Does GlobalGAP certification promote agrifood exports?

Dela-Dem Doe Fiankor[a*], Insa Flachsbarth[a], Amjad Masood[b], and Bernhard Brümmer[a,c]

[a]*Department of Agricultural Economics and Rural Development, University of Goettingen, Germany*

[b]*Khwaja Fareed University of Engineering and Information Technology, Pakistan*

[c]*Centre for Biodiversity and Sustainable Land Use, University of Goettingen, Germany*

Abstract

In global agricultural value-chains, private food standards are proliferating. Yet, their trade effects remain poorly understood. This paper assesses the effect of GlobalGAP certification on exports of apples, bananas and grapes. We estimate a structural gravity model using a global dataset of certified producers and the share of certified land area in total harvest area. While our results confirm GlobalGAP standards as catalysts to trade, we find that the trade-enhancing effect varies across products and destination markets. Furthermore, the trade effect is driven more by growth in the area of certified farms than by new certified producers.

Keywords: agricultural trade, GlobalGAP, private food standards, gravity model

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*Corresponding author: dfianko@agr.uni-goettingen.de

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1 Introduction

Standards are proliferating, both geographically and in terms of addressing new concerns (Swinnen, 2016). The agrifood sector, in particular, is prone to their increasing stringency. Food safety standards are prominent in the governance of global agricultural value chains, from farm to fork. Unlike *de jure* mandatory public standards, private standards are voluntary. However, the proliferation of private standards and the increasing market power of multinational retail chains and agribusiness firms means voluntary compliance is *de facto* mandatory to gain and maintain access to high-value markets (Henson and Humphrey, 2010).

Tariffs and quantitative restrictions on international trade are low, providing an impetus for retailers to diversify their product origins. Thus, besides the increasing consumer demand for food safety, the growing relevance of private food standards is due in part to efforts by retail chains to control entire production processes and ease supply chain management within increasingly globalised and competitive agrifood markets (Clarke, 2010). This way, they limit the associated risks of working with various spatially dispersed actors and activities in the supply chain (Dolan and Humphrey, 2000), ensure due diligence and protect their reputations (Subervie and Vagneron, 2013). Standards allow for product differentiation, decreasing consumer uncertainty and increasing demand (Vandemoortele and Deconinck, 2014). By adopting standards, producers also signal to retailers their commitments to quality attributes, such as safety, environmental sustainability and decent labour conditions (Goedhuys and Sleuwaegen, 2016).

Yet, the literature on how standards affect trade is inconclusive. High compliance costs may reduce trade flows (Shepherd and Wilson, 2013) from countries where farmers fail to get certified, but the associated improvement in information asymmetry and the reduced consumer search costs may enhance trade (Henson and Jaffee, 2008). Standards may have no trade effects (Schuster and Maertens, 2015), different short and long run trade effects (Maertens and Swinnen, 2009) or favour developed country producers over their counterparts in developing countries (Xiong and Beghin, 2014; Ferro et al., 2015; Curzi et al., 2018) as the latter are usually standard takers. They may also benefit exporters with large trade volumes, but hinder exports from small trading partners (Anders and Caswell, 2009; Fernandes et al., 2017) since large exporters may find it more profitable to invest in compliance.

The heterogeneity of the standards-trade effect creates room for further and better empirical research (Beghin et al., 2015; Honda et al., 2015). In agricultural and food markets, private standards are ubiquitous, yet studies on public standards predominate the empirical literature (e.g., Anders and Caswell, 2009; Ferro et al., 2015).[1] Indeed, part of the empirical difficulty is because data on private standards are often confidential and inaccessible. It is nevertheless important to analyse their trade effects because they are often more stringent than public standards (Colen et al., 2012). Understanding the heterogeneity of the private standards and trade effect will reveal important policy implications, e.g., for producers deciding between the choice of standards and destination markets (Andersson, 2018).

In this paper, we focus on the GlobalGAP standard, one of the foremost private standards in the global agrifood sector. It is emerging as a quasi-mandatory precondition to access various high-value markets. This has trade cost implications; meeting GlobalGAP requirements involve passing several control points based on food safety, traceability, environmental sustainability and worker occupational health (GlobalGAP, 2015). These can be barriers to resource-constrained producers, influence adoption decisions (Lippe and Grote, 2017) and hinder market access.[2] For example, to get certified, farms undergo detailed third-party audits of their documented procedures against GlobalGAP requirements. Control points include traceability (e.g., producers must guarantee products can be traced back to their farms, register exact planting and harvesting dates), record keeping (e.g., producers record all substances applied to crops, exact amounts, application dates), use of certified seed varieties and fertilisers, irrigation without contaminated water, and Integrated Pest Management (e.g., control pests in ecologically sensitive ways). Upon approval, a certificate is issued but subject to annual renewal. Hence, to choose compliance, the expected utility of producing the certified products (e.g., increased trade volumes) must be large enough to compensate producers for the extra costs involved. For retailers, the transaction costs of identifying farmers producing according to industry-accepted standards are also reduced.

However, whether and to what extent GlobalGAP certification affects exports is an empirical question that has received little attention in the agricultural trade literature. We provide the first *ex-post* empirical analysis of compliance with GlobalGAP on bilateral trade flows. Our study is novel in two ways. First, we question the generality of existing studies, which are all either country/region-specific, product-specific or use cross-sectional data (see also Beghin et al., 2015). These include

[1] Out of about 240 different standards listed in the International Trade Centre Standards Map database, about 190 are private (http://sustainabilitymap.org/standardidentify/). These may be established by firms (e.g., Tesco Nurture, and Nature's Choice), independent standard-setting bodies or NGOs (e.g., Fairtrade International, Rainforest Alliance, Marine Stewardship Council), and industry bodies or coalition of firms (e.g., BRC, IFS, GlobalGAP).

[2] In some countries agricultural productivity is too low to bear the fixed entry and variable costs of certification, which may crowd them out of export markets. In this case, imposing standards may reduce trade flows.

studies on export vegetable production in Kenya (Asfaw et al., 2010b), lychees in Madagascar (Subervie and Vagneron, 2013), pineapple exports from Ghana (Kleemann et al., 2014), asparagus exporting firms in Peru (Schuster and Maertens, 2015), and EU banana (Masood and Brümmer, 2014) and fruit and vegetable imports (Andersson, 2018). We analyse the effects in a full multi-country and multi-sector (i.e., apples, bananas, and grapes) framework. Our second contribution is to the broader private standards and trade literature. To our knowledge, existing studies measure certification as the count of certified firms, land area or producers in a country (see, e.g., Herzfeld et al., 2011; Vural and Akgüngör, 2015; Ehrich and Mangelsdorf, 2018; Andersson, 2018). These ignore the scale of certification within a country, as higher counts of certified producers, firms or area may not always imply a higher concentration of certified production in a country's total production. We propose the share of certified land area in the total harvest area of a country as an additional measure. We argue that this adds valuable information in two ways: it (1) puts the increase of certification in proportion to the total increase in production, and (2) allows for an interpretation of size effects, which can result from an increase in certified area without increases in the number of certified producers.

Empirically, we specify a gravity equation, account for zero trade flows, and address the potential endogeneity of certification. We hypothesise that GlobalGAP enhances trade if compliance is successful. The intuition behind this expectation is clear; certification reduces the transaction costs involved in importer-exporter relationships, and the certification process may serve as an important learning instrument for exporting countries (Goedhuys and Sleuwaegen, 2016) — who according to recent theoretical models (e.g., Chaney, 2008; Helpman et al., 2008) are the most productive and self-select into becoming exporters. These should facilitate market access. Nevertheless, this effect may vary by product, origin and destination market. Hence, our analysis considers both intensive and extensive margins and questions the heterogeneity of the effects according to characteristics of the origin and destination markets. In many cases, the findings support our hypothesis; GlobalGAP certifications may be extra costs for producers, but they sustain import demand.

The paper proceeds as follows. Section 2 provides some background information on the relationship between standards and trade, focusing on GlobalGAP. This is followed by a description of the data and the empirical strategy in Sections 3 and 4. We present and discuss the results in Section 5, and offer concluding remarks with policy implications in Section 6.

2 Private food standards and trade

2.1 Empirical evidence

We review and summarise the rather scant empirical literature related to the private food standards and agricultural trade nexus in Table 1.[3] These studies use mainly country-level data (Mangelsdorf et al., 2012; Shepherd and Wilson, 2013; Vural and Akgüngör, 2015; Ehrich and Mangelsdorf, 2018), but the use of firm-level data is becoming prominent (Melo et al., 2014; Latouche and Chevassus-Lozza, 2015; Schuster and Maertens, 2015). Inferring from the table, while the empirical findings are mixed, positive trade effects dominate. Beyond the well established, positive and negative effects, some studies find no statistically significant effects. Our review indicates that the direction of the effect depends on the particular standard and/or product and/or country-pairs under study. A specific standard may have heterogeneous effects across products; e.g., for voluntary product standards in the EU food and agriculture market, Shepherd and Wilson (2013) find positive trade effects for dairy and egg products, negative effects for cereals and no statistically significant effects for fats and oils. Mangelsdorf et al. (2012) find that voluntary international standards in China hinder exports of fish and tea, but enhance exports of sugar and vegetables.

Table 1 also situates our study within the broader standards and trade literature; no previous study considers the effects of any private food standard on exports from all producing to all importing countries. This study is the first considering global bilateral trade flows. This is crucial because GlobalGAP has indeed become 'global', with increasing importance for retailers even outside Europe.

2.2 The case of GlobalGAP standards

In this section, we discuss the trade cost implications of GlobalGAP. Formally known as the Global Partnership for Good Agricultural Practices, GlobalGAP is the most widely used certification scheme in the global agrifood export sector. Over time, the number of certified producers and the area cultivated to fruits and vegetables has increased across all continents (Figure 1).

GlobalGAP is a process standard. It indicates at every stage of production — from soil management, plant protection to non-processed end product — how crops must be produced and handled. Developed within a business-to-business context, it assures retailers of product safety and does not signal quality directly to consumers. Producers may be better informed about their product attributes, but these are not always directly observable by buyers. To reduce the transaction cost-

[3] For a detailed review of the effects of public standards on trade, see Honda et al. (2015).

Table 1: Summary of empirical studies on the trade effects of voluntary food standards

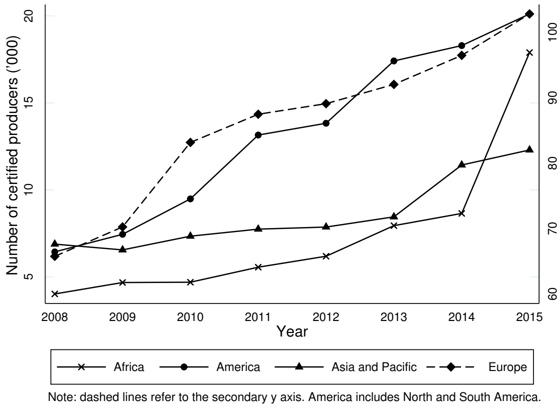
Study	Trade flows	Standards	Products	Effect
Ehrich and Mangelsdorf (2018)	Bilateral trade (87 countries)	IFS	Manufactured food products	+
Latouche and Chevassus-Lozza (2015)	France – EU	IFS, BRC	Agrifood products	+
Melo et al. (2014)	Chile – RoW	ChileGAP	Fresh fruits	+
Andersson (2018)	RoW – EU-15	GlobalGAP	Fruits and vegetables	+
Masood and Brümmer (2014)	RoW – EU-27	GlobalGAP	Banana	+
Henson et al. (2011)	SSA – RoW	GlobalGAP	Fresh produce	+
Schuster and Maertens (2015)	Peru – RoW	Multiple	Asparagus	•
Mangelsdorf et al. (2012)	China – RoW	SAC	Fish, Tea	-
			Sugar, Vegetables	+
			Meat, cereals, milk	•
Vural and Akgüngör (2015)	24 exporters – 22 importers	ISO 22000	Fresh fruits	+
			Fresh vegetables	+
Shepherd and Wilson (2013)	RoW – EU	CEN	Dairy and eggs	+
			Oil seeds	+
			Cereals	-
			Malt, starches, inulin	-
			Fats and oils	•
			Cereal preparations	•

Notes: Standards are represented as CEN = European Committee for Standardization, IFS = International Featured Standards, BRC = British Retail Consortium standards, SAC = Standards Administration of the Peoples Republic of China. RoW means rest of the world. •: no statistically significant effects were found.

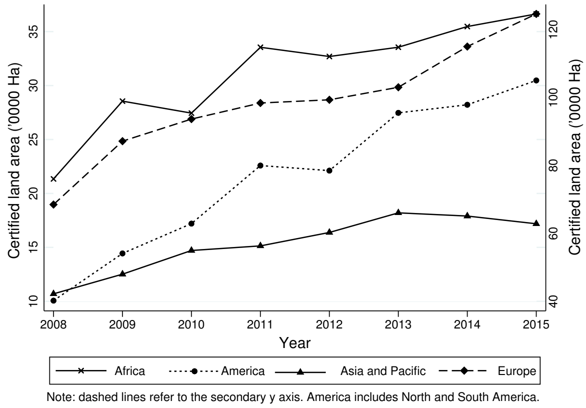
increasing effect of such information asymmetries, members of the Euro-Retailer Produce Working Group reacting to consumer concerns (e.g., product safety) and technical regulations (e.g., due diligence) harmonised their then different agrifood standards (van der Meulen, 2011) to form EurepGAP in 1997. To mark their global relevance they changed their name to GlobalGAP in 2007. The standard is thus not proprietary to a single retailer, and product differentiation is a minor objective. For retailers, reduced transaction costs and improved supply chain management are motivations for requiring certification.

Granted that standards open up market access to participating producers, they also often imply the use of improved and more costly technology (Swinnen, 2016). That is, while retailers demand certification, the costs of compliance are at the expense of the producer. These costs — which can be recurring (e.g., annual certification renewals), non-recurring (e.g., upgrading infrastructure and facilities), tangible (e.g., establishing laboratory facilities) or intangible (e.g., opportunity costs) — vary depending on the quality of existing domestic food safety regulations in the producing country (or specifically the farm). In countries with low domestic public standards, the initial cost of upgrading is higher if they need to implement new policies, processes, and installations. For countries with stringent domestic standards, producers already bear higher costs to comply. This allows them

Figure 1: Development of GlobalGAP certified producers and land area by region



(a) Certified producers



(b) Certified land area

Source: GlobalGAP data, own graph

access to other markets with tight requirements at negligible or no extra costs (Drogué and DeMaria, 2012; Xiong and Beghin, 2014).

If compliance fails due to high setup and production costs, standards imposed by multinationals can hinder trade (Maertens and Swinnen, 2009). For example, to be GlobalGAP certified, producers pay initial certification fees, annual registration fees (charged per product and per hectare) and the associated costs of implementing the standard. These are likely to be initial barriers to trade for farmers. To ease compliance, especially for producers in developing regions, GlobalGAP allows certification of farmers in groups. They also introduced the so-called localg.a.p. schemes[4], which allow adapting existing domestic standards to GlobalGAP while maintaining international standards. There are also reported cases of technical and financial support from donors and trade facilitators (Subervie and Vagneron, 2013), in which case farmers do not have to bear the full cost of certification.

If compliance is successful, there are potential trade benefits. Standards reduce transaction costs by providing a common language within supply chains. This links increasingly demanding retailer requirements with increasing participation of distant suppliers and raises consumer confidence in product safety (Henson and Jaffee, 2008; Ferro et al., 2015). They lower coordination costs, and reduce information asymmetries and the cost of solving moral hazards for buyers facing heterogeneous suppliers (Carlo et al., 2014). Standards help in reducing market failures; they allow retailers

[4]The localg.a.p. program, seen as a cost-effective solution for emerging markets, serves as a stepping stone toward full GlobalGAP certification. It allows retailers and food service providers the chance to initiate food safety programs to prepare their supply base for eventual GlobalGAP certification. Examples include ChileGAP, ChinaGAP, KenyaGAP, MexicoGAP.

a common basis to compare products, and production subject to harmonised standards helps producers achieve economies of scale (Wilson, 2008). When standards are not harmonised, producers most likely face a wide divergence between their domestic and international food safety standards (Maertens and Swinnen, 2009). By harmonising different agrifood standard requirements, GlobalGAP allows producers to export to different high-value markets without having to adopt country or retailer-specific production processes.

The GlobalGAP system provides a cost-effective way for retailers to identify farmers producing according to industry-accepted standards, i.e., those who are voluntarily certified. Hence, for producers, certification is a quality signalling mechanism or cost of doing business. For them, the mandatory initial investments and recurrent expenditures are nevertheless likely to result in increased productivity and/or enhanced product quality arising from other indirect trade effects of certification. Some studies find significant positive effects of GlobalGAP certification on firm performance, e.g., better-trained employees (Colen et al., 2012) and reduced incidence of acute illnesses (Asfaw et al., 2010a). Following GlobalGAP protocols ensures better farm management, and increases exportable yields and sales volume.[5]

In summary, GlobalGAP certification harmonises agricultural practices across farms in different countries and signals product quality to retailers. These properties lower the transaction costs and information asymmetries involved in producer and retailer relationships and enhance international trade (Clougherty and Grajek, 2008). Given these mechanisms, we hypothesise that once certified, GlobalGAP standards have positive effects on trade.

3 Data

We use an Integrated Farm Assurance Standard (i.e., the GlobalGAP certificate) dataset supplied by the GlobalGAP Secretariat in Cologne, Germany. GlobalGAP offers 16 standards for three scopes: crops, livestock, and aquaculture. We limit our study to crops, specifically fruits and vegetables, where producers are mostly certified. There are about 150,000 certified fruit and vegetable producers in 120 countries covering about 3 million hectares of land area. We focus on apples, bananas and grapes, which together with potatoes constitute the top four GlobalGAP certified open field crops

[5] For instance, the GlobalGAP Chain of Custody certification ensures market agents handling certified products properly segregate certified and non-certified products in packing units (GlobalGAP, 2015). In their study on GlobalGAP certified lychee producers in Madagascar, Subervie and Vagneron (2013) also find that local treatment plants provided separate sorting lines for certified and non-certified products. These guarantee certified, but not non-certified farmers, the opportunity to sell larger quantities.

in terms of area (GlobalGAP, 2012).[6] We note that including only three crops limits our ability to draw general conclusions about trade effects for the entire agrifood sector. However, with these products, we include a major fraction of the overall certified crop sector —i.e., about 30 percent of certified fruits and vegetable producers —in our analysis. Furthermore, with multiple products, we can explore the heterogeneity of the trade effect, while assessing whether the trend remains independent of specific products. It also allows us to assess how the trade effects vary across income distributions; while developing countries dominate the export market for banana, the reverse is the case for apples and grapes (Table A1).

A bit more background on the different GlobalGAP certification schemes may help motivate our choice of target variables. There are four GlobalGAP certification options; of interest to our study are options one (where individual farmers apply for certification) and two (where a collection of farmers apply for group certification). The remaining options are the single producer and group certification benchmarked schemes. For each certified country, our dataset contains annual data on (1) the number of product-specific certificates issued and (2) the number of certified producers per product. Data on (1) aggregate both individual and group certificates and understates the actual number of farmers seeking certification. Group certifications help to achieve economies of scale, but variations in group size obscure the actual numbers of certified producers in a country. Taking mean values across countries, this effect is highest for bananas with eight times as many certified producers as the number of certificates issued (Table 2). Certification-specific investments lead smallholder farmers, who predominate developing countries, to pursue group certifications (see, e.g., Mausch et al., 2009). To measure certification, we use the count of certified producers per product in our empirical analysis, as the number of certificates issued might understate the certification effect. Our dataset also contains data on GlobalGAP certified land area per product.[7] Hence, we will also use the share of certified area in total harvest area as a comparative measure.

[6] Due to data limitations, we cannot include potatoes in our analysis.

[7] The number of hectares for countries or products with less than 10 producers is not provided by GlobalGAP. This, according to GlobalGAP is to ensure that it is not possible to identify individual producers. In such cases we calculate missing values for certified area by multiplying the average land size per certificate issued across countries in a year by the number of certificates issued in a country per year.

Table 2: Overview of individual versus group certification per product (2010 - 2015)

	Mean			Total (Millions)		
	Apples	Bananas	Grapes	Apples	Bananas	Grapes
Number of certified producers	239·39	72.08	85.29	20.40	7.30	7.03
Number of issued certificates	71·49	8.30	26.78	6.09	0.84	2.21
Producers per certificate	3·35	8.68	3.19	3.35	8.68	3.19

Source: GlobalGAP data, own calculations

For exploratory purposes, Figure A1 available at ERAE online plots graphically in panel (a) the relationship between GlobalGAP certification and development (measured as per capita GDP) and, in panel (b) the relationship between certification and exports. The observed correlation is positive in both cases. In Table A2 available at ERAE online we explore detailed characteristics of selected certified countries with the highest shares of certified area per product. Interestingly, countries with high counts of certified producers do not always have large shares of their total harvest area certified. This justifies our approach of using both measures in the empirical analysis. Take the case of two banana-producing countries: Peru and Costa Rica. Over the study period, Peru, with 4010 certified producers, had only 56 percent of harvest area certified while Costa Rica, with 90 certified producers, had about 71 percent of harvest area certified. Production and exports are also higher in Costa Rica compared to Peru.

Our data series covers the period 2010 to 2015 and includes exports from 163 producing countries to 157 importing countries (see Table A3 available at ERAE online).[8] The dataset includes 91 apple-producing countries, 108 banana-producing countries, and 88 grape-producing countries. Out of these, 45 countries had at least one certified apple producer, 39 countries had at least one certified banana producer and 44 countries had at least one certified grape producer. We use trade data — from the United Nations Comtrade database via the World Integrated Trade Solution — at the six-digit level of the Harmonised System (HS)-2007 classification. It includes apples (HS080810 and HS081330), bananas (HS080300)[9] and grapes (HS080610 and HS080620). Data on agricultural production and harvest area are from FAOSTAT of the Food and Agricultural Organisation. Country pair data on distance, colonial ties, common language, and contiguity are from the Centre d'Etudes Prospectives et d'Informations Internationales, data on effectively applied tariffs are from the International Trade Centre, and data on regional trade agreements come from De Sousa (2012).

[8] We limit the bilateral trade data to six years to match the available GlobalGAP data.

[9] Banana trade flows recorded in the six-digit HS2007 classification includes plantains. But trade volumes are low compared to bananas, and should not alter our results. Since GlobalGAP certified area contains only bananas, the remaining banana-specific variables exclude plantains.

See Table A4 available at ERAE online for detailed summary statistics on all included variables.

4 Empirical application

To quantify the effect of GlobalGAP certification on global agrifood trade, we follow a consolidated tradition and use an augmented gravity equation. Hence, the gravity theory will guide our analysis and estimates. The gravity model has over the years developed into the preferred tool for trade policy analysis and is favoured among empirical researchers estimating the impact of standards on trade flows (Anders and Caswell, 2009; Ferro et al., 2015). Aside from its intuitive appeal, it has solid theoretical foundations, represents a realistic general equilibrium environment, and has good predictive power (Yotov et al., 2016). Taking the micro-founded specification of Anderson and Van Wincoop (2004) as our starting point, we estimate the following theory-consistent gravity model based on a constant elasticity of substitution demand in a general equilibrium structure:

$$\ln X_{ijkt} = \ln E_{jt} + \ln Y_{ikt} - \ln Y_{kt} + (1-\sigma_k)\ln T_{ijkt} - (1-\sigma_k)\ln P_{jkt} - (1-\sigma_k)\ln \Pi_{ikt} + \varepsilon_{ijkt} \quad (1)$$

where X_{ijkt} is trade flows (in current US dollars) of product k from exporting country i to importing country j in year t. σ_k is the intra-sectoral elasticity of substitution. E_{jt} is nominal GDP, which proxies the importing country's expenditure on product k. Y_{ikt} is the domestic production of k in the exporting country. GDP is usually used as a proxy for the mass of exporting countries, but we consider sector-specific production as a better measure of the supply-side capacity in our model. This variable captures adequately the effect of domestic production of product k on exports. We *a priori* expect that bigger producing countries will on average also export more. Y_{kt} is aggregate world production for sector k. P_{jkt} and Π_{ikt} are the sectoral inward and outward multilateral resistance terms respectively. ϵ_{ijkt} is the error term. Critical for our analysis is the trade cost term T_{ijkt}, which we define as the following log-linear function:

$$T_{ijkt} = D_{ij}^{\beta_1} \tau_{ijkt}^{\beta_2} \text{GlobalGAP}_{ikt}^{\beta_3} \text{O}_{ijkt} \exp \sum_{n=4}^{7} \beta_n \Omega_{ijt} \quad (2)$$

D_{ij} is the bilateral distance between the capital cities of i and j, and Ω_{ij} is a vector of traditional gravity covariates including dummies for common language (Language_{ij}), colonial ties (Colony_{ij}), sharing a common border (Contiguity_{ij}), and membership of a regional trade agreement (RTA_{ijt}). τ_{ijkt} is product-specific *ad valorem* tariffs defined as (1 + Tariff_{ijkt}). Following Emlinger et al.

(2008) we include the variable O_{ijkt} to account for all remaining trade resistance terms. These include exchange rates, institutions, infrastructure, product-specific non-tariff measures imposed by the importing country (e.g., SPS, TBT, quantitative restrictions) and further unobservable time-varying country and product-specific variables.

It is important that the trade cost implications of GlobalGAP certification reflect in our empirical models. We augment the standard definition of T_{ijkt} in equation (2) with our variable of interest, GlobalGAP_{ikt}. As we discuss in Section 2.2, GlobalGAP standards have trade cost implications. On the supply side, adjusting to new production procedures as per the requirements of the standard induces extra costs for producers. Besides, producing subject to a common benchmark may also lower their transaction costs. On the demand side, by reducing information asymmetries, GlobalGAP lowers the transaction costs for importers. Hence, we model GlobalGAP_{ikt} as trade costs that are proxied by their diffusion. Furthermore, it is imperative for our analysis that our measures capture adequately the certification effect on trade. As a first measure of certification, we follow the existing literature and use the count of certified producers of product k in country i in year t (see, e.g., Herzfeld et al., 2011; Vural and Akgüngör, 2015; Ehrich and Mangelsdorf, 2018; Andersson, 2018). While this measure captures the certification effect (whether producers in country i are certified or not), it also captures a size effect (whether there are many producers or many hectares of cropland area in country i).[10] We propose an alternative measure which focuses on the certification effect only. Using FAO data on total harvest area, we measure certification as the share of GlobalGAP certified land area in total harvest area of product k.[11] We use these two indicators separately to measure the diffusion of GlobalGAP standards in a country.

4.1 Estimation issues and model specification

Key to proper estimation of equation (1) is how we account for the unobservable multilateral resistance (MR) terms, accommodate zero trade flows and deal with the potential endogeneity of the standards-trade relationship. In this section, we address these estimation issues.

The MR terms account for the fact that trade flows between country pairs do not only depend on bilateral trade costs but trade costs prevailing with all their other trading partners (Anderson and Van Wincoop, 2003), i.e., the effects of T_{ijkt} should be measured against P_{jkt} and Π_{ikt}. Hence,

[10] We thank an anonymous reviewer for pointing out this distinction.

[11] For some years, Austria, Belgium, Chile, Greece, Italy, New Zealand and the United Arab Emirates had values > 1. In these cases, we replaced them by the value of 1. Dropping these 2,335 observations or replacing them with the mean values do not affect our results quantitatively.

failing to account for these third-country effects means inaccurately predicting how GlobalGAP standards affect bilateral trade flows. The general strategy employed in the literature is to proxy these theoretical constructs using country fixed effects (Baldwin and Taglioni, 2007). In our empirical setting, these proxies must be time and product varying. However, GlobalGAP_{ikt} in equation (2) is time varying only in the exporter-product dimension, and so collinear with the outward MR term, Π_{ikt}. To overcome this identification challenge, we use instead importer-product-time (γ_{jkt}), exporter-time (ϕ_{it}) and product-time (ψ_{kt}) fixed effects.[12]

There are two potential sources of endogeneity in our empirical setting: omitted variable biases and simultaneity of the standards-trade effect. By incorporating a series of fixed effects (i.e., γ_{jkt}, ϕ_{it}, and ψ_{kt}) into our estimation equations, we account for the remaining unobservable trade resistance terms (i.e., O_{ijkt} in equation 2) whose omission may lead to endogeneity in the standards-trade relationship. Second, while certification will affect trade, the intensity of existing trade is also likely to enhance the decision to seek certification. To deal with this potential reverse causality bias, we use a one-year lag of GlobalGAP certification. This is because while past and present certification status are highly correlated, we do not expect past certifications to influence current trade flows (see, e.g., Shepherd and Wilson, 2013; Ferro et al., 2015; Andersson, 2018). Nevertheless, as a robustness check, we also estimate instrumental variable regressions.

Since we study product specific agricultural trade flows at the HS6 digit level, zeroes dominate our bilateral trade dataset. It is impossible to account for informative zero trade flows if we log-transform the dependent variable as in equation (1). Common practices employed to deal with zeroes in trade data, e.g., truncation and censoring, are arbitrary and without strong theoretical or empirical justification and can distort results significantly (Haq et al., 2012). So, we eliminate uninformative zeroes by limiting our exporter sample to only producing countries, and then use more appropriate estimation techniques to deal with all remaining zeroes.[13] Another potential source of bias in our setting is the inherent heteroskedasticity of trade data. Using the Poisson pseudo-maximum-likelihood (PPML) estimator, we simultaneously account for zero trade flows and heteroskedasticity (Santos Silva and Tenreyro, 2006). The estimator's log-linear objective function allows us to specify

[12]While, the γ_{jkt} term accounts for annual importer-product-specific effects it misses out on seasonal variations within a year. Hence, e.g., for the EU's import regime for fruits and vegetables, our analysis accounts for yearly variations, but not intra-annual seasonal and price stabilisation effects such as zero-tariff quota regimes and the entry price scheme. Analysing these specific policies goes beyond the scope of this study. For a more detailed discussion see Cioffi and dell'Aquila (2004), Cioffi et al. (2011), and Santeramo and Cioffi (2012).

[13]It is intuitive to assume that countries that are not producing, e.g., due to climatic or biological reasons, are either not exporting or only re-exporting. Re-exporters are not interesting for our study because GlobalGAP certification is a farm level process standard. We identify producing countries using the FAO dataset on production quantities. All remaining zeroes are informative for our study and dropping them may bias our findings.

the gravity equation in its multiplicative form without log-transforming the dependent variable.

Combining equations (1) and (2), and taking into account the estimation issues discussed above, we specify the PPML estimation equation as:

$$\begin{aligned} \mathrm{X}_{ijkt} = \exp\Big[& \gamma_{jkt} + \phi_{it} + \psi_{kt} + \beta_0 + \beta_1 \ln \mathrm{GlobalGAP}_{ikt-1} + \beta_2 \ln \mathrm{Y}_{ikt} + \beta_3 \ln \mathrm{D}_{ij} \\ & + \sum_{n=4}^{6} \beta_n \Omega_{ij} + \beta_7 \mathrm{RTA}_{ijt} + \beta_8 \ln(1+\mathrm{Tariff}_{ijkt}) + \beta_9 \mathrm{NoGAP}_{ikt-1} \Big] + \varepsilon_{ijkt} \end{aligned} \tag{3}$$

Similar variable definitions hold as in equations (1) and (2). In all estimation equations, our variable of interest is $\mathrm{GlobalGAP}_{ikt-1}$. To account for producing countries with zero certifications, we add a constant value of 1 to $\mathrm{GlobalGAP}_{ikt-1}$ for those cases with zero values before taking logarithms, and also include a 'no certification' dummy (i.e., NoGAP_{ikt-1}) which takes the value of 1 when the country has no GlobalGAP certification and 0 otherwise (Battese, 1997).[14] In this way, we allow for different slopes between exporters with GlobalGAP certification and those without any GlobalGAP certification. If the slope coefficient is indifferent across certified and non-certified countries, we will expect a statistically insignificant NoGAP_{ikt-1} variable. For our results to be in line with our hypothesis, we expect a positive coefficient for the GlobalGAP variable (i.e., $[\partial X_{ijkt}/\partial \mathrm{GlobalGAP}_{ikt-1}] > 0$).

To account for possible product heterogeneity, we estimate a second specification in which we interact dummies for the different products (i.e., apples, bananas and grapes) with the $\mathrm{GlobalGAP}_{ikt-1}$ variable. The resulting estimation equation is:

$$\begin{aligned} \mathrm{X}_{ijkt} = \exp\Big[& \gamma_{jkt} + \phi_{it} + \psi_{kt} + \beta_0 + \alpha_1 \ln \mathrm{GlobalGAP}_{ikt-1} \times \mathrm{Apple} + \alpha_2 \ln \mathrm{GlobalGAP}_{ikt-1} \times \mathrm{Banana} \\ & + \alpha_3 \ln \mathrm{GlobalGAP}_{ikt-1} \times \mathrm{Grape} + \beta_1 \ln \mathrm{Y}_{ikt} + \beta_2 \ln \mathrm{D}_{ij} + \sum_{n=3}^{5} \beta_n \Omega_{ij} + \beta_6 \mathrm{RTA}_{ijt} \\ & + \beta_7 \ln(1+\mathrm{Tariff}_{ijkt}) + \beta_8 \mathrm{NoGAP}_{ikt-1} \Big] + \varepsilon_{ijkt} \end{aligned} \tag{4}$$

We go a step further in the analysis and assess specifically to what extent the trade effect of certification differs depending on the income status of the exporting country. Here, we are interested in whether the exporting country's development status influences the effectiveness of the certification effect on trade. In developed countries with well-functioning institutions to enforce food safety, the trade effects of certification may be less relevant. The reverse may be the case for developing countries, who will then enjoy an even larger trade effect of certification. To assess if this is the case, we split our certification variable into two; one for developing countries — which we define to include

[14] In principle, this means that we define our variable of interest in equation (3) as $[\beta_1 \ln(\mathrm{GlobalGAP}_{ikt-1} + \mathrm{NoGAP}_{ikt-1}) + \beta_9 \mathrm{NoGAP}_{ikt-1}]$. Where $\mathrm{NoGAP}_{ikt-1} = 1$ if $\mathrm{GlobalGAP}_{ikt-1} = 0$ and $\mathrm{NoGAP}_{ikt-1} = 0$ if $\mathrm{GlobalGAP}_{ikt-1} > 1$.

all those not listed as high income in the World Bank income classifications — and the other for developed countries (equation 5).

$$
\begin{aligned}
\mathrm{X}_{ijkt} = \exp\Big[& \gamma_{jkt} + \phi_{it} + \psi_{kt} + \beta_0 + \omega_1 \ln \mathrm{GlobalGAP}_{ikt-1} \times \mathrm{Developing} + \omega_2 \ln \mathrm{GlobalGAP}_{ikt-1} \times \mathrm{Developed} \\
& + \beta_1 \ln \mathrm{Y}_{ikt} + \beta_2 \ln \mathrm{D}_{ij} + \sum_{n=3}^{5} \beta_n \Omega_{ij} + \beta_6 \mathrm{RTA}_{ijt} + \beta_7 \ln(1 + \mathrm{Tariff}_{ijkt}) + \beta_8 \mathrm{NoGAP}_{ikt-1} \Big] + \varepsilon_{ijkt}
\end{aligned} \tag{5}
$$

Finally, to check the robustness of our results to the choice of estimation technique, we use the Heckman selection model. It accounts for zero trade flows in a two-step procedure. Our benchmark specification assesses the intensive margin of trade (i.e., the volume of export conditional on trading), thus, though the Heckman procedure is not robust to heteroskedastic errors and model misspecification (Ferro et al., 2015), it has an additional benefit for our empirical setting. It allows us to distinguish the effect of GlobalGAP standards on the extensive margin of trade (i.e., the probability of trading). In the first stage (i.e., the extensive margin), we estimate a probit equation on whether country pairs in our sample engage in bilateral trade for product k or not. From the parameter estimates in the first stage, we compute the inverse Mill's ratio (λ_{ijkt}) for each country pair which captures selection bias in the residual of the gravity equation. In the second stage, we include λ_{ijkt} as an extra explanatory variable and estimate the expected values of trade flows conditional on trade using ordinary least squares. Robust identification in the Heckman model requires an exclusion variable that affects the extensive but not the intensive margin; we use common religion ($\mathrm{Religion}_{ij}$) as the exclusion restriction (Helpman et al., 2008). The underlying idea is that fixed trade costs, here proxied by the religion dummy, affects the probability to export but not the volume of exports.[15] Indeed, similar religions, like similar cultures, may reduce trade costs, but the complexities inherent in international trading relationships, the potential for costly errors, and other related costs may be large enough to reduce the number of transactions it generates (Cipollina and Salvatici, 2010).

5 Results and discussion

Table 3 reports the results of our benchmark estimations in equation (3). The columns differ only in the choice of GlobalGAP measure: (1) the number of certified producers, and (2) the ratio of certified land area to total harvest area. The overall fit of the estimations is consistent with theoretical priors. All the standard gravity variables have their expected signs and are statistically significant

[15] This choice is also justified as including $\mathrm{Religion}_{ij}$ in equation 3 yields statistically insignificant results, i.e., common religion has no effect on trade at the intensive margin. The results are available upon request from the authors.

at conventional levels. The magnitudes of the coefficient estimates are readily comparable to those in the gravity literature (see Head and Mayer, 2014). Domestic production in the exporting country, speaking a common language, sharing a common border, past colonial ties and regional trade agreements are trade enhancing while bilateral distance and tariffs hinder bilateral trade. In line with the gravity theory, the estimated trade elasticity of our distance measure is close to unity. The tariff coefficient suggests that a one percent decrease in the *ad valorem* tariff, on average, induces an increase in trade of 0.4 percent.[16]

The estimated parameters on the GlobalGAP variables, considering the difference in certification measures, show a positive and statistically significant effect of certification on exports in both model estimations. In column (1), the estimated elasticity of trade to a one percent increase in the number of certified producers is 0.33. In column (2), the estimated elasticity is higher; a one percent increase in the share of GlobalGAP certified land area in total harvest area increases bilateral trade by 0.45 percent, *ceteris paribus*. The difference in coefficient estimates of the two certification measures is in part because average land holdings per producers differ across countries (Table A2). We note that an

Table 3: GlobalGAP certification and agrifood exports: baseline results

	Certified producers	Certified area / Harvest area
	(1)	(2)
Log GlobalGAP$_{ikt-1}$	0.334***	0.449***
	(0.044)	(0.047)
Log Production$_{ikt}$	0.277***	0.538***
	(0.075)	(0.068)
Log Distance$_{ij}$	−1.204***	−1.221***
	(0.103)	(0.101)
Language$_{ij}$	0.429**	0.436**
	(0.167)	(0.171)
Contiguity$_{ij}$	0.414**	0.422**
	(0.190)	(0.188)
Colony$_{ij}$	0.483**	0.462*
	(0.239)	(0.240)
RTA$_{ijt}$	0.866***	0.873***
	(0.166)	(0.166)
Log (1 + Tariff$_{ijkt}$)	−0.378***	−0.362***
	(0.078)	(0.078)
No GAP$_{ikt-1}$	−3.002***	−4.377***
	(0.639)	(0.357)
Observations	178584	178584

Notes: Robust country-pair-product clustered standard errors in parentheses. ***, **, * denote significance at 1%, 5% and 10% respectively. Importer-product-time, exporter-time and product-time fixed effects included in all regressions. Intercepts included but not reported.

[16]Giving a structural interpretation to the tariff coefficient in equation (1), we can infer the elasticity of substitution (i.e., $\beta_8 = 1 - \sigma_k$). As theory predicts, the elasticity of substitution is positive and greater than 1.

increase in the certified area per country includes an increase in the certified area of already certified farms, but also from newly certified farms. This makes it difficult to fully disentangle the land size effect from the effect of an increase in certified producers. However, the much lower coefficient of the latter compared to the former points to the dominance of the size effect, i.e., the trade effect from a percentage change in certified area is larger than from a percentage change in the number of certified producers.[17] This finding suggests that once producers gain access to export markets through certification, they expand their production. Furthermore, the NoGAP$_{ikt-1}$ variable captures the fact that non-certified producing countries have on average lower exports compared to their certified counterparts.

Table 4 reports the product-specific estimates. Overall, GlobalGAP enhances bilateral trade, but the magnitude of the trade effect is heterogeneous across products.[18] This is driven in part by differences in the market structure of the different products. For example, the trade-enhancing effects are economically substantial for all three products but comparatively small for bananas. This is because developed countries dominate apple and grape production, with a rather dispersed market structure; hence, the relatively high trade effect of GlobalGAP certification reflects the high competition among producers for market share. On the other hand, banana production is concentrated in developing

Table 4: GlobalGAP certification and agrifood exports: product specific results

	Certified producers	Certified area / Harvest area
	(1)	(2)
Log GlobalGAP$_{ikt-1}$ × Apples	0.395***	0.415***
	(0.063)	(0.067)
Log GlobalGAP$_{ikt-1}$ × Bananas	0.161***	0.242***
	(0.054)	(0.080)
Log GlobalGAP$_{ikt-1}$ × Grapes	0.431***	0.469***
	(0.072)	(0.054)
Observations	178584	178584

Notes: Robust country-pair-product clustered standard errors in parentheses. ***, **, * denote significance at 1%, 5% and 10% respectively. Importer-product-time, exporter-time and product-time fixed effects included in all regressions. Intercepts included but not reported. Gravity controls for domestic production, distance, contiguity, colony, common language, RTAs and tariffs have their expected signs and are statistically significant but are omitted from the table for brevity.

[17] Since an increase in the share of certified area can result from either increasing the certified land area or a decrease in total harvest area (holding certification rates constant), we estimate another specification with the absolute size of certified area. With a coefficient of 0.58, the size effect still dominates the effect of an increase in producers. As a further attempt to disentangle and quantify the effects of size and producers, we re-estimate our baseline specification but include both certification measures. Our main findings remain unchanged (see, Table A5).

[18] A joint Wald test ($p < 0.001$) rejects the null hypothesis of the equality of the estimated slope coefficients across products in both models. Pair-wise comparisons on the other hand show that these differences are statistically significant between apples - bananas, banana - grapes but not for apples - grapes.

countries.[19] Hence, the relatively low effect for banana may arise from a particular characteristic of the sector, i.e., the historic presence of well-established banana plantations (e.g., Dole, Chiquita, Fyffes, Del Monte, Compagnie fruitiere) that are often vertically integrated, and have always structured the supply to the world market (UNCTAD, 2016). They often times have their own production units in producer countries, and develop quality standards internal to the firm. Thus, GlobalGAP certification may not have made a huge difference in their export volumes. The perishability of the products may also explain the differences in the trade elasticity of certification we observe across products. While all three products are perishable, grapes especially have little protective coating, are prone to surface injuries and impact bruising and thus have shorter post-harvest lives. Since the demand for all three products is higher in developed countries, GlobalGAP signals product quality and gives certified producers a competitive edge in exports over their non-certified counterparts. For all products, bilateral trade responds more positively to increases in certified area than to increases in the number of certified producers. This is consistent with our baseline findings.

5.1 Differences in trade effects by development status

To gain further insights into the effect of certification on exports, we focus attention on the development level of the exporting country. The results — interpreted as the extent to which GlobalGAP certification affects trade depending on whether a country is developed or developing — reported in Table 5 confirm a general trade enhancing effect of GlobalGAP certification for both developed and developing countries.

Table 5: GlobalGAP certification and agrifood exports: by income group

	Certified producers	Certified area / Harvest area
	(1)	(2)
Log GlobalGAP$_{ikt-1}$ × Developing$_{it}$	0.417***	0.343***
	(0.060)	(0.078)
Log GlobalGAP$_{ikt-1}$ × Developed$_{it}$	0.259***	0.472***
	(0.066)	(0.050)
Observations	178584	178584

Notes: Robust country-pair-product clustered standard errors in parentheses. ***, **, * denote significance at 1%, 5% and 10% respectively. Importer-product-time, exporter-time and product-time fixed effects included in all regressions. Intercepts included but not reported. All gravity controls have their expected signs and are statistically significant but are omitted from the table for brevity. Developed countries are defined as high-income countries. Middle and low-income countries are defined as developing countries.

The findings for developing countries are compelling. In column (1), the magnitudes of the

[19] Over the study period, the average share of developed countries' production in total production was 58 percent for apples, 71 percent for grapes and 4 percent for bananas (see Table A1 in the appendix available at ERAE online). The principal banana producing countries are found in Latin and Central America, the Caribbeans and Africa.

trade effects are bigger than for developed countries. This supports our prior argument that the certification-trade effect is larger for developing countries. This is because, for retailers, the transaction cost reducing effect of certification is more pronounced in their dealings with developing country producers. Obviously, information asymmetry and missing institutions to enforce food safety standards are more conspicuous in developing countries. This supports the findings by Andersson (2018) who find a larger certification-trade effect for low-income compared to high-income exporting countries. In column (2), however, the standard-trade effect for developing countries is comparable in magnitude to the effect for developed countries. Indeed the hypothesis that the two have the same coefficient (i.e., $\omega_1 = \omega_2$ in equation (5)) cannot be rejected with a χ^2 value of 2.40.

5.2 The effect on the extensive margin of trade

Next, we discuss the effects of GlobalGAP on the extensive trade margin, i.e., the probability of exporting. Because probits are nonlinear, we report marginal effects of the first-stage estimates of the Heckman sample selection model in columns (1) and (3) of Table 6.[20] The coefficient estimate of λ_{ijkt} which measures selection effects is statistically significant; omitting zero trade observations would bias our estimates. The exclusion restriction, i.e., sharing a common religion, performs considerably well. It has a statistically significant and positive effect in the selection equation and is exogenous to the outcome equation. The estimated marginal effects of the different certification measures are positive and statistically significant. GlobalGAP certification increases the probability of exporting by 2 percent. Effects of this magnitude are consistent with recent empirical evidence,

Table 6: GlobalGAP certification and agrifood exports: Heckman model

	Producers		Certified area / Harvest area	
	$\Pr(X_{ijkt} > 0)$	$\ln(X_{ijkt})$	$\Pr(X_{ijkt} > 0)$	$\ln(X_{ijkt})$
	(1)	(2)	(3)	(4)
Log GlobalGAP$_{ikt-1}$	0.017***	0.523***	0.016***	0.507***
	(0.001)	(0.028)	(0.001)	(0.025)
Religion$_{ij}$	0.025***		0.025***	
	(0.003)		(0.003)	
IMR (λ_{ijkt})		0.918***		0.921***
		(0.009)		(0.009)
Observations	178,584	25,185	178,584	25,185

Notes: Robust country-pair-product clustered standard errors in parentheses. ***, **, * denote significance at 1%, 5% and 10% respectively. Columns (1) and (3) refer to the first stage Probit (i.e., the extensive margin) and columns (2) and (4) are the OLS stage (i.e., the intensive margin) of the Heckman regression. Importer-product-time, exporter-time and product-time fixed effects included in all regressions. Intercepts included but not reported. All gravity controls have their expected signs and are statistically significant but are omitted from the table for brevity. IMR is the inverse Mills ratio.

[20] The coefficient estimates from both stages of the Heckman model are available at ERAE online (Table A6).

e.g., Andersson (2018) find that increases in the number of GlobalGAP certified producers or certificates in a country increases the probability of EU-15 imports of fruits and vegetables by 6 percent. Our results imply that the probability of new trade relationships is positively influenced by certification.

5.3 Destination market heterogeneity

In this section, we explore the consistency of our findings across different destination markets. We define two markets, 'high-value' and 'low-value', depending on their abilities to enforce strict food safety standards. The use of food safety standards as a mandatory market access requirement may be more evident in high-value markets. Hence, our first destination market segment focuses on exports to the EU and high-income OECD countries. The market for non-certified GlobalGAP products is limited in many of these countries (see Colen et al. (2012) and Andersson (2018) for the case of the EU). GlobalGAP, being a retailer-led industry standard, may also be required more by countries with a higher concentration of supermarket chains. Using data on modern grocery distributions within countries, our second market segment focuses on importing countries with a concentration of domestic supermarkets above the mean across all countries (i.e., 32 percent).[21]

Table 7: GlobalGAP certification and agrifood exports: destination market heterogeneity

	EU & OECD imports		Modern Grocery Distribution	
	(1)	(2)	(3)	(4)
Log GlobalGAP$_{ikt-1}$ × High-value$_j$	0.321***	0.481***	0.359***	0.482***
	(0.048)	(0.051)	(0.046)	(0.047)
Log GlobalGAP$_{ikt-1}$ × Low-value$_j$	0.353***	0.384***	0.259***	0.316***
	(0.049)	(0.056)	(0.048)	(0.055)
Observations	178584	178584	178584	178584

Notes: Robust country-pair-product clustered standard errors in parentheses. ***, **, * denote significance at 1%, 5% and 10% respectively. Importer-product-time, exporter-time and product-time fixed effects included in all regressions. Intercepts included but not reported. All gravity controls have their expected signs and are statistically significant but are omitted from the table for brevity. The measure of GlobalGAP standard: columns (1) and (3) use the number of certified producers and column (2) and (4) use the share of certified land area in total harvest area.

In both cases, the positive trade effects of GlobalGAP certification remains (Table 7). The estimated GlobalGAP coefficients are statistically different across the two groups, except for column (1). The trade effects are larger for exports to the 'high-value' markets. This confirms that there exist significant destination market heterogeneities regarding the use of certification. However, we also find a clear positive and significant trade-effect for the so-called 'low-value' markets, which we interpret as evidence of a growing demand for certified produce even in developing countries. This points

[21] The data on modern grocery distributions was retrieved from www.planetretail.com.

to an increasing demand for certified produce that goes beyond the large multinational retailers and agribusiness companies. Many developing countries are experiencing a supermarket revolution (Qaim, 2017), with increasing numbers of smaller retail conglomerates which are emulating the global trend of certification.

5.4 Robustness checks

Finally, we conduct two robustness checks to confirm our main findings in Table 3. To rule out endogeneity bias in our baseline model specification, we run two-stage least squares estimations[22], instrumenting for GlobalGAP_{ikt-1}.[23] The results available at ERAE online (Table A7) are similar to our benchmark specification with all the coefficients retaining their expected sign and statistical significance. The magnitudes of the GlobalGAP coefficients remain close to those in our benchmark specification. Also, as we observe in Figure (1), the spread of certification across regions is uneven; the number of certified producers and area cultivated remains higher in Europe, especially within the EU. To see if this drives our results, we use a sample that excludes EU exports. The results show this is not the case; our positive coefficients remain for GlobalGAP, but with slightly higher trade effects.[24] This means that non-EU exporters experience a more than average trade effect of certification.

6 Conclusion

How private food standards and their associated certification schemes affect bilateral trade flows remain largely ambiguous. We provide further insights using the case of GlobalGAP standards. The study is novel in two ways. First, we question the generality of existing studies because of their country or product-specific approaches and contribute the first multi-country and multi-product study. Second, using the share of certified area in total harvest area as an additional measure of certification, we deviate from the existing literature — which uses counts of certified producers,

[22] Our attempts to estimate an instrumental variable Poisson model — using both ivpoisson or ivppml — generally failed to converge due to the large number of fixed effects involved.

[23] We use as an instrument for certification in apple producing countries the certification in grape producing countries, and *vice versa*. This is because apple and grape producing farms are located mainly in regions with similar climatic and soil conditions. This is not the case for bananas which are produced mainly in the tropics, hence we use banana certifications in neighbouring countries as an instrument. To justify the validity of these instruments, we argue following Ehrich and Mangelsdorf (2018) that countries cannot self-select themselves into becoming neighbours, hence there are no arguments why compliance with a standard in neighbouring countries should influence directly exports of a country. Neither will we expect that certification to one product affects directly exports of another product. Yet, these certification variables are in themselves strongly correlated with each other and satisfy the relevance condition.

[24] The results are available upon request from the authors.

production area, or firms (Vural and Akgüngör, 2015; Ehrich and Mangelsdorf, 2018; Andersson, 2018). We argue that the scale of production under certification is an overlooked consideration in the existing literature, but adds valuable information because it isolates the effect of certification and rules out trade effects emerging from general growth trends in agricultural production.

The results of our gravity estimations confirm a general trade enhancing effect of GlobalGAP certification at both intensive and extensive margins of trade. Thus, while voluntary certification may pose extra costs for producers, they also sustain import demand. These findings are robust to the different certification measures, controls for endogeneity, and remain stable across different model specifications and sub-samples. The positive trade effects are driven more by increases in the area of certified farms, than from the entry of new certified producers. However, the effect sizes are heterogeneous. By product, the trade effect is lowest for bananas. Once certified, the positive trade effects remain regardless of the development status of the exporting country. However, we find a more pronounced trade effect if the number of certified producers increases in developing countries. High transaction costs, typical for many developing countries, are major barriers to trade. Certification can serve as a substitute for a lack of well-functioning institutions to enforce food safety and to overcome information asymmetries (Fiankor et al., forthcoming). Unsurprisingly, the trade effects are higher for exports to high-value EU and OECD markets but interestingly are substantial even for exports to markets outside these regions.

In general, our findings are consistent with the 'standards-as-catalyst' strand of the standards literature. The positive trade effects coincide with micro-level findings that the returns on GlobalGAP investments are considerable in terms of export growth (Henson et al., 2011) and affect positively the quantities sold on international markets (Subervie and Vagneron, 2013), but differ from findings that private standards do not enhance trade (Schuster and Maertens, 2015). At the macro-level, it complements the findings that GlobalGAP certifications enhance EU fruit and vegetable imports (Masood and Brümmer, 2014; Andersson, 2018). But, our study is the first to reveal the described important heterogeneities at a global level. Our findings also support those found in the literature for other voluntary standards in the agrifood sector, such as the IFS, BRC and ISO standards (Latouche and Chevassus-Lozza, 2015; Vural and Akgüngör, 2015; Ehrich and Mangelsdorf, 2018).

Given that voluntary GlobalGAP certification is fast becoming a *de facto* mandatory global standard, yet promotes agrifood exports, policies should aim at facilitating private standard adoption. This is especially relevant in developing countries for two reasons: (1) the transaction cost reducing effect of private standards has the potential to increase trade volumes even more than in developed countries, and (2) GlobalGAP also increases the probability to enter export markets — a finding most relevant for the more marginalised developing countries. A necessary precondition for high certification rates is the modernisation of export-oriented sectors. Public sector technical and financial support may help producers, especially those in developing countries, overcome the initial costs of certification. Furthermore, enhancing good governance and a country's institutional quality can lead to value-chain upgrading, and thereby higher certification rates (Herzfeld et al., 2011). Another policy implication relates to the dominance of the size effect over the trade effect of additional certified farmers. To reverse this trend that large certified farms experience export growth, while new market entrants contribute disproportionately less, policies should specifically target smaller producers. This is particularly relevant in a development context, e.g., in the banana sector where it would lead to more inclusive growth as gains from trade would then be more evenly distributed. However, since apples and grapes are produced mainly in developed countries, our findings also suggest that certification plays a major role in gaining and retaining global market shares even for developed country producers.

One *caveat* inherent in our empirical analysis — and all the literature that has employed the gravity approach — is that public trade databases have no distinction between certified and non-certified commodity trade flows. As HS codes have been introduced for certified organic products, we recommend the same for products under private sustainability standards. This would lead to a clearer identification of the trade effects of private standards distinct from increased trade due to other structural changes in the agricultural sector. To enhance our country-level findings, firm-level data would allow the analysis of entry and exit dynamics of certification, help to better identify barriers to certification, and how firms react individually to food safety standards. Further research could also explore possible nonlinearities in the certification and trade effect using more flexible semi/non-parametric model specifications.

Supplementary data

Supplementary data are available at ERAE online.

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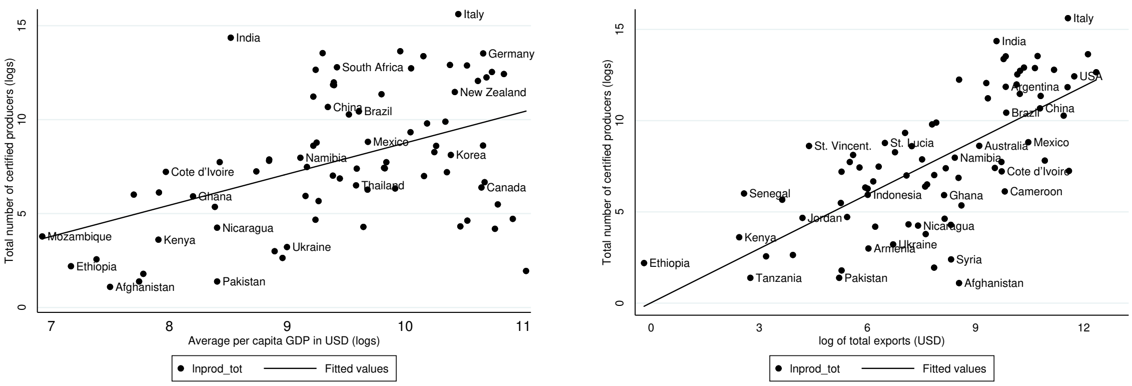
Appendix

Table A1: Average production and imports (2010 - 2015)

	Developed countries			Developing countries		
	Apple	Banana	Grapes	Apple	Banana	Grapes
Production ('000 Tonnes)	555	43	1118	403*	1160	459
Share in total	0.58	0.04	0.71	0.42	0.96	0.29
Imports ('000 USD)	735	1544	1393	342	245	255
Share in total	0.68	0.86	0.85	0.32	0.14	0.15

Source: FAO and UNComtrade data, own calculations. Developed countries are defined as high income countries, whiles middle and low income countries constitute developing countries. *The figure for apple production in developing countries excludes China — the largest producer and consumer of apples.

Figure A1: GDP per capita, exports and spread of GlobalGAP certification (2010 - 2015)



(a) Certification and GDP per capita (b) Certification and exports

Source: GlobalGAP, UNComtrade and, World Bank data, own graph

Table A2: Characteristics of selected certified countries (2010 - 2015)

	GlobalGAP certified				
	Share in harvest area (%)	Producers	Exports ('000 USD)	Production ('000 Tonnes)	Harvest area (Hectares)
Apple					
New Zealand	0.92	243	2949	434	8762
Chile	0.91	726	5417	1675	36114
Belgium	0.84	622	969	271	7275
South Africa	0.83	317	2224	821	22559
The Netherlands	0.82	772	1426	339	8042
Italy	0.56	11877	5682	2295	55698
France	0.37	708	4259	1721	42796
Israel	0.36	21	146	109	2751
Slovenia	0.34	27	84	98	2642
Czech Republic	0.30	44	119	118	8992
USA	0.25	482	5812	4533	131491
Bananas					
Costa Rica	0.71	90	9905	2257	42543
Peru	0.56	4010	1078	184	6736
Colombia	0.51	477	11022	1967	77797
Dominican Republic	0.44	919	2684	1018	28087
Cote d'Ivoire	0.43	10	1774	324	7428
South Africa	0.39	20	52	414	7692
Honduras	0.38	19	1761	798	22932
Ecuador	0.30	748	24413	7053	195803
Guatemala	0.23	15	5865	3158	69074
Saint Lucia	0.23	327	69	11	1124
Grapes					
Peru	0.42	92	3712	414	20508
Namibia	0.24	13	483	23	5828
Chile	0.23	768	14010	2432	196854
Mexico	0.20	25	2698	337	27389
South Africa	0.18	353	5296	1867	113976
Israel	0.13	85	68	77	7613
Egypt	0.09	205	1193	1463	68543
India	0.07	3341	1305	2001	115023
Brazil	0.06	104	1090	1459	80280
Greece	0.05	1276	1424	693	79556

Table A3: List of importing and exporting countries

Afghanistan*, Angola, Albania, Algeria, Antigua and Barbuda†, Argentina, Armenia, Aruba†, Australia, Austria, Azerbaijan, Barbados*, Burundi, Brunei Darussalam†, Belgium, Benin, Bangladesh, Bulgaria, Bahrain, Bahamas, Bosnia and Herzegovina, Botswana†, Belarus, Belize*, Bermuda, Bolivia, Brazil, British Virgin Islands*, Barbados, Bhutan, Burkina Faso†, Cabo Verde, Cambodia, Canada, Central African Republic, Chile, China, Cote d'Ivoire, Cameroon, DR Congo*, Congo*, Cook Islands*, Colombia, Comoros*, Croatia, Costa Rica, Cuba*, Cyprus, Czech Republic, Dominica*, Denmark, Dominican Republic, Ecuador, Egypt, Equatorial Guinea*, Estonia, Ethiopia, Finland, Fiji, France, Gabon*, Gambia†, Germany, Georgia, Ghana, Guinea*, Greece, Grenada*, Greenland†, Guatemala, Guyana, Hong Kong†, Honduras, Haiti*, Hungary, Iceland†, Indonesia, India, Ireland, Iran, Iraq*, Israel, Italy, Jamaica, Jordan, Japan, Kazakhstan, Kenya, Kyrgyzstan, Kiribati*, Republic of Korea, Kuwait, Laos, Lebanon, Libya*, Lithuania, Luxembourg, Latvia, Macao†, Morocco, Moldova†, Madagascar*, Mexico, Macedonia, Mali, Malta, Mozambique, Montserrat, Mauritius, Mauritania†, Malawi, Malaysia, Mongolia†, Montserrat, Myanmar†, Namibia, New Caledonia, Nicaragua, Netherlands, Norway, Nepal, New Zealand, Niger†, Nigeria†, Oman, Palestine†, Pakistan, Panama, Peru, Philippines*, Papua New Guinea, Palau†, Poland, D.P.R. Korea*, Portugal, Paraguay, French Polynesia, Qatar, Romania, Russian Federation, Rwanda, Saint Lucia, Samoa, Saudi Arabia, South Africa, Sudan, Senegal, Singapore†, Sierra Leone*, El Salvador, Saint Kitts and Nevis†, Sao Tome and Principe†, Somalia*, Serbia/Montenegro, Spain, Suriname*, Slovakia, Slovenia, Sweden, Swaziland*, Seychelles, Sri Lanka†, Switzerland, Syria, Togo*, Thailand, Tajikistan*, Turkmenistan*, Tonga, Trinidad and Tobago, Tunisia, Turks and Caicos Islands†, Turkey, Tanzania, Uganda, United Arab Emirates, United Kingdom, Ukraine, Uruguay, USA, Uzbekistan*, Saint Vincent and the Grenadines, Venezuela*, Viet Nam, Yemen, Zambia, Zimbabwe

* means the country is only an exporter and † means the country is only an importer

Table A4: Summary statistics of variables used in the gravity equation

Variable	Mean	Std. Dev.	Min	Max.	N	Unit
Contiguity	0.02	0.14			267006	
Language	0.13	0.34			267006	
Colony	0.01	0.12			267006	
Religion	0.13	0.33			267006	
RTA	0.18	0.38			267006	
Certified area / Harvest area	0.06	0.18			267006	
Certified Producers	130	808	0	12678	267006	
Certified area	1908	6755	0	64862	267006	Hectares
Harvest area	61115	180274	0	2328300	267006	Hectares
Distance	7726	4542	60	19904	267006	Kilometers
Tariff	7.66	13.23	0	181.62	267006	Percentages
Trade	645	11426	0	9693086	267006	1000 USD
Production Exporter	0.92	3.20	0	42.61	267006	Million tonnes

Table A5: GlobalGAP certification and agrifood exports

	(1)
Log $\text{GlobalGAP}^{\text{Producers}}_{ikt-1}$	0.144***
	(0.051)
Log $\text{GlobalGAP}^{\text{Hectares}}_{ikt-1}$	0.343***
	(0.056)
Log Production_{ikt}	0.466***
	(0.071)
Log Distance_{ij}	-1.237***
	(0.102)
Language_{ij}	0.437***
	(0.169)
Contiguity_{ij}	0.416**
	(0.186)
Colony_{ij}	0.481**
	(0.236)
RTA_{ijt}	0.867***
	(0.166)
Log (1 + Tariff_{ijkt})	-0.352***
	(0.078)
No GAP_{ikt-1}	-3.783***
	(0.481)
Observations	178584

Notes: Robust country-pair-product clustered standard errors in parentheses. ***, **, * denote significance at 1%, 5% and 10% respectively. Importer-product-time, exporter-time and product-time fixed effects included in all regressions. Intercepts included but not reported. All gravity controls have their expected signs and are statistically significant but are omitted from the table for brevity.

Table A6: Results of the Heckman Two-Step Estimation

	Producers		Certified area / Harvest area	
	$\Pr(X_{ijkt} > 0)$	$\ln(X_{ijkt})$	$\Pr(X_{ijkt} > 0)$	$\ln(X_{ijkt})$
	(1)	(2)	(3)	(4)
Log GlobalGAP$_{ikt-1}$	0.161***	0.523***	0.144***	0.507***
	(0.008)	(0.028)	(0.007)	(0.025)
Log Production$_{ikt}$	0.102***	0.187***	0.157***	0.409***
	(0.007)	(0.023)	(0.007)	(0.023)
Log Distance$_{ij}$	-0.616***	-1.402***	-0.611***	-1.413***
	(0.017)	(0.059)	(0.017)	(0.059)
Language$_{ij}$	0.403***	0.724***	0.407***	0.721***
	(0.034)	(0.112)	(0.034)	(0.111)
Contiguity$_{ij}$	0.510***	1.232***	0.521***	1.240***
	(0.058)	(0.131)	(0.058)	(0.131)
Colony$_{ij}$	0.461***	0.824***	0.455***	0.854***
	(0.063)	(0.165)	(0.064)	(0.164)
RTA$_{ijt}$	0.263***	0.697***	0.264***	0.738***
	(0.030)	(0.099)	(0.030)	(0.099)
Log (1 + Tariff$_{ijkt}$)	-0.201***	-0.515***	-0.198***	-0.507***
	(0.014)	(0.050)	(0.015)	(0.051)
NoGAP$_{ikt-1}$	-0.355***	-1.405***	-1.281***	-4.485***
	(0.038)	(0.136)	(0.040)	(0.144)
Religion$_{ij}$	0.229***		0.228***	
	(0.030)		(0.030)	
Observations	178,584	25,185	178,584	25,185

Notes: Robust country-pair-product clustered standard errors in parentheses. ***, **, * denote significance at 1%, 5% and 10% respectively. Importer-product-time, exporter-time and product-time fixed effects included in all regressions. Intercepts included but not reported. Measure of GlobalGAP standard: columns (1) - (2) use number of certified producers and column (3) - (4) use certified land area.

Table A7: GlobalGAP certification and agrifood exports: IV regressions

	Producers		Certified area / Harvest area	
	First stage	IV (2SLS)	First stage	IV (2SLS)
	(1)	(2)	(3)	(4)
Log GlobalGAP$_{ikt-1}$	0.938***	0.432***	0.781***	0.407***
	(0.004)	(0.027)	(0.010)	(0.031)
Log Production$_{ikt}$	-0.008	0.138***	-0.043***	0.332***
	(0.005)	(0.023)	(0.008)	(0.022)
Log Distance$_{ij}$	0.017***	-1.126***	0.030***	-1.121***
	(0.006)	(0.057)	(0.011)	(0.056)
Language$_{ij}$	0.002	0.532***	-0.022	0.515***
	(0.012)	(0.114)	(0.021)	(0.113)
Contiguity$_{ij}$	0.009	1.128***	0.014	1.130***
	(0.013)	(0.133)	(0.027)	(0.132)
Colony$_{ij}$	-0.002	0.605***	-0.027	0.620***
	(0.015)	(0.166)	(0.029)	(0.164)
RTA$_{ijt}$	-0.039***	0.573***	-0.051***	0.600***
	(0.011)	(0.100)	(0.018)	(0.101)
Log (1 + Tariff$_{ijkt}$)	-0.032***	-0.431***	-0.043***	-0.425***
	(0.006)	(0.051)	(0.011)	(0.052)
NoGAP$_{ikt-1}$	0.010	-1.384***	1.658***	-3.760***
	(0.024)	(0.132)	(0.053)	(0.146)
Observations	25185	25185	25185	25185
Underidentification		1480.322		1388.341
Weak identification		52588.634		6566.972

Notes: Robust country-pair-product clustered standard errors in parentheses. ***, **, * denote significance at 1%, 5% and 10% respectively. Importer-product-time, exporter-time and product-time fixed effects included in all regressions. Intercepts included but not reported. 2SLS is two-stage least squares estimation. We use GlobalGAP certifications for apple as instruments for grape and vice versa. We instrument for banana, using banana certifications in neighbouring countries. Underidentification and weak identification tests are Kleibergen-Paap rk LM statistic and Cragg-Donald Wald F statistic, respectively.