Honduras	New Zealand	Tunisia
Burundi	Hungary	Nicaragua	Turkey
Cambodia	Iceland	Nigeria	Turkmenistan
Cameroon	India	Norway	Uganda
Canada	Indonesia	Oman	Ukraine
Cape Verde	Iran	Pakistan	United Arab Emirates
Central African Republic	Iraq	Panama	United Kingdom
Chad	Ireland	Papua New Guinea	United States of America
Chile	Israel	Paraguay	Uruguay
China	Italy	Peru	Uzbekistan
Colombia	Ivory Coast	Philippines	Vanuatu
Comoros	Jamaica	Poland	Venezuela
Congo	Japan	Portugal	Viet Nam
Costa Rica	Jordan	Qatar	Yemen
Cuba	Kenya	Romania	Yugoslavia, former
Cyprus	Korea	Russian Federation	Zambia
Czech Republic	Kuwait	Rwanda	Zimbabwe

4.A.6 Descriptives

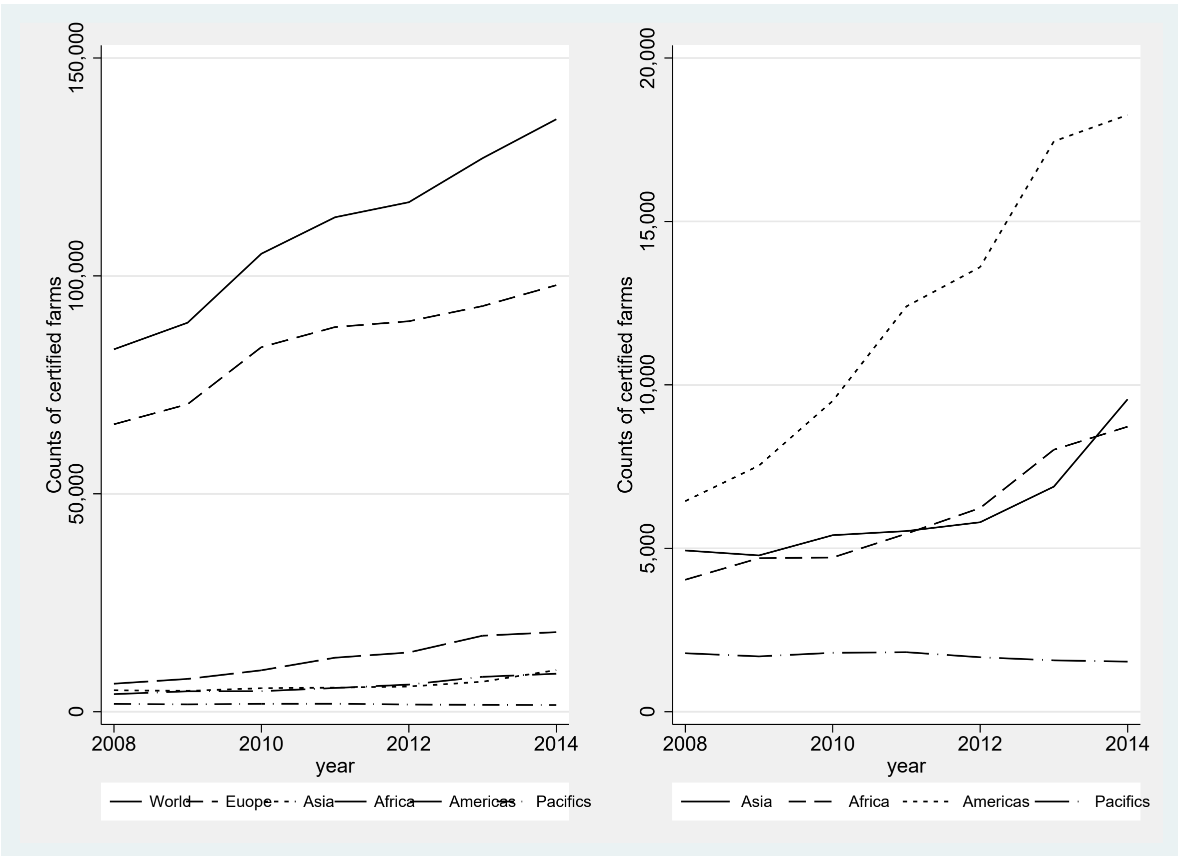
Figure 4.A.5: Spread of GlobalGAP certified producers worldwide



Number of certified crop producers in 2008 *Number of certified crop producers in 2014*

As already briefly discussed in Section 4.A.1, and shown in more detail in Figures 4.A.5 and 4.A.6, the speed and geographical spread of GlobalGAP certification rates strongly varies across the world. Europe is the continent where countries have the highest certification rates in all periods. This is unsurprising given that GlobalGAP is a European retailer standard and most farmers predominantly supply European markets. With more than (17,500) 30,000 certified Spanish farmers and more than (7,000) 20,000 certified Italian farmers in (2008) 2014, these two countries increased their global certified market share from about 30% in 2008 to almost 38% in 2014. Most other European countries also show comparatively high GlobalGAP certification rates (above 1,000 certified farmers per country), but the numbers grow at a slower pace. Figure 4.A.5 also shows that GlobalGAP plays an increasingly role outside of Europe. Some African and Latin American countries show comparatively high certification rates with a continuously increasing trend. For example, Kenya's number of certified farmers grew four-fold to reach about 2,400 by 2014 and Peru's numbers even increased twelve-fold to reach more than 6,400 farms by 2014. Even the small and poor country Senegal showed a remarkable increase in certification rates growing from only a handful in 2008 to reach 290 certified farmers in 2014. By contrast, large countries like Canada or Russia show very low or no certification of GlobalGAP over the entire period of investigation. One reason may be that they are net food importers and are not dependent on delivering the core GlobalGAP markets. In the Pacific region, only New Zealand plays a major role in the GlobalGAP market, likely due to its high apple production for the European market.

Figure 4.A.6: Trend in certification rates between 2008 and 2014 in different world regions



Note: Right panel without Europe and global total for better readability.

Source: own elaboration based on data provided by GlobalGAP

Chapter 5

General conclusion

The rapid expansion of private agri-food standards around the world and their potential trade-impeding effects has aroused the interest of policy-makers and the science community. One of the main points of the discussion concerns the need to regulate private agri-food standards to the same extent as already done for public agri-food standards if they cause unjustified trading losses. Although limited, there is evidence that private agri-food standards could enhance market access and therefore promote sustainable development, particularly if VSSs are adopted. With its three essays, this dissertation provides relevant insights into this debate. It looks at the potential of value-chain upgrading through VSSs, the interplay of VSSs and public food safety standards as well as the determinants driving the global spread of private agri-food standards. In the following, the main findings, policy recommendations, limitations and scope for future research will be described.

5.1 Main findings

In our first essay (see Chapter 2) we answer two research questions: How do VSSs affect cocoa beans exports? Can we observe spill-over effects along the value chain on cocoa paste, butter and powder exports? We estimate a sectoral gravity model of trade for a panel dataset of 42 exporters, 38 importers and 7 years. We find empirical evidence that VSSs increase trade values of raw cocoa beans as well as cocoa paste (first-stage cocoa grindings). However, we find mixed results for second-stage cocoa grinding. These results suggest that VSSs could be a policy instrument to enhance market access for raw cocoa exports but do not yet fully support value-chain upgrading in cocoa-producing countries.

In the second essay (see Chapter 3), we turn away from the pure focus on private agri-food standards and also take into account public agri-food standards. The research questions addressed in this context are: How do heterogeneous public agri-food standards affect coffee and cocoa exports? Are VSSs a means to overcome this trade barrier and does this effect differ at the

extensive (at least one farmer is certified) or intensive margin of certification (intensity of certification)? The parameter estimates of our sectoral gravity model applied to a nine-year panel dataset reveal a trade-impeding effect of regulatory heterogeneity in public agri-food standards. This trading loss can be partially compensated by the adoption of a VSS. This moderating effect can only be observed at the intensive margin of certification. In other words, only having one producer in the country certified and signalling the ability to comply to VSS is not sufficient to overcome the negative effect of strict public regulations. However, if the share of certified land area increases, the moderating effect occurs.
Following our mixed results for the extensive and intensive margin of certification in Chapter 3, we take a closer look on the determinants driving the margins in our third essay (see Chapter 4). Specifically, we provide answers to the following research questions: What are the factors explaining why some countries are left out of the GlobalGAP market, i.e. show zero certified farmers? What factors drive high certification rates? The empirical results of our panel data analysis including 168 countries over six years highlight six factors that are especially relevant for the spread and/or entry of private agri-food standards in a country, namely existing trade relations with the EU, a strong focus on agricultural exports, urbanisation, a favourable business environment, good information and transportation infrastructure, as well as strict public food regulations in the producing country.

5.2 Policy recommendations

In the following, I will provide some policy implications drawn from the main findings described above. These recommendations should be taken with caution because they only apply to the specific products, certification schemes, countries and timeframes considered in this dissertation. The public support of cocoa or coffee beans farmers to become certified to a VSS - i.e. Rainforest Alliance Certified or UTZ Certified - is desirable because it can enhance their access to export markets and thus promote export-led growth and sustainable development. This is especially true for farmers located in countries with relatively lax public regulations compared with their export destination. Possible policy instruments to promote certified cocoa and coffee production include the provision of information on VSS and their benefits as well as the creation of economic incentives by e.g. reducing taxes or paying subsidies to certified farmers. Furthermore, a well-functioning business environment and infrastructure not only strengthen the export sector in general but in particular the adoption of agri-food standards. In this context, public investment in good national road networks and the improvement of framework conditions for functional land and credit markets could have a significant impact. Another option to reduce farmers' costs of adopting private agri-food standards is the adjustment of public regulations to the stricter requirements of the private standard where justified.
To a limited degree, this positive interaction between private and public standards can also be observed the other way around, whereby the development of VSS that are fully aligned to public standards required in export destinations could help to exploit the full potential of pre-empting public regulations with private agri-food standards. Building partnerships with public

actors in exporting destinations, private stakeholder and standard-setting organisations could be a possible policy instrument to be considered. In the long term, the full harmonisation of exporters and importers public regulations might be the most desirable solution.
Another important component contributing to sustainable development is value-chain upgrading. The implementation and adoption of a VSS can partially support this, as shown in our first essay for different cocoa products and UTZ Certified. Nevertheless, there remains room for improvement, which could be addressed by policy-makers. For instance, public authorities in producing countries could especially attract FDI from cocoa grinders certified to a VSS by providing tax incentives to companies with certification. Moreover, importing regions could make origin grinding more profitable by lowering tariffs for certified cocoa grindings as the remaining tariff escalation, among other things, in the cocoa sector makes origin grinding unprofitable in some countries.

5.3 Limitations and outlook

There are several limitations concerning the datasets and model specifications used in this dissertation. In the following, I will only highlight the main limitations faced in the trade analyses (see Chapters 2 and 3) because these represent the main part of the dissertation.
Our trade analyses in Chapters 2 and 3 include data that does not distinguish between certified and uncertified trade flows. This might lead to an upward bias of our results if countries with a high share of certified production in reality only export a few certified products to their major trading partners, and vice versa. This kind of data is currently not available, but its provision should be promoted because it would enrich studies analysing the trade effects of private agri-food standards. It would not only lead to less biased results but also allows estimating the extent to which increasing the adoption of private agri-food standards reinforces/weakens existing trading relations or creates new trading relations. Another data limitation that I would like to highlight is the lack of data for multiple certifications. This data would enable us to take into account the simultaneous effects of other certification schemes and isolate the effect of the certification scheme of interest. It also allows us to understand whether harmonisation (for example, in the case of Rainforest Alliance Certified and UTZ Certified) has a positive trade effect.
In addition to the aforementioned data limitations, our model specifications also have some weaknesses. In our model specifications in Chapters 2 and 3, we do not decompose the demand-enhancing and trade-cost effects of the agri-food standards. Future research could do so because it allows for a better welfare analysis (Xiong and Beghin, 2014). Other aspects to be considered in future welfare analysis could be the social and environmental benefits of VSSs to evaluate whether they are socially optimal for the global market or unjustifiably strict. Furthermore, for our trade analysis of different stages of the cocoa value chain in Chapter 2, we would ideally use a three-stage least square estimation method to appropriately reflect the system character of the model. We leave this to future research.

Bibliography

Abadi Ghadim, A. K. and Pannell, D. J. (1999). A conceptual framework of adoption of an agricultural innovation. *Agricultural Economics*, 21(2):145–154.

Alänge, S., Jacobsson, S., and Jaryehammar, A. (1998). Some aspects of an analytical framework for studying the diffusion of organizational innovations. *Technology Analysis & Strategic Management*, 10(1):3–22.

Anders, S. M. and Caswell, J. A. (2009). Standards as barriers versus standards as catalysts: Assessing the impact of HACCP implementation on U.S. seafood imports. *American Journal of Agricultural Economics*, 91(2):310–321.

Anderson, J. E. and van Wincoop, E. (2003). Gravity with gravitas: A solution to the border puzzle. *The American economic review*, 93(1):170–192.

Anderson, J. E. and van Wincoop, E. (2004). Trade costs. *Journal of Economic Literature*, 42(3):691–751.

Anderson, J. E. and Yotov, Y. V. (2016). Terms of trade and global efficiency effects of free trade agreements, 1990-2002. *Journal of International Economics*, 99:279–298.

Anderson, K. (2016). *Agricultural trade, policy reforms, and global food security*. Palgrave studies in agricultural economics and food policy. Palgrave Macmillan, New York, NY, U.S.A.

Andersson, A. (2019). The trade effect of private standards. *European Review of Agricultural Economics*, 46(2):267–290.

Ansah, E. O., Kaplowitz, M. D., Lupi, F., and Kerr, J. (2020). Smallholder participation and procedural compliance with sustainable cocoa certification programs. *Agroecology and Sustainable Food Systems*, 44(1):54–87.

Armington, P. S. (1969). A theory of demand for products distinguished by place of production. *Staff Papers - International Monetary Fund*, 16(1):159–178.

Arora, S. and Gangopadhyay, S. (1995). Toward a theoretical model of voluntary overcompliance. *Journal of Economic Behavior & Organization*, 28(3):289–309.

Arton, A., Leiman, A., Petrokofsky, G., Toonen, H., and Longo, C. S. (2020). What do we know about the impacts of the Marine Stewardship Council seafood ecolabelling program? A systematic map. *Environmental Evidence*, 9(1).

Asfaw, S., Mithöfer, D., and Waibel, H. (2009). EU food safety standards, pesticide use and farm-level productivity: The case of high-value crops in Kenya. *Journal of Agricultural Economics*, 60(3):645–667.

Asfaw, S., Mithöfer, D., and Waibel, H. (2010a). Agrifood supply chain, private–sector standards, and farmers' health: Evidence from Kenya. *Agricultural Economics*, 41(3–4):251–263.

Asfaw, S., Mithöfer, D., and Waibel, H. (2010b). What impact are EU supermarket standards having on developing countries' export of high-value horticultural products? Evidence from Kenya. *Journal of international food & agribusiness marketing*, 22(3–4):252–276.

Baldwin, R. and Taglioni, D. (2007). Trade effects of the Euro: a comparison of estimators. *Journal of Economic Integration*, 22(4):780–818.

Banterle, A., Cereda, E., and Fritz, M. (2013). Labelling and sustainability in food supply networks. *British Food Journal*, 115(5):769–783.

Barrett, C. B., Carter, M. R., and Timmer, C. P. (2010). A Century-Long Perspective on Agricultural Development. *American Journal of Agricultural Economics*, 92(2):447–468.

Barrientos, S. (2016). Beyond Fair Trade: Why are mainstream chocolate companies pursuing social and economic sustainability in cocoa sourcing? In Squicciarini, M. P. and Swinnen, J., editors, *The economics of chocolate*, pages 213–227. Oxford University Press, Oxford.

Bass, F. M. (1969). A New Product Growth for Model Consumer Durables. *Management Science*, 15(5):215–227.

Bass, F. M. (1980). The Relationship Between Diffusion Rates, Experience Curves, and Demand Elasticities for Consumer Durable Technological Innovations. *The Journal of Business*, 53(3):S51–S67.

Bateman, R. (2015). *Pesticide Use in Cocoa: A Guide for Training Administrative and Research Staff*. International Cocoa Organization (ICCO), London, 3rd edition.

Beg, M. S., Ahmad, S., Jan, K., and Bashir, K. (2017). Status, supply chain and processing of cocoa - a review. *Trends in Food Science & Technology*, 66:108–116.

Beghin, J., Disdier, A.-C., Marette, S., and van Tongeren, F. (2012). Welfare costs and benefits of non-tariff measures in trade: a conceptual framework and application. *World Trade Review*, 11(3):356–375.

Beghin, J. C., Maertens, M., and Swinnen, J. (2015). Nontariff measures and standards in trade and global value chains. *Annual Review of Resource Economics*, 7(1):425–450.

Berliner, D. and Prakash, A. (2013). Signaling environmental stewardship in the shadow of weak governance: The global diffusion of ISO 14001. *Law and Society Review*, 47(2):345–373.

Berliner, D. and Prakash, A. (2014). Public authority and private rules: How domestic regulatory institutions shape the adoption of global private regimes. *International Studies Quarterly*, 58(4):793–803.

Bleaney, M. and Greenaway, D. (2001). The impact of terms of trade and real exchange rate volatility on investment and growth in sub-Saharan Africa. *Journal of Development Economics*, 65(2):491–500.

Bleaney, M. F. (1996). Macroeconomic stability, investment and growth in developing countries. *Journal of Development Economics*, 48(2):461–477.

Borsky, S., Leiter, A., and Pfaffermayr, M. (2018). Product quality and sustainability: The effect of international environmental agreements on bilateral trade. *The World Economy*, 41(11):3098–3129.

Bray, J. G. and Neilson, J. (2017). Reviewing the impacts of coffee certification programmes on smallholder livelihoods. *International Journal of Biodiversity Science, Ecosystem Services & Management*, 13(1):216–232.

Colen, L., Maertens, M., and Swinnen, J. (2012). Private Standards, Trade and Poverty: GlobalGAP and Horticultural Employment in Senegal. *The World Economy*, 35(8):1073–1088.

Correia, S. (2019). Reghdfe: Stata module to perform linear or instrumental-variable regression absorbing any number of high-dimensional fixed effects. Statistical Software Components, Boston College Department of Economics.

Correia, S., Guimarães, P., and Zylkin, T. (2019). ppmlhdfe: Fast poisson estimation with high-dimensional fixed effects.

Curzi, D., Luarasi, M., Raimondi, V., and Olper, A. (2018). The (lack of) international harmonization of EU standards: import and export effects in developed versus developing countries. *Applied Economics Letters*, 25(21):1552–1556.

Dannenberg, P. (2012). *Standards in internationalen Wertschöpfungsketten: Akteure, Ziele und Governance in der Obst- und Gemüse-Wertekette Kenia - EU*, volume 53 of *Wirtschaftsgeographie*. Lit-Verlag, Münster.

Deans, H., Ros-Tonen, M. A. F., and Derkyi, M. (2018). Advanced value chain collaboration in Ghana's cocoa sector: An entry point for integrated landscape approaches? *Environmental management*, 62(1):143–156.

Deininger, K. and Jin, S. (2006). Tenure security and land-related investment: Evidence from Ethiopia. *European Economic Review*, 50(5):1245–1277.

DeMaria, F. and Drogue, S. (2016). EU trade regulation for baby food: Protecting health or trade? *The World Economy*, 93(1):1–24.

Deutsche Welle (2018). World Cocoa Conference: Low prices still hurt African farmers. `https://www.dw.com/en/world-cocoa-conference-low-prices-still-hurt-african-farmers/a-43523832`. Accessed: 27.09.2018.

Disdier, A.-C., Fontagné, L., and Mimouni, M. (2008). The Impact of Regulations on Agricultural Trade: Evidence from the SPS and TBT Agreements. *American Journal of Agricultural Economics*, 90(2):336–350.

Disdier, A.-C. and Marette, S. (2010). The combination of gravity and welfare approaches for evaluating nontariff measures. *American Journal of Agricultural Economics*, 92(3):713–726.

Drogué, S. and DeMaria, F. (2012). Pesticide residues and trade, the apple of discord? *Food Policy*, 37(6):641–649.

Easley, D. and Kleinberg, J. (2010). *Networks, crowds, and markets : reasoning about a highly connected world*. Cambridge University Press, Cambridge.

Egger, P. and Larch, M. (2008). Interdependent preferential trade agreement memberships: An empirical analysis. *Journal of International Economics*, 76(2):384–399.

Ehrich, M. and Mangelsdorf, A. (2018). The role of private standards for manufactured food exports from developing countries. *World Development*, 101:16–27.

Eichengreen, B. and Irwin, D. (1998). The Role of History in Bilateral Trade Flows. In Frankel, J., editor, *The Regionalization of the World Economy*, pages 33–57. University of Chicago Press, Chicago.

Elamin, N. E. and de Cordoba, S. F. (2020). The trade impact of voluntary sustainability standards: A review of empirical evidence. Research Paper 50, United Nations.

Engel, S. (2004). Achieving environmental goals in a world of trade and hidden action: the role of trade policies and eco-labeling. *Journal of Environmental Economics and Management*, 48(3):1122–1145.

European Commission (2020). RASFF portal. https://webgate.ec.europa.eu/rasff-window/portal/. Accessed: 11.01.2020.

Feenstra, R. C. (2004). *Advanced international trade: Theory and evidence.* Princeton Univ. Press, Princeton, NJ.

Fenger, N. A., Bosselmann, A. S., Asare, R., and de Neergaard, A. (2017). The impact of certification on the natural and financial capitals of Ghanaian cocoa farmers. *Agroecology and Sustainable Food Systems*, 41(2):143–166.

Fernandes, A. M., Ferro, E., and Wilson, J. S. (2015). Product standards and firms' export decisions. Policy Research Working Paper 7315, World Bank Group.

Ferrier, G. D., Reyes, J., and Zhu, Z. (2016). Technology Diffusion on the International Trade Network. *Journal of Public Economic Theory*, 18(2):291–312.

Ferro, E., Otsuki, T., and Wilson, J. S. (2015). The effect of product standards on agricultural exports. *Food Policy*, 50:68–79.

Fiankor, D.-D. D., Flachsbarth, I., Masood, A., and Brümmer, B. (2019). Does GlobalGAP certification promote agrifood exports? *European Review of Agricultural Economics*, 91:1–26.

Fischer, R. and Serra, P. (2000). Standards and protection. *Journal of International Economics*, 52(2):377–400.

Fischer, S. (1993). The role of macroeconomic factors in growth. *Journal of Monetary Economics*, 32(3):485–512.

Fold, N. (2001). Restructuring of the European chocolate industry and its impact on cocoa production in West Africa. *Journal of Economic Geography*, 1(4):405–420.

Fold, N. and Neilson, J. (2016). Sustaining supplies in smallholder-dominated value chains: Corporate governance of the global cocoa sector. In Squicciarini, M. P. and Swinnen, J., editors, *The economics of chocolate*, pages 195–212. Oxford University Press, Oxford.

Fountain, A. and Hütz-Adams, F. (2015). Cocoa Barometer 2015. https://www.voicenetwork.eu/wp-content/uploads/2019/07/Cocoa-Barometer-2015.pdf. Accessed: 11.04.2020.

Fromm, I. (2016). From small chocolatiers to multinationals to sustainable sourcing: A historical review of the Swiss chocolate industry. In Squicciarini, M. P. and Swinnen, J., editors, *The economics of chocolate*, pages 71–87. Oxford University Press, Oxford.

Fulponi, L. (2006). Private voluntary standards in the food system: The perspective of major food retailers in OECD countries. *Food Policy*, 31(1):1–13.

Gelman, A. and Hill, J. (2006). *Data Analysis Using Regression and Multilevel/Hierarchical Models.* Cambridge University Press, Cambridge.

Ghura, D. and Goodwin, B. (2000). Determinants of private investment: a cross-regional empirical investigation. *Applied Economics*, 32(14):1819–1829.

Global Forum for Food and Agriculture (2020). Global Forum for Food and Agriculture - communiqué 2020: Food for all! Trade for secure, diverse and sustainable nutrition. https://www.gffa-berlin.de/wp-content/uploads/2020/02/GFFA-Communique-2020-EN.pdf. Accessed: 13.12.2020.

GlobalGAP (2015). Annual Report 2015. Growing a Global Solution. Technical report, GLOB-

ALG.A.P. c/o FoodPLUS GmbH, Cologne, Germany.

GlobalGAP (2016). Annual Report 2016. Technical report, GLOBALG.A.P. c/o FoodPLUS GmbH, Cologne, Germany.

GlobalGAP (2017). Integrated Farm Assurance: All Farm Base, Crops Base, Fruit and Vegetables: Control Points and Compliance Criteria. https://www.globalgap.org/.content/.galleries/documents/170630_GG_IFA_CPCC_FV_V5_1_en.pdf. Accessed: 23.03.2018.

GlobalGAP (2018a). GLOBALG.A.P. history. https://www.globalgap.org/uk_en/who-we-are/about-us/history/. Accessed: 08.03.2018.

GlobalGAP (2018b). GLOBALG.A.P. Retail & Food Service Members. https://www.globalgap.org/uk_en/who-we-are/members/retailers-food-service/. Accessed: 01.05.2018.

Greene, W. (2007). Fixed and random effects models for count data. NYU Working Paper 2451/26046, New York University.

Guan, Z., Xu, Y., and Ip Ping Sheong, J. (2019). The impact of application of FSC Chain of Custody certification on global wood products trade. *European Journal of Wood and Wood Products*, 77(4):633–643.

Hägerstrand, T. (1967). *Innovation diffusion as a spatial process.* University of Chicago Press, Chicago.

Halabi, S. F. and Lin, C.-F. (2017). Assessing the Relative Influence and Efficacy of Public and Private Food Safety Regulation Regimes: Comparing Codex and Global G.A.P. Standards. *Food and drug law journal*, 72(2):262–294.

Handford, C. E., Elliott, C. T., and Campbell, K. (2015). A review of the global pesticide legislation and the scale of challenge in reaching the global harmonization of food safety standards. *Integrated environmental assessment and management*, 11(4):525–536.

Handschuch, C., Wollni, M., and Villalobos, P. (2013). Adoption of food safety and quality standards among Chilean raspberry producers – do smallholders benefit? *Food Policy*, 40:64–73.

Hartig, F. (2019). Dharma: Residual diagnostics for hierarchical (multi-level / mixed) regression models. r package version 0.2.6. https://CRAN.R-project.org/package=DHARMa. Accessed: 18.02.2019.

Havinga, T. (2015). Retail driven food safety regulation. In Hammoudi, A., Grazia, C., Traversac, J.-B., and Surry, Y., editors, *Food safety, market organization, trade and development*, pages 59–76. Springer, Cham.

Haynes, J., Cubbage, F., Mercer, E., and Sills, E. (2012). The search for value and meaning in the cocoa supply chain in Costa Rica. *Sustainability*, 4(7):1466–1487.

Head, K. and Mayer, T. (2014). Chapter 3 - gravity equations: Workhorse, toolkit, and cookbook. In Gopinath, G., Helpman, E., and Rogoff, K., editors, *Handbook of International Economics*, volume 4, pages 131–195. Elsevier.

Head, K., Mayer, T., and Ries, J. (2010). The erosion of colonial trade linkages after independence. *Journal of International Economics*, 81(1):1–14.

Henson, S. and Humphrey, J. (2010). Understanding the complexities of private standards in global agri-food chains as they impact developing countries. *The Journal of Development*

Studies, 46(9):1628–1646.

Henson, S. and Jaffee, S. (2006). Food safety standards and trade: Enhancing competitiveness and avoiding exclusion of developing countries. *The European Journal of Development Research*, 18(4):593–621.

Henson, S. and Jaffee, S. (2008). Understanding developing country strategic responses to the enhancement of food safety standards. *The World Economy*, 31(4):548–568.

Henson, S., Masakure, O., and Cranfield, J. (2011). Do Fresh Produce Exporters in Sub-Saharan Africa Benefit from GlobalGAP Certification? *World Development*, 39(3):375–386.

Herzfeld, T., Drescher, L. S., and Grebitus, C. (2011). Cross-national adoption of private food quality standards. *Food Policy*, 36(3):401–411.

Holzapfel, S. and Wollni, M. (2014). Is GlobalGAP Certification of Small-Scale Farmers Sustainable? Evidence from Thailand. *The Journal of Development Studies*, 50(5):731–747.

Ingram, V., van Rijn, F., Waarts, Y., and Gilhuis, H. (2018). The impacts of cocoa sustainability initiatives in West Africa. *Sustainability*, 10(11):4249.

ISEAL Alliance (2018). Multiple certification in coffee & cocoa: Multiple certification patterns of ISEAL member schemes in the coffee and cocoa industries. Technical report, ISEAL Alliance, London, UK.

ITC (2001). *Cocoa: A guide to trade practices.* International Trade Centre UNCTAD/WTO, Geneva.

ITC (2011). The interplay of public and private standards. Literature Review Series on the Impacts of Private Standards Part III, International Trade Centre.

ITC (2015). Standards map. `http://www.standardsmap.org/identify`. Accessed: 18.11.2019.

Janssen, E. and Riera, O. (2016). Too hot to handle: The explosive growth of chocolate in India. In Squicciarini, M. P. and Swinnen, J., editors, *The economics of chocolate*, pages 419–438. Oxford University Press, Oxford.

Johansson, B. (2014). Generation and Diffusion of Innovation. In Fischer, M. M. and Nijkamp, P., editors, *Handbook of Regional Science*, pages 391–412. Springer Berlin Heidelberg, Berlin, Heidelberg.

Jones, S. and Gibbon, P. (2011). Developing agricultural markets in Sub-Saharan Africa: Organic cocoa in rural Uganda. *Journal of Development Studies*, 47(10):1595–1618.

Jonfia-Essien, W. A. (2012). Emerging international standards in cocoa trade: recent treatise on MRL. In Navarro, S., Banks, H. J., Jayas, D. S., Bell, C. H., Noyes, R. T., Ferizli, A. G., Emekci, M., Isikber, A. A., and Alagusundaram, K., editors, *Proc 9th. Int. Conf. on Controlled Atmosphere and Fumigation in Stored Products, Antalya, Turkey. 15 – 19 October 2012*, pages 136–143. ARBER Professional Congress Services, Turkey.

Kareem, F. O., Brümmer, B., and Martinez-Zarzoso, I. (2016). European union market access conditions and africa's extensive margin of food trade. *The World Economy*, 93(1):1–24.

Kareem, F. O., Martínez-Zarzoso, I., and Brümmer, B. (2018a). Protecting health or protecting imports? evidence from eu non-tariff measures. *International Review of Economics and Finance*, 53:185–202.

Kareem, F. O., Martínez-Zarzoso, I., and Brümmer, B. (2018b). Protecting health or protecting imports? Evidence from EU non-tariff measures. *International Review of Economics and*

Finance, 53:185–202.

Kersting, S. and Wollni, M. (2012). New institutional arrangements and standard adoption: Evidence from small-scale fruit and vegetable farmers in Thailand. *Food Policy*, 37(4):452–462.

Kinzius, L., Sandkamp, A., and Yalcin, E. (2019). Trade protection and the role of non-tariff barriers. *Review of World Economics*, 155(4):603–643.

Kleemann, L., Abdulai, A., and Buss, M. (2014). Certification and access to export markets: Adoption and return on investment of organic-certified pineapple farming in Ghana. *World Development*, 64:79–92.

Kleinwechter, U. and Grethe, H. (2006). The adoption of the Eurepgap standard by mango exporters in Piura, Peru. In International Association of Agricultural Economists, editor, *26 th Conference of the IAAE*, Gold Coast, Australia.

Krugman, P. (1980). Scale Economies, Product Differentiation, and the Pattern of Trade. *The American Economic Review*, 70(5):950–959.

Krugman, P. (1996). Urban Concentration: The Role of Increasing Returns and Transport Costs. *International Regional Science Review*, 19(1-2):5–30.

Langan, M. and Price, S. (2020). West Africa's cocoa sector and development within Africa-EU relations: engaging business perspectives. *Third World Quarterly*, 41(3):487–504.

Langen, N. and Hartmann, M. (2016). Chocolate brands' communication of CSR in Germany. In Squicciarini, M. P. and Swinnen, J. F. M., editors, *The economics of chocolate*, pages 247–267. Oxford University Press, Oxford.

Lee, J., Gereffi, G., and Beauvais, J. (2012). Global value chains and agrifood standards: Challenges and possibilities for smallholders in developing countries. *Proceedings of the National Academy of Sciences of the United States of America*, 109(31):12326–12331.

Lemeilleur, S., N'Dao, Y., and Ruf, F. (2015). The productivist rationality behind a sustainable certification process: Evidence from the Rainforest Alliance in the Ivorian cocoa sector. *International Journal of Sustainable Development*, 18(4):310–328.

Lernoud, J., Potts, J., Sampson, G., Schlatter, B., Huppe, G., Voora, V., Willer, H., Wozniak, J., and Dang, D. (2018). *The state of sustainability markets 2018: Statistics and emerging trends*. ITC, Geneva.

Li, Y. and Beghin, J. C. (2012). A meta-analysis of estimates of the impact of technical barriers to trade. *Journal of Policy Modeling*, 34(3):497–511.

Li, Y. and Beghin, J. C. (2014). Protectionism indices for non-tariff measures: An application to maximum residue levels. *Food Policy*, 45:57–68.

Magnusson, A., Skaug, H., Nielsen, A., Berg, C., Kristensen, K., Maechler, M., van Bentham, K., Bolker, B., Sadat, N., Lüdecke, D., Lenth, R., O'Brien, J., and Brooks, M. (2020). Generalized linear mixed models using template model builder: Version 1.0.2.1. `https://cran.r-project.org/web/packages/glmmTMB/glmmTMB.pdf`. Accessed: 02.08.2020.

Marie-Vivien, D., Garcia, C. A., Kushalappa, C. G., and Vaast, P. (2014). Trademarks, geographical indications and environmental labelling to promote biodiversity: The case of agroforestry coffee in India. *Development Policy Review*, 32(4):379–398.

Marx, A. (2018). Integrating voluntary sustainability standards in trade policy: The case of the

European Union's GSP scheme. *Sustainability*, 10(12):4364.

Masakure, O., Henson, S., and Cranfield, J. (2009). Standards and export performance in developing countries: Evidence from Pakistan. *The Journal of International Trade & Economic Development*, 18(3):395–419.

Masood, A. and Brümmer, B. (2014). Determinants of Worldwide Diffusion of GlobalGAP Certification. GlobalFood Discussion Papers 48, University of Goettingen.

McCluskey, J. J. and Winfree, J. A. (2009). Pre-empting public regulation with private food quality standards. *European Review of Agricultural Economics*, 36(4):525–539.

Millard, E. (2011). Incorporating agroforestry approaches into commodity value chains. *Environmental management*, 48(2):365–377.

Mohammed, R. and Zheng, Y. (2017). International diffusion of food safety standards: The role of domestic certifiers and international trade. *Journal of Agricultural and Applied Economics*, 49(02):296–322.

Mohan, S., Khorana, S., and Choudhury, H. (2013). Why developing countries have failed to increase their exports of agricultural processed products. *Economic Affairs*, 33(1):48–64.

Nelson, R. R. and Winter, S. G. (1982). *An Evolutionary Theory of Economic Change*. The Belknap Press of Harvard Univ. Press., Cambridge, Mass.

Neumayer, E. and Perkins, R. (2005). Uneven Geographies of Organizational Practice: Explaining the Cross-National Transfer and Diffusion of ISO 9000. *Economic Geography*, 81(3):237–259.

Novy, D. (2013). International trade without CES: Estimating translog gravity. *Journal of International Economics*, 89(2):271–282.

OECD (2018). Statistics on aid to agriculture, rural development and other food-security-related sectors by sub-sector, commitments, 2005-16 (QWIDS). `https://www.oecd.org/development/stats/agriculture.htm`. Accessed: 22.11.2019.

Olivero, M. P. and Yotov, Y. V. (2012). Dynamic gravity: Endogenous country size and asset accumulation. *The Canadian journal of economics*, 45(1):64–92.

Overdevest, C. and Zeitlin, J. (2014). Assembling an experimentalist regime: Transnational governance interactions in the forest sector. *Regulation & Governance*, 8(1):22–48.

Poelmans, E. and Swinnen, J. (2016). A brief economic history of chocolate. In Squicciarini, M. P. and Swinnen, J. F. M., editors, *The economics of chocolate*, pages 11–42. Oxford University Press, Oxford.

Porter, M. E. (1990). *The competitive advantage of nations*. Free Press, New York, NY.

Potts, J., Lynch, M., Wilkings, A., Huppé, G. A., Cunningham, M., and Voora, V. A. (2014). *The state of sustainability initiatives review 2014: Standards and the green economy*. International Institute for Sustainable Development (IISD) and the International Institute for Environment and Development (IIED).

Reardon, T., Timmer, C. P., Barrett, C. B., and Berdegue, J. (2003). The Rise of Supermarkets in Africa, Asia, and Latin America. *American Journal of Agricultural Economics*, 85(5):1140–1146.

Reardon, T., Timmer, C. P., and Minten, B. (2012). Supermarket revolution in Asia and emerging development strategies to include small farmers. *Proceedings of the National Academy of*

Sciences of the United States of America, 109(31):12332–12337.

Richter, R. and Furubotn, E. G. (2010). *Neue Institutionenökonomik: Eine Einführung und kritische Würdigung*. Neue ökonomische Grundrisse. Mohr Siebeck, Tübingen, 4th edition.

Rogers, E. M. (1995). *Diffusion of innovations*. Free Press, New York.

Rueda, X. and Lambin, E. F. (2013). Responding to globalization: Impacts of certification on Colombian small-scale coffee growers. *Ecology and Society*, 18(3):21.

Santeramo, F. G. and Lamonaca, E. (2019). The effects of non–tariff measures on agri–food trade: A review and meta–analysis of empirical evidence. *Journal of Agricultural Economics*, 70(3):595–617.

Santos Silva, J. M. C. and Tenreyro, S. (2006). The log of gravity. *The review of economics and statistics*, 88(4):641–658.

Schuster, M. and Maertens, M. (2015). The impact of private food standards on developing countries' export performance: An analysis of asparagus firms in Peru. *World Development*, 66:208–221.

Sellare, J., Meemken, E.-M., Kouame, C. N., and Qaim, M. (2020). Do sustainability standards benefit smallholder farmers also when accounting for cooperative effects? Evidence from Côte d'Ivoire. *American Journal of Agricultural Economics*, 102(2):681–695.

Shepherd, B. and Wilson, N. L. W. (2013). Product standards and developing country agricultural exports: The case of the European Union. *Food Policy*, 42:1–10.

Snider, A., Gutiérrez, I., Sibelet, N., and Faure, G. (2017). Small farmer cooperatives and voluntary coffee certifications: Rewarding progressive farmers of engendering widespread change in Costa Rica? *Food Policy*, 69:231–242.

Souza Monteiro, D. M. and Caswell, J. A. (2009). Traceability adoption at the farm level: An empirical analysis of the Portuguese pear industry. *Food Policy*, 34(1):94–101.

Sunding, D. and Zilberman, D. (2001). The agricultural innovation process: Research and technology adoption in a changing agricultural sector. In Gardner, B. L. and Rausser, G. C., editors, *Handbook of Agricultural Economics: Agricultural Production*, volume 1, chapter 4, pages 207–261. Elsevier.

Sustainable Agriculture Network (2011). List of prohibited pesticides (November 2011). `https://coricafe.com/library/Sustainability/RAINFOREST%20ALLIANCE%20-%20Prohibited%20Pesticides.pdf`. Accessed: 07.02.2020.

Sustainable Agriculture Network (2017a). Rainforest Alliance guide for the sustainable agriculture standard: Implementation and evaluation of criteria requirements. `https://www.rainforest-alliance.org/business/wp-content/uploads/2018/01/09_the-guide_en.pdf`. Accessed: 19.02.2018.

Sustainable Agriculture Network (2017b). Rainforest Alliance lists for pesticide management: Lists of prohibited and risk mitigation use pesticides. `https://www.rainforest-alliance.org/business/sas/wp-content/uploads/2017/11/02_lists-pesticides-management_en.pdf`. Accessed: 19.02.2018.

Swinnen, J. (2016). Economics and politics of food standards, trade, and development. *Agricultural Economics*, 47(S1):7–19.

Swinnen, J. and Maertens, M. (2007). Globalization, privatization, and vertical coordination in food value chains in developing and transition countries. *Agricultural Economics*, 37:89–102.

Swinnen, J., Maertens, M., and Colen, L. (2015). The role of food standards in trade and development. In Hammoudi, A., Grazia, C., Traversac, J.-B., and Surry, Y., editors, *Food safety, market organization, trade and development*, pages 133–149. Springer, Cham.

Swinnen, J. and Vandemoortele, T. (2009). Are food safety standards different from other food standards? A political economy perspective. *European Review of Agricultural Economics*, 36(4):507–523.

Swinnen, J. and Vandemoortele, T. (2011). Trade and the political economy of food standards. *Journal of Agricultural Economics*, 62(2):259–280.

Talbot, J. M. (2002). Tropical commodity chains, forward integration strategies and international inequality: coffee, cocoa and tea. *Review of International Political Economy*, 9(4):701–734.

Tamru, S. and Swinnen, J. (2016). Back to the roots: Growth in cocoa and chocolate consumption in Africa. In Squicciarini, M. P. and Swinnen, J. F. M., editors, *The economics of chocolate*, pages 439–456. Oxford University Press, Oxford.

Terlaak, A. and King, A. A. (2006). The effect of certification with the ISO 9000 quality management standard: A signaling approach. *Journal of Economic Behavior & Organization*, 60(4):579–602.

Tinbergen, J. (1962). *Shaping the world economy : suggestions for an international economic policy*. The Twentieth Century Fund, New York.

Tinguely, X. (2013). *The Clustering of Innovative Activity*, chapter 5, pages 86–108. Palgrave Macmillan UK, London.

UN Comtrade (2017). WITS - COMTRADE by product. `http://wits.worldbank.org/WITS/WITS/QuickQuery/ComtradeByProduct/`. Accessed: 05.10.2017.

UNCTAD (2019). *International classification of non-tariff measures: 2019 version*. United Nations, Geneva.

UTZ (2015). Standalone facts and figures: UTZ annual report 2015. Technical report, UTZ Head Office, Amsterdam, The Netherlands.

UTZ (2016). Better together: 2016 in achievements. Technical report, UTZ Head Office, Amsterdam, The Netherlands.

UTZ (2017). Monitoring and evaluation system: Public M&E system report: Version 3.1. `https://www.isealalliance.org/sites/default/files/resource/2017-11/UTZ_Impacts_Code_PSR_Jan_2017.pdf`. Accessed: 28.06.2020.

UTZ (2019). Membership and program fee overview (July 2019): Program related payments charged by UTZ. `https://utz.org/wp-content/uploads/2017/06/Membership-Program-Fee-Overview.pdf`. Accessed: 24.06.2020.

UTZ Certified (2009). UTZ Certified Good Inside code of conduct: For cocoa: Version 1.0 - April 2009. Technical report, UTZ Certified Good Inside, Amsterdam, The Netherlands.

UTZ Certified (2012). UTZ Certified Good Inside: List of banned crop protection products: Version June 2012. Technical report, UTZ Certified Good Inside, Amsterdam, The Netherlands.

UTZ Certified (2015). Chain of Custody standard and Chain of Custody cocoa annex: Version 1.1 December 2015. Technical report, UTZ Certified, Amsterdam, The Netherlands.

Valente, T. W., Dyal, S. R., Chu, K.-H., Wipfli, H., and Fujimoto, K. (2015). Diffusion of innovations theory applied to global tobacco control treaty ratification. *Social Science & Medicine*, 145:89–97.

Vanderhaegen, K., Akoyi, K. T., Dekoninck, W., Jocqué, R., Muys, B., Verbist, B., and Maertens, M. (2018). Do private coffee standards 'walk the talk' in improving socio-economic and environmental sustainability? *Global Environmental Change*, 51:1–9.

Vural, B. M. and Akgüngör, E. S. (2019). Quantifying the trade and welfare effects of EU aflatoxin regulations on the dried fruit industry. *German Journal of Agricultural Economics*, 68(2):99–117.

Weatherspoon, D. D. and Reardon, T. (2003). The Rise of Supermarkets in Africa: Implications for Agrifood Systems and the Rural Poor. *Development Policy Review*, 21(3):333–355.

Webb, M. (2015). Overview of Food Safety Standards. In Hammoudi, A., Grazia, C., Traversac, J.-B., and Surry, Y., editors, *Food safety, market organization, trade and development*, pages 45–58. Springer, Cham.

WHO (2010). *WHO recommended classification of pesticides by hazard and guidelines to classification 2009*. World Health Organization, Geneva.

Winchester, N., Rau, M.-L., Goetz, C., Larue, B., Otsuki, T., Shutes, K., Wieck, C., Burnquist, H. L., Pinto de Souza, M. J., and Nunes de Faria, R. (2012). The impact of regulatory heterogeneity on agri-food trade. *The World Economy*, 35(8):973–993.

Winkelmann, R. (2008). *Econometric Analysis of Count Data*. Springer Berlin Heidelberg, Berlin, Heidelberg.

Wooldridge, J. (2002). *Econometric Analysis of Cross Section and Panel Data*. MIT Press, Camebridge.

World Bank (2018). Doing Business. `http://www.doingbusiness.org/`. Accessed: 26.03.2018.

WTO (2005). Committee on sanitary and phytosanitary measures: Summary of the meeting held on 29-30 June 2005. WTO document G/SPS/R/37/Rev.1, World Trade Organization.

WTO (2008). Committee on sanitary and phytosanitary measures: Summary of the meeting of 8-9 October 2008. WTO document G/SPS/R/53, World Trade Organization.

WTO (2010). Sanitary and phytosanitary measures. The WTO agreements series, World Trade Organization, Geneva.

Xiong, B. and Beghin, J. (2012). Does European aflatoxin regulation hurt groundnut exporters from Africa? *European Review of Agricultural Economics*, 39(4):589–609.

Xiong, B. and Beghin, J. (2014). Disentangling demand-enhancing and trade-cost effects of maximum residue regulations. *Economic Inquiry*, 52(3):1190–1203.

Yesuf, M. and Bluffstone, R. A. (2009). Poverty, Risk Aversion, and Path Dependence in Low-Income Countries: Experimental Evidence from Ethiopia. *American Journal of Agricultural Economics*, 91(4):1022–1037.

Yotov, Y. V., Piermartini, R., Monteiro, J.-A., and Larch, M. (2016). *An advanced guide to trade policy analysis: The structural gravity model*. World Trade Organization, Geneva.

Young, H. P. (2009). Innovation Diffusion in Heterogeneous Populations: Contagion, Social Influence, and Social Learning. *American Economic Review*, 99(5):1899–1924.