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Transformation of Global Agri-Food Systems:
Trends, Driving Forces, and Implications for Developing Countries

University of Goettingen

GlobalFood Discussion Papers

No. 112

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November 2017

RTG 1666 GlobalFood · Heinrich Düker Weg 12 · 37073 Göttingen · Germany
www.uni-goettingen.de/globalfood

ISSN (2192-3248)

Suggested Citation:

Fiankor, D.D.D., I. Flachsbarth, A. Masood, B. Brümmer (2017). Does GlobalGAP certification promote agrifood exports? GlobalFood Discussion Paper 112, University of Goettingen. <http://www.uni-goettingen.de/de/213486.html>.

Does GlobalGAP certification promote agrifood exports?

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Abstract

With increasing global agrifood trade, private food standards and certifications have proliferated. Yet, their trade effects remain ambiguous. We provide further empirical evidence by assessing the effect of GlobalGAP certification on agrifood exports to high-value markets in EU and OECD countries. Empirically, we estimate a structural gravity model—that accounts for zero trade and endogeneity of certification—using a novel dataset of certified producers and land area cultivated to apples, bananas, and grapes from 2010 to 2015. While our results generally confirm the trade-enhancing effect of GlobalGAP certification for both developed and developing countries, we show that the effects vary across products.

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

JEL classification: F14, Q17, Q18

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This research was financially supported by the German Research Foundation (DFG) through the Global-Food Program (grant number RTG 1666). We thank the GlobalGAP Head Office, Cologne for providing us data on certification. We received much appreciated comments from Malte Ehrich, Inmaculada Martínez-Zarzoso, Nina Grassnick and participants at the 19th annual European Trade Study Group Conference in Florence. Dela-Dem Doe Fiankor gracefully acknowledges financial support from the Katholischer Akademischer Ausländer-Dienst (KAAD), Germany.

1 Introduction

With increasing trade in high-value agrifood products, public and private food standards have gained prominence in governing global value chains, and continue to play important roles in agricultural production, processing, marketing, and trade. Unlike *de jure* mandatory public standards, private standards are voluntary. Even so, the proliferation of the latter and their associated certifications for agricultural products means they are now seen by many producers as *de facto* mandatory requirements to gain and maintain access to high-value markets (Henson and Humphrey, 2010). In effect, while public standards, proxied by the number of sanitary and phytosanitary measures notified to the World Trade Organization, grew by about 400% between 1995 and 2015 (Ehrich and Mangelsdorf, 2018), producers under voluntary GlobalGAP certification increased by almost six folds between the mid 1990s and 2011 (Swinnen, 2016).

Underlying the proliferation of private food standards is the retail sector's response to food safety scares and increasing consumer demand for food safety. With decreasing tariffs and quantitative restrictions on international trade, large retail chains can source their products from various origins. Thus, the growing relevance of private food standards is due in part to efforts by retail chains to control entire production processes and facilitate supply chain management within increasingly globalized and competitive agrifood markets (Clarke, 2010). This ensures limiting the associated risks of working with various spatially dispersed actors and activities in the supply chain (Dolan and Humphrey, 2000), ensuring due diligence and, protecting their reputations (Subervie and Vagneron, 2013). It allows for product differentiation, decreasing consumer uncertainty and increasing demand (Vandemoortele and Deconinck, 2014). By adopting standards, producers signal to potential buyers commitments to quality attributes such as safety, environmental sustainability and decent labour conditions (Goedhuys and Sleuwaegen, 2016). To demonstrate these commitments, accredited (third-party) certifiers audit and issue certificates of conformity to producers as proof that their production methods meet retailer requirements.

Yet, the literature on how food standards and certifications affect agricultural trade is inconclusive. While increased trade costs required to meet standards may reduce trade flows (Shepherd and Wilson, 2013), the associated improvement in information asymmetry and the reduced consumer search cost may increase consumer confidence and boost trade (Henson and Jaffee, 2008). Standards may also have no effects on trade (Schuster and Maertens, 2015) or have different short and long run effects (Maertens and Swinnen, 2009). This ambiguity creates room for additional empirical evidence to help reach more general conclusions (Honda et al., 2015). Because data on private standards are often confidential and inaccessible, public standards predominate the existing empirical literature (e.g. Anders and Caswell, 2009; Ferro et al., 2015). It is nevertheless, important to analyze the trade effects of private standards in major markets because they are often more stringent than public standards (Fulponi, 2006) and their potential trade enhancing or impeding effects have important policy implications.

This paper represents another effort in response to calls for further empirical analyses of private standards on agrifood trade. Recent such efforts have focused mainly on product standards e.g., the International Featured Standards and British Retail Consortium certifications (Shepherd and Wilson, 2013; Latouche and Chevassus-Lozza, 2015; Ehrich and

Mangelsdorf, 2018) which emphasize final product outcomes to be achieved. In contrast, we study more generic process standards which are involved in all stages of production beginning at the farm level. Specifically, we focus on GlobalGAP standards, which is the foremost global private agrifood pre-farm gate process standard and one of the most important in Europe (Henson et al., 2011). By the year 2010, more than 40 European retail chains required from their suppliers, proof of GlobalGAP certification (Colen et al., 2012). As a result, many developed and developing countries' producers are embracing GlobalGAP as an entry ticket to high-value markets.

When faced with tighter importing country standards, exporters may divert trade to other markets with lax regulations, or they may alter their existing standards, comply and maintain market access (Lee et al., 2012). Complying with GlobalGAP standards involve costs that can be barriers to resource-constrained producers, significantly influence adoption decisions (Lippe and Grote, 2017) and pose market access problems. For exporters to choose compliance, the benefits of producing the certified product (e.g. increased trade volumes) must be large enough to compensate them for the extra costs involved. Yet, whether producers achieve the expected positive trade effect of GlobalGAP certification is seldom tested empirically in the literature at the macro level.

In this paper, by focusing on compliant countries, where producers have overcome the market access problem through voluntary certification, we test whether and to what extent compliance enhances exports to high-value markets. Thus, we provide an ex-post analysis of the effect of GlobalGAP standards on international trade. In doing so, we make two empirical contributions to the food standards and agricultural trade literature. First, with a growing literature on the effects of GlobalGAP standards on trade, most of the existing studies are country and/or product specific and use cross-sectional data. The empirical findings are also mixed. In Kenya, relative to their non-certified counterparts, certified farmers obtain significantly higher net incomes from export vegetable production (Asfaw et al., 2010b), and GlobalGAP certified fresh produce exporting firms in 10 Sub-Saharan African (SSA) countries have higher export revenues (Henson et al., 2011). GlobalGAP certified lychee farmers in Madagascar receive higher premiums and sell higher quantities (Subervie and Vagneron, 2013) and, in Ghana, GlobalGAP investments to reach pineapple export markets yield positive returns (Kleemann et al., 2014). But, using data from 87 asparagus exporting firms in Peru over 18 years, Schuster and Maertens (2015) cannot confirm that GlobalGAP certification has any effect on export performance. These studies are informative but limited in explaining whether the effects are due to sectoral and country characteristics (Beghin et al., 2015). We adopt a cross-country perspective and study the effects of GlobalGAP certification on exports from all producing countries to high-value markets in the EU and OECD countries. Hence, our approach has the advantage of providing more generalized analytical results (Honda et al., 2015). Second, using a unique dataset, ours is the first to assess the effect of GlobalGAP on trade flows across different agrifood products, i.e., apples, bananas, and grapes. Our dataset also allows us to take a longer time horizon than any existing study in the literature, i.e., over the period 2010 to 2015. Closely related is Masood and Brümmer (2014) who, used a three-year panel dataset and focused only on banana trade, show that increasing intensity of GlobalGAP standards affects positively EU imports. We acknowledge and accommodate agrifood product heterogeneity and conduct our analysis at the HS6 product level.

Empirically, we specify a structural gravity equation, account for the inherent heteroskedasticity of trade data and zero trade flows using the Poisson pseudo-maximum-likelihood estimator, and address the potential endogeneity of GlobalGAP certification. We hypothesize that once certification is achieved, positive trade effects dominate for GlobalGAP standards. The intuition behind this expectation is clear, as a business-to-business (B2B) standard, GlobalGAP certified products benefit from retailer networks. This reduces search and transaction costs and enhances exports. The certification process may also serve as an important learning instrument for certified exporting countries—who according to recent theoretical models (e.g. Chaney, 2008; Helpman et al., 2008) are the most productive and self-select into becoming exporters—which increases their certainty of accessing high-value markets (Goedhuys and Sleuwaegen, 2016). Nevertheless, because countries at different development levels dominate the production and export market for apples, bananas, and grapes, we expect possible variations across products. In many cases, the findings support our reasoning. While our results generally confirm the trade-enhancing effect of GlobalGAP on agrifood exports, we show that the effects vary across products and income classifications.

The rest of the paper proceeds as follows. The next section reviews the private food standards and trade literature, provides background information on GlobalGAP, and discusses its potential effects on trade. Section three introduces and describes the data. Section four explains the empirical framework and econometric specifications. Section five presents and discusses the results, and section six concludes.

2 Private food standards and trade

2.1 Empirical evidence

This section reviews the scant macro-level literature related to the effects of private food standards on trade flows in agricultural markets.¹ In high-value agrifood markets, private standards are ubiquitous; the International Trade Centre Standards Map database lists more than 200 voluntary standards. These may be established by firms, independent standard setting bodies or Non-Governmental Organizations, and industry bodies or coalition of firms (Hobbs, 2010). Most studies analysing the private standards and trade nexus use country-level data (Mangelsdorf et al., 2012; Shepherd and Wilson, 2013) in which case they apply gravity models to analyze the effect on bilateral trade flows. Increasingly, the use of firm-level data is becoming prominent (Melo et al., 2014; Latouche and Chevassus-Lozza, 2015; Schuster and Maertens, 2015). Like the present study, country-level studies provide an understanding of how standards affect exports of particular countries or products (Honda et al., 2015). Empirical evidence in the literature vary depending on the specific standard, specific crop or level of development of the countries considered. In many cases, the trade effects are positive for developed countries and negative for developing countries.

Latouche and Chevassus-Lozza (2015) study the market access effect of French firms adopting two European private standards - the International Featured Standards (IFS) and the

¹For a detailed review on the effects of public standards on trade flows see Honda et al. (2015).

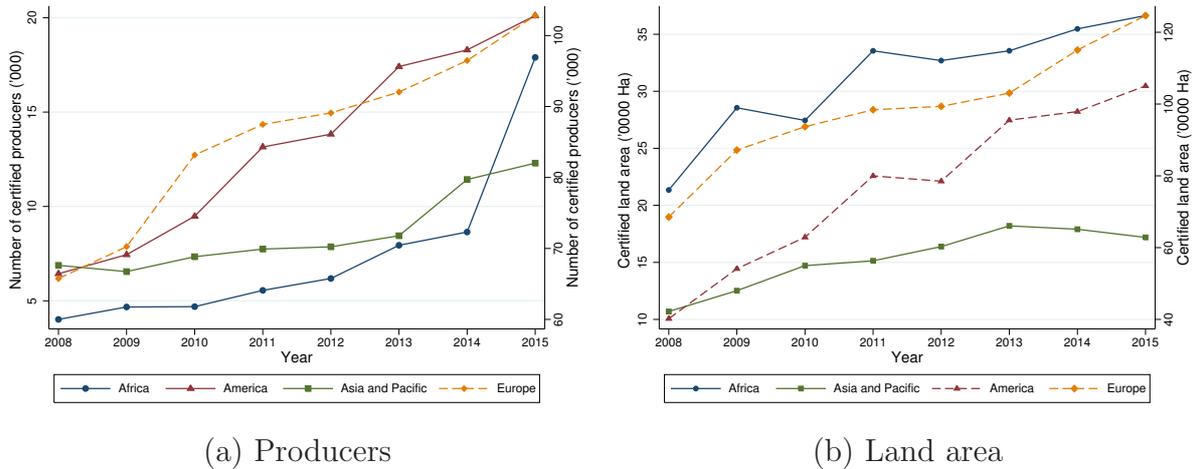
British Retail Consortium (BRC) standards. They find that unlike IFS certification, firms that adopt the BRC certification enjoy better access to certain EU markets through a significant decrease in their entry costs. However, using a gravity model Ehrich and Mangelsdorf (2018) show that on average IFS increases bilateral exports of manufactured agricultural commodities. The effects are not homogeneous across national income distributions with the positive effects disappearing for low-income countries. Using data on a random sample of fresh fruit exporting firms in Chile, Melo et al. (2014) find that when considering the dimensions of regulations and standards, private standards enhance trade while mandatory standards restrict trade. Using data from the World Bank’s EU Standards Database, Shepherd and Wilson (2013) show that voluntary standards are trade inhibiting for raw or lightly processed agricultural exports to the EU. Nevertheless, EU standards harmonized to ISO norms have much weaker trade impeding effects, and in some cases even promote trade. Mangelsdorf et al. (2012) takes a different route and consider how exporting country standards affect exports. Using the case of China, they find that although voluntary standards have positive effects on exports, the effects are smaller and/or insignificant compared to mandatory standards.

2.2 The case of GlobalGAP standards

The Global Partnership for Good Agricultural Practices (GLOBALG.A.P.) is one of the most visible private standards in global agricultural trade and *de facto* mandatory for producers to gain and maintain access to markets, especially in the EU. It is a B2B retail industry pre-farm gate level process standard that indicates at every stage of production—from soil management, plant protection to non-processed end product—how products must be produced and handled. It aims at assuring retailers of product safety and not signalling quality directly to consumers. While producers may be better informed about their product attributes, these are not directly observable to buyers and acquiring such information increases transaction costs. To reduce these costs, members of the Euro-Retailer Produce Working Group reacting to consumer concerns (e.g. product safety) and technical regulations (e.g. due diligence) harmonized their own often different agrifood standards (van der Meulen, 2011) to form GlobalGAP in 1997. GlobalGAP standards are not proprietary to a single retailer, hence, product differentiation is a minor objective (Hobbs, 2010). For retailers, reduced transaction costs and improved supply chain management are more likely motivations for requiring certification. Certification is based on food safety, traceability, environmental sustainability and worker occupational health (GlobalGAP, 2015).

To be GlobalGAP certified, producers need to pay annual registration fees charged per product and per hectare, and the associated costs of implementing the standard. Initial certification costs and continuous compliance and renewal of certificates imply GlobalGAP certifications are likely to be initial barriers to trade for farmers. Nevertheless, it is the most widely used certification scheme in the agrifood export sub-sector in many SSA countries (Colen et al., 2012). Some other countries have taken steps to develop their own domestic standards and benchmark them fully to the GlobalGAP standards (e.g. ChileGAP, ChinaGAP, KenyaGAP, MexicoGAP, New Zealand GAP, SwissGAP). Over time we observe rapid growths in both the number of certified producers and the area cultivated to fruits and vegetables across all continents (Figure 1). So, the increasing role of GlobalGAP as a major private standard linking developed and developing countries’ farmers to international retailers cannot be overstated.

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



Source: GlobalGAP data, own graph. (Note: dashed lines refer to the secondary y axis)

Granted that standards open up market access to participants, they also often imply the use of improved and more costly technology (Swinnen, 2016). For producers to acquire certification as proof that their production methods meet prescribed standards, they incur extra costs of compliance. 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 how different standards are between country pairs, i.e., the quality of existing domestic food safety regulations in the producing country (or specifically the farm). In countries with low existing domestic standards, the initial cost of upgrading may be higher because they may need to implement new policies, processes, and installations (GlobalGAP, 2015). These costs may marginalize poor farmers from high-value markets, or even when they are included, rents in the supply chain are extracted by large companies (Colen et al., 2012). But, for countries with stringent domestic standards, producers already bear higher costs to comply, but these also allow them to access markets with tighter requirements (Drogué and DeMaria, 2012). If compliance significantly raises setup and production costs, standards can hinder trade (Maertens and Swinnen, 2009).

However, once compliance costs are borne and certification is achieved, there are potential trade benefits from compliance. To facilitate overcoming the market access problem of compliance, especially for producers in developing regions, GlobalGAP allows farmers to be certified in groups. They also introduced benchmarked schemes (the so-called localg.a.p. schemes), 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.

Once certified, 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, reduce information

asymmetries along supply chains and reduce the cost of solving moral hazards for buyers facing heterogeneous suppliers (Carlo et al., 2014). Standards help in reducing market failures; they allow retailers a common basis to compare products, and production subject to harmonized standards helps producers achieve economies of scale (Wilson, 2008). When standards are not harmonised, compliance costs can be even higher as this will require specific investments by producers to adapt their production to the idiosyncratic production methods required by different buyers. The result is, producers most likely facing wide divergence between their domestic and international food safety standards (Maertens and Swinnen, 2009). By harmonizing different agrifood standard requirements, GlobalGAP allows producers to export to all markets in the EU and many other high-value markets without having to adopt country or retailer-specific production processes.

As a B2B standard, 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. GlobalGAP certification also redistributes some of the food safety costs—e.g. soil and water testing, employee training and annual audits—away from retailers to producers. These mandatory initial investments and recurrent expenditures are likely to result in increased productivity and/or enhanced product quality arising from other indirect trade effects of certification. Many studies find significant positive effects of certification on firm performance, e.g., GlobalGAP certified farms in Senegal have better-trained employees (Colen et al., 2012), and in Kenya report reduced incidence of acute illnesses (Asfaw et al., 2010a) and increased farm-gate price premiums (Kariuki et al., 2012). Hence, for producers, aside from improved access to international markets, following GlobalGAP protocols ensure improved input control, record-keeping, traceability systems, and farm management which result in increased exportable yields and improved profitability. Producers are able to credibly signal these product and production process qualities to retailers through certification leading to increased sales volume.²

In summary, GlobalGAP certification harmonizes agricultural practices across farms in different countries, provides a common language along the value chain, and signals product quality to retailers. These properties lower the transaction costs and information asymmetries involved with producer and retailer relationships and enhance international trade (Clougherty and Grajek, 2008). However, there is the possibility that even after bearing the costs of certification, standards may have no effects on trade (see e.g. Schuster and Maertens, 2015). Given these mechanisms, we hypothesize that after certification, positive trade effects will dominate for GlobalGAP standards. To test this hypothesis, we specify and estimate a gravity model in the next section after describing our dataset.

3 Data

We use a unique Integrated Farm Assurance Standard (i.e. the GlobalGAP certificate) dataset supplied by the GlobalGAP Secretariat in Cologne, Germany. Currently, the stan-

²For instance, the GlobalGAP Chain of Custody certification ensures that 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.

standard setting body offers 16 standards for three scopes—crops, livestock, and aquaculture—in over 100 countries. We limit our study to crops, specifically fruits and vegetables, where producers are most certified. There are about 150,000 certified fruits and vegetable producers in 120 countries covering about 3 million hectares (Ha) of land area. We focus specifically on bananas (243,400 Ha), grapes (237,800 Ha), and apples (198,500 Ha), which constitute the top four GlobalGAP certified open field crops in terms of area. In terms of certified producers per product, they also constitute the top eight (GlobalGAP, 2012).

Our GlobalGAP dataset includes for apples, bananas, and grapes, 45, 39, and 44 certified producing countries, respectively for the years 2010 to 2015. GlobalGAP is a pre-farm gate standard, thus, we extend the dataset to include as exporters, all producing countries. GlobalGAP standards originated from and are widely required by EU retailers; hence, we include as importers all members of the EU-27 (excluding Croatia) and the OECD states. Table A1 in the Appendix provides a detailed list of included countries. A novelty of our dataset is the multiplicity of certified products; it allows us to study the effect of GlobalGAP certification on exports of apples (HS 080810 and HS 081330), bananas (HS 080300) and grapes (HS 080610 and HS 080620) to the EU. It also allows us to assess how the trade effects vary across income distributions; whiles developing countries dominate the export market for banana and grapes, the reverse is mostly the case for apples.

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 the present study are Option one (where individual farmers apply for certification) and Option two (where a collection of farmers apply for group certification). The remaining options are the single producer and group certification benchmarked schemes. For successive years and for each country, our dataset contains extensive data on (1) the number of product-specific certificates issued and (2) the number of certified producers per product. Data on the former aggregates both individual and group certificates and does not allow us to assess the actual number of farmers seeking certification. Group certifications help to achieve economies of scale, but they obscure the individual number of certified producers in a country. As we see in the third row of Table 1, taking mean values across countries, the obscuring effect is highest for banana producing countries. We observe four times as many certified banana producers as the number of banana certificates issued. Specific investments associated with certification lead smallholder farmers, who predominate developing countries, to pursue group certifications. For example, in Kenya Mausch et al. (2009) find that smallholders are mostly group certified, whereas medium and large-scale farms opt for individual certification. Therefore, to capture the effect of certification, we use the count of certified producers per product (see e.g. Herzfeld et al., 2011; Ehrich and Mangelsdorf, 2018). Our dataset also contains data on the area of land cultivated to specific GlobalGAP certified products per year. We employ these two indicators, as a measure of the diffusion of GlobalGAP standards in a country. Ideally, we consider the ratio of producers per hectare a better measure, but the number of hectares for countries or products with less than 10 producers is not provided by GlobalGAP.³

³This according to GlobalGAP is to ensure that it is not possible to draw back conclusions to single producers. Thus, area of production data is only available for 29 apple producing countries, 14 banana producing countries and 23 grape producing countries.

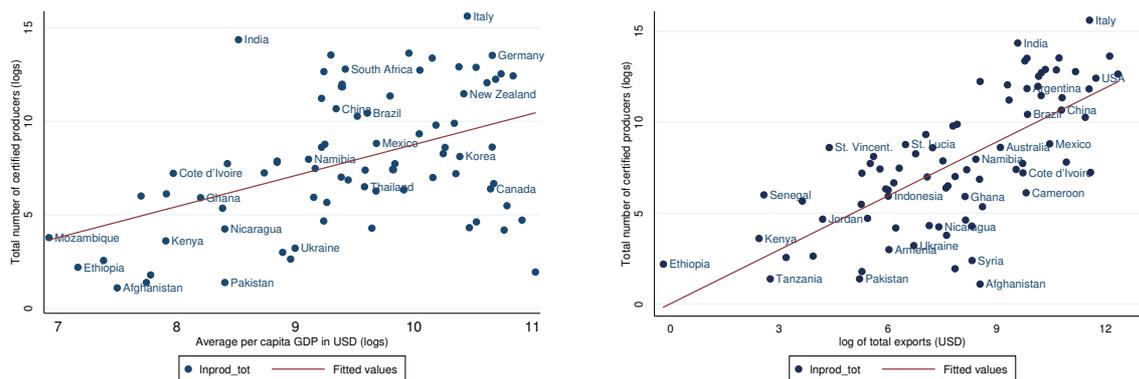
Table 1: Number of certified producers and certificates per product (2010 - 2015)

	Mean			Total (Millions)		
	Apples	Bananas	Grapes	Apples	Bananas	Grapes
Certified producers	281.41	48.74	112.67	34.13	6.06	11.94
Certificates per product	84.47	11.15	35.09	10.25	1.39	3.72
Producers per certificate	3.33	4.37	3.21	3.33	4.37	3.21

Source: GlobalGAP data, own calculations

As an initial exploratory analysis of our dataset, Figure 2 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. Richer countries including Germany, Italy, and New Zealand have on average more certified producers of all three products, and countries with a higher diffusion of certification e.g., Italy, India, Brazil, and Argentina, also enjoy on average higher exports.

Figure 2: GDP per capita, exports and spread of GlobalGAP certification



(a) Certification and GDP per capita

(b) Certification and exports

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

The remaining gravity model data are derived from different sources. GDP and agricultural production data are from the World Bank World Development Indicators database and, FAOSTAT of the Food and Agricultural Organization respectively. Bilateral trade flow data are from the United Nations Commodity Trade (UNComtrade) database via the World Integrated Trading System (WITS). Country pair data on distance, colonial ties, common language, and contiguity are from the Centre d'Etudes Prospectives et d'Informations Internationales (CEPII), data on effectively applied tariffs are from the International Trade Centre, and data on regional trade agreements come from De Sousa (2012). Table A2 in the Appendix presents detailed summary statistics on all included variables.

4 Empirical application

4.1 The gravity model

The gravity model has over the years developed into the preferred tool for trade policy analysis. Aside from being intuitive, it has solid theoretical foundations, represents a realistic general equilibrium environment, and has good predictive power (Yotov et al., 2016). It is favoured among empirical researchers estimating the impact of standards on trade flows (e.g. Anders and Caswell, 2009; Ferro et al., 2015). Earlier applications of the model were naïve and flawed as they ignored what we now know as the multilateral resistance (MR) terms (Anderson and van Wincoop, 2003). Intuitively, MR implies that trade flows between two countries do not only depend on bilateral trade costs between them but trade costs prevailing with all their other trade partners. It is important to account for these MR terms else we commit the “gold medal mistake” (Baldwin and Taglioni, 2007) and are unable to predict accurately how GlobalGAP standards affect trade flows in the gravity framework. Following Anderson and van Wincoop (2003) we specify a modified structural gravity model as:

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

Where X_{ijt} is trade flows from exporting country i to importing country j in year t in current US dollars. E_{jt} is nominal GDP, which proxies the import demand of j in t . Y_{it} is the annual level of domestic production⁴ of product k in i . Y_t is aggregate world production, σ is the elasticity of substitution and P_{jt} and Π_{it} are the importing and exporting country MR terms respectively. ε_{ijt} is the error term. t_{ijt} are trade costs, which we define as:

$$t_{ijt} = D_{ij}^{\beta_1} (1 + \tau_{ijt})^{\beta_2} \text{RTA}_{ijt}^{\beta_3} \text{GAP}_{it}^{\beta_4} \exp \sum_{k=1}^3 \beta_k \Omega_{ij} \quad (2)$$

As conventional in gravity models, 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, colonial ties and sharing a common border. τ_{ijt} is product-specific *ad valorem* tariffs and RTA is a dummy for the presence of a regional trade agreement (RTA). We augment the trade cost component of the model with a variable, GAP_{it} , which is our measure of GlobalGAP certification.

4.2 Estimation issues

Estimating equation (1) is not without econometric and modelling issues. First, the MR terms are theoretical constructs and not directly observable. Following much of the recent literature, we use country fixed effects as proxies (Baldwin and Taglioni, 2007). In panel data settings, these proxies must be time-varying. However, given that our GlobalGAP

⁴We argue that using GDP as a proxy for the mass of exporting countries is less suitable in the context of sectoral (e.g. agriculture) trade, hence, we use sector-specific annual production. This is a better measure of the supply-side capacity of the exporting countries.

measure (GAP_{it}) in equation (2) is time varying only in the exporter dimension, it is collinear with the Π_{it} terms in equation (2). We need to establish a proper identification strategy that allows us to combine our variable of interest with the MR terms. This is because including the structural time-varying fixed effects will absorb all time-varying country characteristics (including our variable of interest) that may influence bilateral trade flows.⁵ We use instead time-invariant importer (γ_j), exporter (λ_i) and year (ψ_t) fixed effects (see e.g. Czubala et al., 2009; Drogué and DeMaria, 2012; Disdier et al., 2015). We consider this adequate because, over our relatively short study period, GlobalGAP requirements are unlikely to have changed much. While acknowledging that this might be insufficient to capture any time-varying multilateral resistance terms, we believe the potential bias in our case is limited.⁶ Following Disdier et al. (2015) we include the size terms E_{jt} and Y_{it} to control for time variation in country’s demand and supply.

Second, because we study sectoral trade flows, zeroes are ubiquitous in our bilateral trade dataset. Log-transforming the dependent variable as in equation (2) makes it impossible to properly account for any informative zero trade flows. Common practices in the literature employed to deal with zeroes in trade data are truncation and censoring. These methods are arbitrary and without strong theoretical or empirical justification and can distort results significantly (Burger et al., 2009). Consequently, we employ more appropriate estimation techniques to deal with the issue of zeroes. We eliminate a number of excess zeroes by limiting our samples to only producing countries. It is intuitive to assume that countries that are not producing probably due to climatic or biological reasons are either not exporting or only re-exporting.⁷ Re-exporters are not interesting for our study because GlobalGAP certification is a farm level process standard. All remaining zeroes will be informative to our study and dropping them will bias our findings.

Third, if the inherent heteroskedastic nature of trade data is not dealt with, estimates can be biased. Using the Poisson pseudo-maximum-likelihood (PPML) estimator, we simultaneously overcome the issues of zero trade flows and heteroskedasticity (Santos Silva and Tenreyro, 2006, 2011). It allows us to specify the gravity model in its multiplicative form and use the dependent variable in levels. Even in micro settings such as agriculture, which are likely to include many disaggregated trade data, the use of the PPML estimator is justified (Prehn et al., 2012).

4.3 Model specification

Another econometric issue that arises is the potential endogeneity of GlobalGAP certification to agricultural trade flows. While certification will affect trade, the intensity of existing trade is also likely to enhance the decision to seek certification. To reduce this potential reverse causality bias, we consider a one-year lag of GlobalGAP certification. This is because while past and current certification status is highly correlated, we do not

⁵To circumvent this problem Heid et al. (2015) recommend an approach involving the inclusion of intra-national trade flows. We are unable to employ this approach because their assumption that the trade policy measure does not affect domestic trade flows will not apply in our case.

⁶As a robustness check we will also approximate the MR terms using the first-order Taylor-series expansion approach of Baier and Bergstrand (2009).

⁷We identify producing countries using the FAO production dataset. Because of limited data on production values, we use instead data on production quantities.

expect past certifications to influence current trade flows (see e.g. Shepherd and Wilson, 2013; Ferro et al., 2015). Taking into account possible agrifood product heterogeneity, we run separate estimations for each product, and specify our initial model as follows:

$$\begin{aligned}
X_{ijt} = \exp & \left(\gamma_j + \lambda_i + \psi_t + \beta_0 + \beta_1 \ln(1 + \text{GAP}_{it-1}) + \beta_2 \text{NoGAP}_{it} + \beta_3 \ln Y_{it} \right. \\
& + \beta_4 \ln Y_{jt} + \beta_5 \ln E_{jt} + \beta_6 \ln D_{ij} + \beta_7 \ln(1 + \tau_{ijt}) + \beta_8 \text{Language}_{ij} + \beta_9 \text{Colony}_{ij} \\
& \left. + \beta_{10} \text{Contiguity}_{ij} + \beta_{11} \text{RTA}_{ijt} \right) \varepsilon_{ijt} \quad (3)
\end{aligned}$$

Similar variable definitions hold as in equations (1) and (2). To control for home bias effects (i.e. resisting foreign imports due to the supply of national products), we introduced the total annual domestic production in the importing country Y_{jt} as an explanatory covariate. Evidence of trade resistance due to home bias would be supported by a negative and statistically significant coefficient of Y_{jt} (Dal Bianco et al., 2016). To ensure we do not lose observations in situations where there are zero certifications per country-product-year pairs, we add a constant value of 1 to our GlobalGAP variables of interest before taking logarithms. Hence, we also include a no certification dummy, i.e. (NoGAP_{it}) which takes the value of 1 when the country has no GlobalGAP certification and 0 otherwise.

Although equation (3) includes country and time fixed effects, there could still remain endogeneity concerns because of omitted variable biases. A natural extension is to follow an instrumental variable approach. Addressing this in a gravity framework is not easy due to lack of relevant and valid instruments. Among the few studies that embark on that path, many observe that while endogeneity may be present, it does not qualitatively affect their findings in terms of signs and statistical significance (e.g. Moenius, 2004; Vigani et al., 2012; Ehrich and Mangelsdorf, 2018). Lacking plausible instruments, a promising approach is to include dyadic fixed effects (Head and Mayer, 2014). These control for all observable and unobservable time-invariant trade cost proxies in our initial specification (i.e. distance, common language, colonial ties and contiguity), reduce possible biases resulting from the omission of any such variables and control for most of the linkages between our GlobalGAP trade policy variables and the error term (Yotov et al., 2016). Introducing country-pair fixed effects (ϕ_{ij}) into our estimations, we specify our benchmark estimation equation as follows:

$$\begin{aligned}
X_{ijt} = \exp & \left(\phi_{ij} + \psi_t + \beta_0 + \beta_1 \ln(1 + \text{GAP}_{it-1}) + \beta_2 \text{NoGAP}_{it} + \beta_3 \ln Y_{it} + \beta_4 \ln Y_{jt} \right. \\
& \left. + \beta_5 \ln E_{jt} + \beta_6 \ln(1 + \tau_{ijt}) + \beta_7 \text{RTA}_{ijt} \right) \varepsilon_{ijt} \quad (4)
\end{aligned}$$

In both estimation equations, our variable of interest is GAP_{it-1} . Given the nature of our data, which measures the spread of certification within countries, we expect a positive and significant β_1 , implying that certification increases trade flows.

5 Results and discussion

In this section, the results of the econometric estimation of equation (4) are discussed. First, we focus on the average effect of certification across the three products and second

we confirm how the effects differ across income classifications of the exporting countries. Then we conduct series of robustness checks to confirm our main results.

5.1 Main results

The empirical results of our benchmark estimation are presented in Table 2. All models are estimated using the PPML estimator with country-pair and time fixed effects (which are omitted for brevity). The odd-numbered columns present results using as a measure of certification the number of certified producers, while the even-numbered columns use certified land area.

The overall fit of the estimations is consistent with what is found in the gravity literature. All standard gravity variables have their expected signs and almost all of them are statistically significant at conventional levels.⁸ In most cases, the size terms proxied by importer GDP (GDP_{jt}) and production in the exporting country ($Production_{it}$) have positive effects on bilateral trade. Importing countries' GDP have positive and statistically significant effects on exports of all products. For level of domestic production in the exporting country, however, the effects are not statistically significant. In contrast, the level of domestic production in the importing countries has a negative and significant effect on exports of apples. For bananas and grapes the home bias effects are insignificant. We conclude that home bias induces trade resistance in apples. Trade agreements enhance exports of grapes but not apples and banana. Tariffs, on the other hand, hinder grape and apple exports. Non-certified producing countries, have on average lower exports of all products than certified producing countries. This is captured by the negative and significant effects of the variable $No\ GAP_{it}$.

Focusing on our variable of interest, the coefficient estimate of β_1 , we observe a positive and statistically significant effect of certification on exports in all model estimations. In terms of economic significance the effects are large for apples and grapes but small for bananas. Specifically, a 1% increase in the number of certified producers increases apple, banana and grape exports by 0.14%, 0.07% and 0.20% on average, respectively. For certified land area, a one percentage increase enhances apple exports by 0.07%, banana exports by 0.01% and grape exports by 0.05%. In all cases, the coefficients of our estimated elasticities are larger for number of certified producers compared to certified land area, i.e., a one percentage increase in the number of certified farmers has a larger positive effect on exports compared to a one percentage increase in certified land area. Aside from missing data on certified land area for countries with less than 10 certified producers, this difference is also because average landholding per certified producer is more than one hectare of land in our sample data. In other words, if average landholding per country were one hectare per certified producer, we would expect the coefficient estimates to be equal in both estimations.

⁸The results of equation (3) containing the traditional gravity covariates of distance, common language, sharing a common border and past colonial ties are presented in Table A3.

Table 2: The effect of GlobalGAP certification on agrifood exports to the EU

	Apples		Bananas		Grapes	
	(1)	(2)	(3)	(4)	(5)	(6)
$\ln \text{GAP}_{it-1}^{\text{Producers}}$	0.136*** (0.033)		0.066* (0.036)		0.201*** (0.058)	
$\ln \text{GAP}_{it-1}^{\text{Hectares}}$		0.074*** (0.022)		0.005 (0.007)		0.045*** (0.015)
No GAP_{it}	-0.352** (0.148)	-0.403*** (0.150)	-0.821*** (0.206)	-0.809*** (0.208)	-0.601** (0.261)	-0.661*** (0.240)
$\ln \text{Production}_{it}$	0.006 (0.023)	0.012 (0.024)	0.182 (0.135)	0.187 (0.138)	-0.001 (0.011)	-0.004 (0.012)
$\ln \text{Production}_{jt}$	-0.165*** (0.063)	-0.171*** (0.061)	0.041 (0.148)	0.036 (0.151)	0.045 (0.107)	0.074 (0.106)
$\ln \text{GDP}_{jt}$	1.223*** (0.232)	1.219*** (0.239)	0.489** (0.212)	0.470** (0.215)	0.908*** (0.224)	0.954*** (0.260)
RTA_{ijt}	0.278 (0.679)	0.336 (0.620)	-0.024 (0.061)	-0.021 (0.064)	0.384*** (0.067)	0.472*** (0.065)
$\ln \text{Tariff}_{ijt}$	-0.108** (0.043)	-0.112*** (0.040)	-0.003 (0.014)	-0.000 (0.016)	-0.034** (0.017)	-0.035* (0.018)
Observations	6,110	6,110	4,585	4,585	6,720	6,720

Notes: Robust country-pair clustered standard errors in parentheses. ***, **, * denote significance at 1%, 5% and 10% respectively. Year and country-pair fixed effects included in all regressions. Measure of GlobalGAP standard: even numbered columns use number of certified producers and odd numbered columns use certified land area.

These findings lend support to the standards-as-catalyst strand of the literature but for banana also show that standards can have minimal or no significant trade effects. The economically insubstantial point estimate effect of certification for banana deserves further discussion. First, banana production is dominated by developing countries which are often affected by inefficient domestic capacities, *inter alia*, missing infrastructure, low or non-existent domestic food safety standards and, inadequate technical capacities to manage food quality and safety. So, even if certification allows production according to industry-accepted standards, these domestic inefficiencies may hinder the expected export growth. Second, while certification grants market access to high-value retail networks, there are other behind-the-border issues, e.g. delayed shipping times, that could lead to import rejections. Thus, even with increasing banana certification, country level inefficiencies mean GlobalGAP standards may not constitute a sufficient condition *per se* for increased banana exports. Third, competing voluntary certification schemes for banana are becoming popular. For instance, although GlobalGAP still has the largest banana certified area globally, Fairtrade, Organic and Rainforest Alliance/SAN certified banana area has increased by almost 60%, 18% and, 28%, respectively since 2008 (Lernoud et al., 2015). Given the low level of banana production in the importing countries, and the reputation especially of the EU as the number one banana consumption market globally, exports of banana products certified to these other standards may be just as important as GlobalGAP. One other reason that possibly justifies the insignificant effect for banana may arise from a particular characteristic of the sector; i.e., the historic presence of big companies (e.g. Dole, Chiquita, Fyffes, Del Monte, Compagnie fruitiere, etc.) that have

always strongly structured the supply to the world market (UNCTAD, 2016). Because they sometimes possess their own production units in producer countries, it is possible these large vertically integrated firms were already ensuring high standards. Thus, the introduction of GlobalGAP certification may not have made a huge difference in their export volumes. It is also possible that increasing certification marginalizes non-certified production or better still non-certified producers target markets with relatively lax food safety requirements.

5.2 Differences in trade effects by development status

As a second exercise, Table 3 investigates how the effects of certification vary across development level of the exporting countries. Because standards and certifications are likely to be a particular constraint on small and medium scale farmers, it is a vital issue for developing countries. Hence, it is important to assess particularly to what extent developing countries' agrifood exports benefit from certification. To ascertain if there are any differences across income classifications, we introduce and interact binary variables for developing and developed countries with our GlobalGAP variables. We then test if the coefficient of the interaction term differs significantly from zero. Our definition of developing includes all countries not listed as high income in the World Bank income classifications.

The developing country dummy is predominantly negative; implying that relative to their developed counterparts, developing countries have on average lower exports. However, once certified, the effects of GlobalGAP standards on developing countries' exports is rather mixed. The effects, interpreted as the extent to which being a developing or developed country affects exports regardless of GlobalGAP certification vary across the three products. For developed countries, we observe positive and significant trade effects for apples and for developing countries positive and significant effects for bananas and grapes. Specifically, conditional on being a developed country, apple exports are increased by 0.16% and 0.09% with a 1% increase in the number of certified producers and certified land area respectively. This finding is possibly driven by the distribution of production; apple production is dominated mainly by developed countries. For banana producing developing countries, a one percentage increase in the number of certified producers increases exports by 0.06%. Lastly, conditional on being a developing country, the effects of certification, measured both by the number of producers or land area, are positive and significant for grape exports. Given the nature of our dataset, this highly significant and positive trade effect for grape-producing developing countries is not surprising. It is driven in most part by upper middle-income countries, who per our definition are developing, and dominate the production of grapes. If we consider this vis-à-vis, the significant but economically small effect we observe for banana—which is a preserve for mainly developing countries—it becomes clearer when we note that banana production, unlike grape production, is dominated by lower middle-income and low-income countries. Keeping in mind the dynamics in the concentration of production, our results show that increasing GlobalGAP certification has enhanced developed countries' exports of apples and, developing countries' exports of bananas and grapes.

Table 3: The effect of GlobalGAP certification on agrifood exports to the EU by income group

	Apples		Bananas		Grapes	
	(1)	(2)	(3)	(4)	(5)	(6)
$\ln \text{GAP}_{it-1}$ * Developed	0.155*** (0.034)	0.087*** (0.027)	0.157 (0.230)	0.409 (0.526)	0.005 (0.058)	0.018 (0.018)
$\ln \text{GAP}_{it-1}$ * Developing	-0.112 (0.078)	-0.040 (0.046)	0.064* (0.037)	0.005 (0.007)	0.280*** (0.082)	0.064*** (0.023)
No GAP_{it}	-0.361** (0.152)	-0.390*** (0.148)	-0.822*** (0.207)	-0.811*** (0.208)	-0.662*** (0.245)	-0.661*** (0.241)
Developing $_{it}$	1.958 (1.488)	-1.422 (1.150)	-1.585 (2.890)	-7.111 (4.747)	-12.318*** (0.735)	-2.579 (2.116)
$\ln \text{Production}_{it}$	0.020 (0.023)	0.019 (0.024)	0.182 (0.135)	0.186 (0.138)	-0.006 (0.009)	-0.007 (0.011)
$\ln \text{Production}_{jt}$	-0.159** (0.063)	-0.166*** (0.060)	0.039 (0.148)	0.035 (0.151)	0.038 (0.107)	0.069 (0.106)
$\ln \text{GDP}_{jt}$	1.214*** (0.229)	1.209*** (0.236)	0.492** (0.212)	0.473** (0.215)	0.875*** (0.241)	0.940*** (0.260)
RTA_{ijt}	0.272 (0.688)	0.338 (0.621)	-0.024 (0.061)	-0.020 (0.064)	0.328*** (0.073)	0.465*** (0.064)
$\ln \text{Tariff}_{ijt}$	-0.101** (0.043)	-0.108*** (0.041)	-0.003 (0.014)	-0.000 (0.016)	-0.024 (0.017)	-0.034* (0.018)
Observations	6,110	6,110	4,585	4,585	6,720	6,720

Notes: Robust country-pair clustered standard errors in parentheses. ***, **, * denote significance at 1%, 5% and 10% respectively. Year and country-pair fixed effects included in all regressions. Measure of GlobalGAP standard: even numbered columns use number of certified producers and odd numbered columns use certified land area. Developed countries are defined as high income countries, while middle and low income countries constitute developing countries.

5.3 Robustness checks

Our analysis thus far, has focused on exports to high-value markets in the EU and OECD member states. This is premised on the fact that food safety standards are more pronounced in these countries. Hence, as a check of robustness, we extend our sample to all importing countries. This increases the number of importing countries to 159 for apples and grapes and 150 for bananas. The results presented in Table (4) confirm our main findings. Nevertheless, compared to our benchmark estimates there are notable changes. The elasticities of our variables of interest are smaller than in the restricted sample in all cases, but for banana. For apples, the coefficient estimates of our certification measures become insignificant, and for bananas the coefficient estimate for $\text{GAP}_{it-1}^{\text{Producers}}$ becomes highly significant. This most likely reflects the observation that GlobalGAP standards are more important to retailers in the high-value markets we study than in most other importing countries. As further robustness checks, we control for GlobalGAP standards using an alternative measure of certification—the number of product specific certificates issued within a country—and our main results are again confirmed (Table A4). Alternatively, we approximate the MR terms using the Baier and Bergstrand (2009) approach and report the results in Table (A5). Without controlling for country and year effects, this approach yields larger coefficient estimates suggesting the existence of time-invariant country characteristics that if not properly accounted for generates upward biases in our GlobalGAP variables. But once we account for these effects, additionally controlling for the Baier and Bergstrand MR terms have no qualitative and quantitative effect on our

preferred model estimates. This implies that in our case, countries' multilateral resistance terms are typically not changing drastically from year to year, hence, most of the variation is cross sectional and captured to a large extent by the country fixed effects (see e.g. Berger et al., 2013).

Table 4: Robustness: exports to all importing countries

	Apples		Bananas		Grapes	
	(1)	(2)	(3)	(4)	(5)	(6)
$\ln \text{GAP}_{it-1}^{\text{Producers}}$	0.019 (0.022)		0.081*** (0.018)		0.083*** (0.032)	
$\ln \text{GAP}_{it-1}^{\text{Hectares}}$		0.003 (0.015)		0.010 (0.007)		0.022** (0.009)
No GAP_{it}	-2.286*** (0.301)	-2.296*** (0.300)	-1.352*** (0.286)	-1.356*** (0.287)	-1.575*** (0.282)	-1.617*** (0.278)
$\ln \text{Production}_{it}$	-0.008 (0.009)	-0.007 (0.009)	0.126** (0.053)	0.116** (0.054)	0.002 (0.005)	-0.000 (0.006)
$\ln \text{Production}_{jt}$	-0.087 (0.070)	-0.086 (0.070)	-0.004 (0.014)	-0.003 (0.014)	0.009 (0.011)	0.010 (0.011)
$\ln \text{GDP}_{jt}$	0.879*** (0.295)	0.870*** (0.295)	0.825*** (0.241)	0.807*** (0.235)	1.096*** (0.165)	1.113*** (0.169)
RTA_{ijt}	0.033 (0.200)	0.046 (0.202)	-0.036 (0.059)	-0.029 (0.063)	0.411*** (0.074)	0.442*** (0.074)
$\ln \text{Tariff}_{ijt}$	-0.017 (0.023)	-0.015 (0.023)	0.036 (0.037)	0.038 (0.037)	0.010 (0.032)	0.012 (0.032)
Observations	14,903	14,903	9,016	9,016	16,822	16,822

Notes: Country-pair clustered standard errors in parentheses. ***, **, * denote significance at 1%, 5% and 10% respectively. Year and country-pair fixed effects included in all regressions. Measure of GlobalGAP standard: even numbered columns use number of certified producers and odd numbered columns use certified land area.

6 Conclusion

With growing international trade in high-value agricultural products, private food standards and certifications are becoming increasingly important. Yet, how standards affect international trade flows remain largely ambiguous. This paper assesses how GlobalGAP standards, arguably the most visible private certification scheme in global agrifood trade, affect exports to high-value markets in the EU and OECD countries. Many related studies are country or product specific, which brings into question their generality. We take a multi-country and multi-product approach and use data on all apple, banana, and grape producing countries from 2010 to 2015. As a measure of certification, we use a novel dataset on the annual number of certified producers and area of land cultivated with apples, bananas, and grapes. Taking into account agrifood product heterogeneity, we study the effect at product levels. We control for potential endogeneity of GlobalGAP certification and trade flows using lags and country-pair fixed effects, and for zero trade flows using the PPML estimator.

Our results show that GlobalGAP certification enhances exports of apples, bananas, and

grapes—emphasising the “standards-as-catalyst” argument—but the effects on banana exports are economically insubstantial. The results are robust to the different certification measures, controls to some extent for reverse causality, and omitted variable biases. Specifically, our estimates suggest that a one percentage increase in the number of certified producers increases apple, banana, and grape exports by 0.14%, 0.07% and, 0.20% on average, respectively. For certified land area, a one percentage increase enhances apple exports by 0.07%, banana exports by 0.01%, and grape exports by 0.05% on average. We also find no evidence of systemic bias against developing countries’ exports. Our findings show that the trade effects for developing country exports of bananas and grapes are positive and significant. These findings are consistent with several strands of the existing literature. First, the positive trade effects for apples, bananas, and grapes coincide with findings that the returns on GlobalGAP investments are considerable in terms of export growth (Henson et al., 2011) and affects positively on quantities sold on international markets (Subervie and Vagneron, 2013; Masood and Brümmer, 2014). Second, our results for banana are in line with the findings of Schuster and Maertens (2015) that GlobalGAP standards may have no significant effects on export performance. This last finding should not be interpreted as a general indication that banana exports are not affected by GlobalGAP standards, but more a reflection of the special nature of the banana export market.

Our findings suggest that in many cases GlobalGAP standards enhance existing trade flows for both developed and developing countries. From a policy perspective, this provides further evidence that food standards that are harmonized to a common international level enhance trade. Also, because they increase confidence between trading partners, meeting private sector requirements enhance trade. Hence, voluntary certification can be an adequate mechanism to incorporate developing countries into global value chains. This observed potential trade benefit from voluntary compliance should incentivize agri-food producing countries to modernize their export-oriented sectors. This requires public sector technical and financial support to help producers especially those in developing countries overcome the initial costs of certification. The last policy implication arises from a caveat that is inherent in our analysis and most of the literature that has employed this approach, i.e., most trade databases have no distinction between certified and non-certified commodity trade flows. Just like HS codes have been introduced for certified organic products, we call for similar for products under other private sustainability standards. Finally, it should be stressed that adequately controlling for multilateral resistance terms in our gravity framework will require the use of time-varying country fixed effects. These terms are however collinear with our variables of interest, hence our choice of time invariant country fixed effects. This limitation in the literature is seen as an open challenge to trade economists to find ways to combine time varying structural fixed effects with country specific effects (Baier et al., 2017). While we control for endogeneity of certification using lagged variables and dyadic fixed effects, future studies could employ instrumental variable techniques.

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7 Appendix

Table A1: List of importing and exporting countries

Importing countries	
	Australia, Austria, Belgium, Bulgaria, Canada, Chile, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Israel, Italy, Japan, Republic of Korea, Latvia, Lithuania, Luxembourg, Malta, Mexico, the Netherlands, New Zealand, Norway, Poland, Portugal, Romania, Slovak Republic, Slovenia, Spain, Sweden, Turkey, United Kingdom, United State of America
Exporting countries by product	
Apple	Afghanistan, Albania , Algeria, Argentina, Armenia, Australia, Austria, Azerbaijan, Belarus, Belgium, Bhutan, Bolivia, Bosnia and Herzegovina, Brazil, Bulgaria, Canada, Chile, China, Colombia, Croatia, Cyprus, Czech Republic, Denmark, Ecuador, Egypt, Estonia, Finland, France, Georgia, Germany, Greece, Guatemala, Honduras, Hungary, India, Iran, Iraq, Ireland, Israel, Italy, Japan, Jordan, Kazakhstan, Kenya, Kyrgyzstan, Latvia, Lebanon, Libya, Lithuania, Luxembourg, Macedonia, Madagascar, Malta, Mexico, Moldova, Morocco, Nepal, Netherlands, New Zealand, Norway, Pakistan, Paraguay, Peru, Poland, Portugal, Republic of Korea, Romania, Russian Federation, Serbia/Montenegro, Slovakia, Slovenia, South Africa, Spain, Sweden, Switzerland, Syria, Tajikistan, Tunisia, Turkey, Ukraine, United Kingdom, United States of America, Uruguay, Uzbekistan, Yemen, Zimbabwe
Banana	Angola, Argentina, Australia, Bahrain, Bangladesh, Barbados, Belize, Benin, Bhutan, Bolivia, Brazil, Burundi, Cabo Verde, Cambodia, Cameroon, Central African Republic, China, Colombia, Congo, Costa Rica, Cyprus, Cote d'Ivoire, Democratic Republic of the Congo, Dominica, Dominican Republic, Ecuador, Egypt, Equatorial Guinea, Ethiopia, Fiji, Gabon, Ghana, Greece, Grenada, Guatemala, Guinea, Guyana, Haiti, Honduras, India, Indonesia, Iran, Israel, Italy, Jamaica, Japan, Jordan, Kenya, Kiribati, Laos, Lebanon, Madagascar, Malaysia, Mali, Mauritius, Mexico, Morocco, Mozambique, Nepal, Nicaragua, Oman, Pakistan, Palestine, Panama, Paraguay, Peru, Philippines, Portugal, Rwanda, Saint Lucia, Saint Vincent and the Grenadines, Samoa, Senegal, Seychelles, South Africa, Spain, Suriname, Tanzania, Thailand, Togo, Tonga, Trinidad and Tobago, Turkey, Uganda, United Arab Emirates, United States of America, Viet Nam, Yemen, Zambia, Zimbabwe
Grape	Afghanistan, Albania, Algeria, Argentina, Armenia, Australia, Austria, Azerbaijan, Bahrain, Belarus, Belgium, Bolivia, Bosnia and Herzegovina, Brazil, Bulgaria, Canada, Chile, China, Colombia, Croatia, Cyprus, Czech Republic, Ecuador, Egypt, Ethiopia, France, Georgia, Germany, Greece, Guatemala, Honduras, Hungary, India, Iran, Iraq, Israel, Italy, Japan, Jordan, Kazakhstan, Kuwait, Kyrgyzstan, Lebanon, Luxembourg, Macedonia, Madagascar, Malta, Mexico, Moldova, Morocco, Namibia, Netherlands, New Zealand, Pakistan, Palestine, Paraguay, Peru, Philippines, Portugal, Qatar, Republic of Korea, Romania, Russian Federation, Saudi Arabia, Serbia/Montenegro, Slovakia, Slovenia, South Africa, Spain, Switzerland, Tajikistan, Tanzania, Thailand, Tunisia, Turkey, Turkmenistan, Ukraine, United Arab Emirates, United Kingdom, United States of America, Uruguay, Uzbekistan, Viet Nam, Yemen, Zimbabwe

Table A2: Summary statistics

Variables	Apples				Bananas				Grapes				Unit
	Mean	S.D.	Min	Max	Mean	S.D.	Min	Max	Mean	S.D.	Min	Max	
Contiguity ^d	0.08	0.27			0.01	0.12			0.06	0.24			
Language ^d	0.07	0.26			0.13	0.33			0.08	0.28			
Colony ^d	0.05	0.22			0.06	0.23			0.05	0.21			
RTA ^d	0.67	0.47			0.38	0.49			0.54	0.50			
Religion ^d	0.21	0.41			0.21	0.41			0.16	0.37			
GAP Producers	527	1926	0	12678	178	698	0	6523	174	587	0	5634	
GAP Hectares	4715	8925	0	47027	5187	13551	0	64862	3217	8272	0	49195	
Distance	4586	4668	60	19586	7402	3374	243	19080	5417	4524	60	19586	Kilometres
GDP importer	1181	2408	8	18036	1466	2841	8	18036	1237	2615	8	18037	Billion USD
Production exporter	2029	27987	0.00	396826	893	9030	0.00	120752	511	7578	0.00	115500	Billion tonnes
Production importer	0.63	0.95	0	5.19	0.04	0.20	0	2.20	1.12	2.18	0	8.01	Million tonnes
Tariff	3.43	7.24	0	51.75	5.15	14.52	0	145.8	2.75	8.49	0	60.58	Percentages
Exports	2899	15467	0	338364	9729	52835	0	931876	4872	30397	0	969308	1000 USD

Notes: Variables denoted by superscript *d* are dummies

Table A3: Main results without country-pair fixed effects

	Apples		Bananas		Grapes	
	(1)	(2)	(3)	(4)	(5)	(6)
$\ln \text{GAP}_{it-1}^{\text{Producers}}$	0.276*** (0.032)		0.438*** (0.060)		0.376*** (0.047)	
$\ln \text{GAP}_{it-1}^{\text{Hectares}}$		0.169*** (0.034)		0.052*** (0.014)		0.160*** (0.022)
No GAP_{it}	-1.451*** (0.284)	-1.513*** (0.268)	-2.098*** (0.290)	-2.281*** (0.321)	-2.129*** (0.343)	-2.243*** (0.342)
$\ln \text{Production}_{it}$	-0.000 (0.023)	0.010 (0.024)	-0.035 (0.080)	-0.024 (0.086)	-0.006 (0.010)	-0.029** (0.013)
$\ln \text{Production}_{jt}$	-0.158** (0.066)	-0.150** (0.062)	-0.236 (0.197)	-0.248 (0.190)	0.103 (0.119)	0.105 (0.108)
$\ln \text{GDP}_{jt}$	1.178*** (0.268)	1.103*** (0.288)	0.624** (0.249)	0.389 (0.242)	0.871*** (0.214)	0.935*** (0.263)
$\ln \text{Distance}_{ij}$	-0.707*** (0.170)	-0.708*** (0.170)	-4.068*** (0.385)	-4.152*** (0.409)	-0.663*** (0.180)	-0.667*** (0.179)
Language_{ij}	0.041 (0.256)	0.039 (0.256)	0.645 (0.397)	0.667* (0.400)	-0.358 (0.229)	-0.360 (0.229)
Contiguity_{ij}	0.560** (0.286)	0.560* (0.286)	0.463 (0.411)	0.470 (0.419)	0.620** (0.303)	0.616** (0.304)
Colony_{ij}	0.585** (0.277)	0.586** (0.277)	1.414*** (0.429)	1.417*** (0.432)	0.828*** (0.200)	0.829*** (0.200)
RTA_{ijt}	3.552*** (0.646)	3.546*** (0.644)	0.009 (0.139)	0.035 (0.142)	1.197*** (0.344)	1.198*** (0.338)
$\ln \text{Tariff}_{ijt}$	0.070 (0.148)	0.063 (0.147)	-0.258* (0.136)	-0.253* (0.139)	-0.001 (0.112)	-0.006 (0.112)
Observations	6,345	6,345	4,795	4,795	6,940	6,940

Notes: Robust country-pair clustered standard errors in parentheses. ***, **, * denote significance at 1%, 5% and 10% respectively. Year, importer and exporter fixed effects included in all regressions. Measure of GlobalGAP standard: even numbered columns use number of certified producers and odd numbered columns use certified land area.

Table A4: Alternative measure of certification (Number of certificates)

	Apples (1)	Bananas (2)	Grapes (3)
$\ln \text{GAP}_{it-1}^{\text{Certificates}}$	0.106*** (0.038)	0.061 (0.053)	0.225** (0.093)
No GAP_{it}	-0.382** (0.151)	-0.813*** (0.207)	-0.597** (0.267)
$\ln \text{Production}_{it}$	0.009 (0.024)	0.196 (0.139)	0.002 (0.011)
$\ln \text{Production}_{jt}$	-0.177*** (0.061)	0.029 (0.151)	0.059 (0.112)
$\ln \text{GDP}_{jt}$	1.241*** (0.229)	0.493** (0.212)	0.885*** (0.234)
RTA_{ijt}	0.320 (0.636)	-0.016 (0.059)	0.383*** (0.072)
$\ln \text{Tariff}_{ijt}$	-0.110*** (0.041)	-0.002 (0.014)	-0.048*** (0.017)
Observations	6,110	4,585	6,720

Notes: Country-pair clustered standard errors in parentheses. ***, **, * denote significance at 1%, 5% and 10% respectively. Year, and country-pair fixed effects included in all regressions. Measure of GlobalGAP standard: number of certificates issued in a country

Table A5: Using the Baier and Bergstrand (2009) method to control for multilateral resistance

	Apples		Bananas		Grapes	
	(1)	(2)	(3)	(4)	(5)	(6)
$\ln \text{GAP}_{it-1}^{\text{Producers}}$	0.136*** (0.033)		0.066* (0.036)		0.201*** (0.058)	
$\ln \text{GAP}_{it-1}^{\text{Hectares}}$		0.074*** (0.022)		0.005 (0.007)		0.045*** (0.015)
No GAP_{it}	-0.352** (0.148)	-0.403*** (0.150)	-0.821*** (0.206)	-0.809*** (0.208)	-0.601** (0.261)	-0.661*** (0.240)
$\ln \text{Production}_{it}$	0.006 (0.023)	0.012 (0.024)	0.182 (0.135)	0.187 (0.138)	-0.001 (0.011)	-0.004 (0.012)
$\ln \text{Production}_{jt}$	-0.165*** (0.063)	-0.171*** (0.061)	0.041 (0.148)	0.036 (0.151)	0.045 (0.107)	0.074 (0.106)
$\ln \text{GDP}_{jt}$	1.223*** (0.232)	1.219*** (0.239)	0.489** (0.212)	0.470** (0.215)	0.908*** (0.224)	0.954*** (0.260)
RTA_{ijt}	0.278 (0.679)	0.336 (0.620)	-0.024 (0.061)	-0.021 (0.064)	0.384*** (0.067)	0.472*** (0.065)
$\ln \text{Tariff}_{ijt}$	-0.108** (0.043)	-0.112*** (0.040)	-0.003 (0.014)	-0.000 (0.016)	-0.034** (0.017)	-0.035* (0.018)
Observations	6,120	6,120	4,645	4,645	6,720	6,720

Notes: Robust country-pair clustered standard errors in parentheses. ***, **, * denote significance at 1%, 5% and 10% respectively. All regressions include multilateral resistance terms approximated for all country pair variables x_{ijt} by the Baier and Bergstrand (2009) method. Measure of GlobalGAP standard: even numbered columns use number of certified producers and odd numbered columns use certified land area.