



Trade effects of voluntary sustainability standards in tropical commodity sectors

Janne Bemelmans^{a,*}, Daniele Curzi^b, Alessandro Olper^{b,c}, Miet Maertens^a

^a Division of Bio-economics, Department of Earth and Environmental Sciences, KU Leuven, Celestijnenlaan 200 E, B-3001 Leuven-Heverlee, Belgium

^b Department of Environmental Science and Policy, University of Milano, Via Celoria 2, 20133 Milano, Italy

^c LICOS – Centre for Institutions and Economic Performance, KU Leuven, Waaistraat, 6 bus 3511, B-3000 Leuven, Belgium

ARTICLE INFO

JEL codes:

F14
F18
F55
Q17
Q18

Keywords:

Agri-food standards
Private standards
Global value chains
Developing countries
International trade

ABSTRACT

This article investigates the trade implications of voluntary sustainability standards (VSS) in tropical commodity sectors. VSS are increasingly important, not only in corporate sustainability strategies, but also in trade policy, thereby shifting the responsibility for the governance of sustainability in the food system from the public to the private sector. There is no regulatory framework assuring that VSS do not distort trade while effectively delivering environmental and social sustainability benefits, and conclusive evidence on the trade effects of VSS is lacking. We compile an innovative database of country-level VSS coverage for five tropical commodities, seven VSS observed for seven years, and use a multi-country, -sector and -standard augmented gravity analysis to estimate the trade effects of VSS adoption. Our results confirm a general trade-enhancing effect of VSS, with on average a one pp increase in VSS coverage resulting in a 1.8 to 3.3% increase in export value. Effects are largest for banana, followed by coffee and tea – and are insignificant for cocoa and palm oil. The trade-enhancing effect of VSS certification does not vary with the income level of the exporter but increases with the income level of the importer and with the income gap between trading partners. Our results imply that VSS can be an effective tool to overcome the trade-inhibiting effect of governance distance between countries. Yet, for VSS to effectively reconcile international food trade with sustainability goals, policy attention is needed to VSS adoption and impact in the poorest countries.

1. Introduction

Sustainable food production remains a key policy challenge, requiring multiple and complementary measures (Springmann et al., 2018). Voluntary sustainability standards (VSS) are non-state, market-based instruments for reconciling international food trade with environmental and social sustainability goals (UNCTAD, 2021). VSS formulate requirements that producers or processors need to comply with, and set up certification schemes to assess, monitor and enforce that compliance. VSS communicate certification of products either to retailers and other businesses only (B2B standards) or to consumers as well (B2C standards), mostly through (eco)labels. VSS adoption is spreading

rapidly with the global certified crop area expanding with an estimated 11% annually (Meier et al., 2020). VSS are most common in tropical commodity sectors, with production typically located in low- and middle-income countries (LMICs) (Tayleur et al., 2017). For example, the 2018 certified cocoa and coffee area is at least 27% respectively 21% of the production area (Meier et al., 2020).

VSS are important from an international food policy perspective, pertaining to corporate and donor strategies as well as to public and trade policy. Food processing companies and retailers increasingly rely on VSS in corporate responsibility programs, and some explicitly state to aim at sourcing 100% own brand tropical products from certified sources¹. Non-governmental and international organizations allocate

Abbreviations: VSS, voluntary sustainability standards; LMICs, low- and middle-income countries; B2B, business-to-business; B2C, business-to-consumer; PPML, Poisson Pseudo-Maximum Likelihood; FE, fixed effects; MRT, multilateral resistance terms; BB, Baier-Bergstrand.

* Corresponding author.

E-mail address: Janne.Bemelmans@kuleuven.be (J. Bemelmans).

¹ Examples are retailers Ahold Delhaize (<https://www.aholddelhaize.com/sustainability/our-position-on-societal-and-environmental-topics/sustainable-agriculture/>), ASDA (<https://www.asda.com/creating-change-for-better/better-planet/>) and processors Nestlé (<https://www.nestle.com/sustainability/sustainable-sourcing/palm-oil>) and Guylia (<https://guylia.com/sustainability/#fairtrade-cacao>).

<https://doi.org/10.1016/j.foodpol.2023.102440>

Received 29 June 2022; Received in revised form 10 February 2023; Accepted 6 March 2023

Available online 19 June 2023

0306-9192/© 2023 Elsevier Ltd. All rights reserved.

substantial donor funding to (smallholder) certification programs in LMICs (Marx et al., 2015). VSS emerge in public procurement policies and due diligence requirements in high-income countries, and are used by LMIC governments to promote agri-food exports and attract foreign investments (UNFSS, 2020, 2022). An increasing number of free trade and preferential market access agreements refer to VSS, sometimes even foreseeing lower tariffs for certified products than for non-certified products² (UNCTAD, 2021).

This increased integration of VSS in public and trade policies is shifting the responsibility for the governance of sustainability in the food system from the public to the private sector. A transparent regulatory framework for VSS, being controlled and enforced through private second- or third-party certification, is lacking. Public food quality and safety standards are regulated through the WTO SPS and TBT agreements to assure that the delivery of food quality and safety is not or minimally distorting trade. There is no similar regulatory framework to assure that VSS effectively deliver environmental and social sustainability benefits without distorting trade (Smith, 2009). This is likely why international organizations stimulate the VSS policy dialogue through initiatives such as the United Nations Forum on Sustainability Standards (UNFSS) and the UNCTAD VSS Assessment Toolkit.

There is no conclusive evidence on VSS impacts. Review studies point out that the adoption of VSS by farms and agri-food companies in LMICs can have positive, zero or negative effects on environmental and social performance indicators (e.g. DeFries et al., 2017; Meemken et al., 2021; Oya et al., 2018). Empirical studies on the trade implications of VSS are scarce. Merely a handful of gravity studies point to an overall trade-enhancing effects of adoption of specific VSS in specific sectors (Andersson, 2019; Fiankor et al., 2020; Fiankor et al., 2019; Grassnick & Brümmer, 2021; Masood & Brümmer, 2014), while only one country- and sector-specific study finds no trade effects (Schuster & Maertens, 2015). Understanding the trade effects of VSS is crucial in the policy debate, especially so because the attention to VSS in corporate strategies and trade policy will likely increase VSS adoption, and because VSS adoption is most important in LMICs for whom commodity exports remain an important source of growth.

In this paper, we empirically analyze how the adoption of VSS³ in tropical commodity sectors affects the export performance of producing countries. Conceptually, VSS adoption could facilitate trade through, among others, product differentiation, productivity and quality effects and signaling product-quality and -safety to buyers. The empirical literature on the trade effects of VSS adoption includes four country-level studies that confirm a positive effect of GlobalGAP adoption in various fruit and vegetable sectors on countries' export performance (Andersson, 2019; Fiankor et al., 2020, 2019; Masood & Brümmer, 2014), and one study on UTZ certification in the cocoa sector (Grassnick & Brümmer, 2021). Studies are highly case-specific, focusing on a single sector and/or a single standard. This results for example in a stronger representation of B2B standards, such as GlobalGAP, that focus more on safety and quality issues, while B2C standards, that focus more on environmental and ethical issues, are barely studied – and in a stronger representation of fresh produce sectors for which supply chains differ substantially from those of tropical commodities that pass through several processing stages, such as coffee and cocoa. To date, evidence on the trade effects of VSS adoption in tropical commodity sectors is only

² E.g. for palm oil in the trade agreement between Indonesia and EFTA states (UNCTAD, 2021).

³ Building on the UNFSS definition, we define VSS as private standards that are voluntary in nature, and that “specify requirements that producers, traders, manufacturers, retailers or service providers may be asked to meet, relating to a wide range of sustainability metrics, including respect for basic human rights, worker health and safety, the environmental impacts of production, community relations, land use planning and others.” (UNFSS, 2022) Fig. A1 in appendix shows the number of sustainability requirements included in the selected VSS.

partial, which hampers the VSS policy dialogue.

In this paper we focus on tropical commodities and on private VSS at the production stage, hence excluding public VSS and VSS directed at processing or distribution stages. We include five commodity sectors (banana, coffee, tea, palm oil and cocoa), seven VSS (GlobalGAP, Fair-trade International, Rainforest Alliance, UTZ, 4C, RSPO and IFOAM – Organics International⁴) and bilateral export flows from all producing countries in the analyses. We thereby broaden the evidence base on the trade effects of VSS, and present more general estimates across sectors and VSS.

We rely on the gravity framework and the Poisson Pseudo-Maximum Likelihood estimator to evaluate how VSS adoption affects the export performance of 110 producing countries between 2012 and 2019. We augment the trade cost component of a traditional gravity model with a VSS coverage variable, measured as the share of certified area over the crop-specific total production area. We use a unique database, compiled from different data sources, and combine different econometric techniques to address issues of heteroscedasticity, endogeneity and multi-lateral resistances. We explore heterogeneity in trade effects of VSS certification across crops and countries.

Our approach with a multi-country, -sector and -standard trade analysis is innovative. First, our data cover multiple VSS and include B2C as well as B2B standards, which allow more general conclusions on the trade effects of VSS adoption. Second, we focus on various tropical commodity sectors and thereby add to the existing evidence that is squeezed towards fruit and vegetable sectors and cocoa. In addition, our analysis allows to compare trade effects of VSS across commodities. Such comparative evidence is to date completely lacking in the literature. Third, our multi-country analysis allows to address heterogeneity in VSS trade effects across origin and destination countries. Few studies have estimated such heterogeneous trade effects – exceptions are Andersson (2019) and Fiankor et al. (2020). Fourth, our multi-country and multi-sector analysis implies a large sample, leading to more general results and conclusions than in previous studies. In addition, we use country-level data on VSS acreage coverage. This is a more accurate measure than the number of certificates or certified farmers used in previous studies, because of varying farm sizes and group certification schemes. We use a relative acreage measure to avoid capturing size effects. Our results confirm a general trade-facilitating effect of VSS adoption, yet, not for all commodity sectors and destination markets.

2. VSS and trade

2.1. Conceptual reflections

Inspired by Grassnick and Brümmer (2021), we identify three main channels through which VSS adoption among commodity producing countries can affect these countries' export performance: through production and volume effects, through supply chain and price effects, and through demand-side effects. We subsequently discuss these channels, and reflect on how effects might differ across sectors, and with importer's and exporter's income levels.

First, VSS may affect production volumes and product quality. VSS lay down a number of production requirements, relating to sustainability as well as good agricultural practices. Some VSS certification schemes provide training and inputs to facilitate the implementation of these practices by certified producers. This may result in yield and product-quality improvements, and increase production volumes, which may enhance countries' competitiveness and export opportunities. However, several recent review studies note that the yield outcome of VSS is VSS and context specific, and determined by producer characteristics and institutional factors (e.g. DeFries et al., 2017; Oya et al.,

⁴ IFOAM – Organics International is a membership-based umbrella organization representing organic VSS.

2018; Schleifer & Sun, 2018). For example, organic requirements may reduce yields when deviating strongly from conventional practices but less so in LMICs where farmers' inorganic input use is limited (Meemken & Qaim, 2018; Oya et al., 2018). Effects may therefore vary between sectors that are dominated by smallholders such as the coffee and cocoa sectors, and those that have more mixed farm sizes, such as the tea, banana and palm oil sectors. Effects may further vary with the income level of the producing countries. On the one hand, because farmers in LMICs generally have poorer production practices, face lower yields and deliver lower product quality, such countries might benefit more from lifting production practices to international standards in VSS. On the other hand, VSS adoption is observed to deliver larger productivity gains in good institutional settings – and might even have no or negative effects when conducive institutions are lacking, more often the case for LMICs (Oya et al., 2018). So, how production and trade effects vary with countries' income level remains an empirical question.

Second, VSS may carry price and cost implications further downstream the supply chain. Some VSS, mostly B2C standards, result in price premia for certified products, which can trickle down the supply chain and result in increased export values for producing countries. Furthermore, VSS might lower transaction costs by reducing information asymmetries between trading partners. VSS inform producers on international norms, and signal food safety, quality and sustainability characteristics to downstream buyers. In doing so, VSS may reduce search, coordination and monitoring costs and address the problems of moral hazard and due diligence along the supply chain (Andersson, 2019; de Mendonça et al., 2014). This trade cost reduction might be especially important in facilitating exports from LMICs to high-income destination markets as information asymmetries are largest in these trade flows (Fiankor et al., 2019; Goedhuys & Sleuwaegen, 2016; Schuster & Maertens, 2015). In addition, the requirements in VSS may facilitate compliance with public standards, which are more stringent in high-income countries. So, VSS may have the strongest trade-enhancing effects for trade flows from low- to high-income countries.

Third, VSS might enhance trade through product differentiation. As indicated above, VSS might signal product quality and safety, and thereby create consumer trust in and demand for products from a specific origin. VSS satisfy the growing consumer demand for sustainably- and ethically-produced goods, the sustainable sourcing strategies of retailers and food processing companies, and the sustainable consumption commitments of governments (Grassnick & Brümmer, 2021; Meier et al., 2020). This demand for sustainability is larger in high-income countries (Marx & Depoorter, 2021; Meier et al., 2020), implying that VSS adoption might especially enhance exports to these countries. Moreover, the demand for sustainability and the potential for product differentiation varies across commodities, implying that the trade effects of VSS can differ across sectors.

2.2. Empirical evidence

Empirical country- and firm-level studies mainly point to positive trade effects of VSS adoption. Country-level gravity studies mainly focus on GlobalGAP in fresh produce sectors, and find a trade-enhancing effect on EU imports in the banana sector (Masood & Brümmer, 2014), and an export-enhancing effect in the apple, banana and grape sectors (Fiankor et al., 2019 & 2020) and for horticultural produce more generally (Andersson, 2019). The latter studies point out that the magnitude of the trade effects differs across crops, and is most pronounced for exports from LMICs. There is only one country-level study on another VSS in another sector, showing that UTZ certification in the cocoa sector enhances exports of cocoa beans but not of higher value-added cocoa products (Grassnick & Brümmer, 2021). Studies focusing on voluntary processing standards in the agri-food sector, e.g. on International Food Standard (IFS) certification (Ehrich & Mangelsdorf, 2018) and on various standards in the Chinese food sector (Mangelsdorf et al., 2012), point out that the trade effect of standards differs across sectors and with

countries' income level.

Firm-level studies compare the export performance of certified and non-certified producers and processing companies. Henson et al. (2011) find that GlobalGAP certification increases export revenues of fresh produce exporters in sub-Saharan Africa, and entails a first-mover advantage. Latouche and Chevassus-Lozza (2015) focus on food safety standards and find that British Retail Consortium (BRC) certification among French agri-food firms increases their probability to export while IFS certification does not. Schuster and Maertens (2015) find no significant trade effect for a set of 11 VSS in the Peruvian asparagus sector.

To summarize, the VSS-trade literature is highly case specific, with an overemphasis on GlobalGAP in the fresh produce sector. Effects observed for GlobalGAP, a B2B standard with a main emphasis on product-safety and -quality, might not necessarily hold for VSS more general, and, as argued above, the trade implications of VSS might vary across sectors and countries.

3. Methodology and data

3.1. Gravity model and estimation approach

We employ a gravity approach to evaluate the trade implications of VSS adoption in tropical commodity sectors, which is the standard method to empirically analyze bilateral trade flows and trade policy implications, including those of agri-food standards and VSS (e.g. Andersson, 2019; Ferro et al., 2015; Fiankor et al., 2020). We estimate the following gravity model⁵ in which the trade-cost term is augmented with a variable that measures VSS certification at country-crop-level:

$$X_{ijkt} = \exp[\beta_0 + \beta_1 VSS_{it} + \beta_2 \ln GDP_{jt} + \beta_3 \ln Production_{it} + \beta_4 \ln Production_{it} + \beta_5 RTA_{ijt} + \beta_6 \ln(1 + Tariff_{ijkt}) + \beta_7 \ln Distance_{ij} + \beta_8 Language_{ij} + \beta_9 Colony_{ij} + \beta_{10} Contiguity_{ij} + \beta_{11} \ln MR_{jkt} + \beta_{12} \ln MR_{ikt}] + \varepsilon_{ijkt} \quad (1)$$

where X_{ijkt} is the export value (in current USD) of product k from exporting country i to importing country j in year t . We focus on export value as trade performance indicator as it captures potential volume and price effects of VSS certification. VSS_{it} measures 'VSS coverage', and is defined as the share of crop-specific certified production area over total production area of the respective crop in country i in year t . We focus on multiple VSS and account for possible double- and triple-certification of the same area by using the minimum level of certified production area (i.e. the coverage of the most widespread VSS) at country-product level, which is the most conservative measure of VSS coverage⁶. GDP_{jt} is the nominal GDP of country j in year t , capturing importer's demand. $Production_{it}$ and $Production_{it}$ are, respectively, the exporter's and global production volume of crop l at 4-digit level⁷ at time t , proxying for supply potential. Further, we include traditional bilateral trade cost variables: ad valorem tariffs for product k at time t ($Tariff_{ijkt}$), regional trade agreements at t (RTA_{ijt}), distance weighted by most populated cities ($Distance_{ij}$), common language ($Language_{ij}$), past colonial relationships ($Colony_{ij}$), and common borders ($Contiguity_{ij}$). Finally, MR_{jkt} and MR_{ikt} represent inward and outward multilateral resistance terms implied by the gravity theory, while ε_{ijkt} is the error-term.

Although, the gravity model has strong theoretical foundations (Anderson, 1979; Anderson & van Wincoop, 2004), it invokes a number of estimation issues: the presence of zero trade flows (Helpman et al., 2008), heteroscedasticity (Santos Silva & Tenreyro, 2006, 2011), and

⁵ We assume Constant Elasticity of Substitution preferences and iceberg trade costs.

⁶ We perform the same analysis using the maximum certified production area, thereby assuming no multiple certification, and find robust results (Tables A5 to A8 in appendix).

⁷ 2-digit level for cocoa.

Table 1
Overview of estimation approaches.

	Fixed Effects (1) FE	Baier-Bergstrand (2) BB	Instrumental variable (3) IV
Estimator	PPML	PPML	PPML
Multilateral resistance terms	Fixed effects	Baier-Bergstrand	Fixed effects
Endogeneity	One-year lag VSS	One-year lag VSS	Instrumental variable
Fixed effects Period	ij – it – jt – kt 2013–2019	j – t – k 2013–2019	ij – it – jt – kt 2012–2018

Notes: PPML = Poisson Pseudo-Maximum Likelihood. i refers to the exporting country, j to the importing country, k to the product and t to the year. (2) BB does not include ij FE as BB-constructed MRT would be absorbed. (1) FE and (2) BB are estimated for 2013–2019 because of the one-year lag VSS variables and VSS data covering the period 2012–2018.

Table 2
HS6 codes and descriptions included.

HS6	Description
Banana	
080300	Bananas, (including plantains), fresh or dried
Coffee	
090111	Coffee; not roasted or decaffeinated
090112	Coffee; decaffeinated, not roasted
090121	Coffee; roasted, not decaffeinated
090122	Coffee; roasted, decaffeinated
Tea	
090210	Tea, green; [not fermented], in packings not exceeding 3 kg
090220	Tea, green; [not fermented], in packings exceeding 3 kg
090230	Tea, black; [(partly) fermented tea], in packings not exceeding 3 kg
090240	Tea, black; [(partly) fermented tea], in packings exceeding 3 kg
Palm oil	
151110	Palm oil and its fractions, crude, not chemically modified
151190	Palm oil and its fractions, other than crude, whether or not refined, but not chemically modified
Cocoa	
180100	Cocoa beans; whole or broken, raw or roasted
180310	Cocoa; paste, not defatted
180320	Cocoa; paste, wholly or partly defatted
180400	Cocoa; butter, fat and oil
180500	Cocoa; powder, not containing added sugar or other sweetening matter

the need to control for multilateral resistance (Anderson & van Wincoop, 2003). In addition, the VSS variable may cause endogeneity problems. To address these issues, we use different econometric techniques that are summarized in Table 1. To deal with zero trade flows and heteroscedasticity, we use the Poisson Pseudo-Maximum Likelihood (PPML) estimator (Santos Silva & Tenreyro, 2006), and cluster standard errors by exporter-importer-product group. The PPML estimator transforms the usual log-linear gravity model, which is why equation (1) is specified as a multiplicative equation.

The inward and outward multilateral resistance terms (MRT) represent, respectively, the importer’s and exporter’s ease of market access. They account for the fact that bilateral trade not only depends on the trade barriers between the respective trade partners but also on barriers faced when trading with other countries (Anderson & van Wincoop, 2003). A simple but effective practice to account for both MRT is the inclusion of importer-product-time and exporter-product-time fixed effects (FE). Yet, exporter-product-time FE would absorb our variable of interest. Therefore, we include importer-time (γ_{jt}), exporter-time (γ_{it}) and product-time (γ_{kt}) FE to jointly control for MRT as a first estimation approach. These FE concurrently capture other factors, such as time-variant world prices at product-level, importer-specific non-tariff barriers and purchasing power, and also absorb the world production variable. However, this FE estimation does not exactly correspond to the theory-driven gravity specifications, excludes a large number of

singletons from our sample, and suffers from the incidental parameter problem. We therefore use a second estimation approach, employing the Baier-Bergstrand (BB) method to account for MRT (Baier & Bergstrand, 2009). Accordingly, we transform the bilateral trade cost variable as follows⁸:

$$Z_{MRTij} = \ln(Z_{ij}) - \left[\frac{1}{N_j} \sum_{m=1}^{N_j} \ln Z_{im} + \frac{1}{N_i} \sum_{p=1}^{N_i} \ln Z_{pj} - \frac{1}{N_j \times N_i} \sum_{m=1}^{N_j} \sum_{p=1}^{N_i} \ln Z_{pm} \right] \tag{2}$$

for $Z_{ij} = \text{Distance}_{ij} (1 + \text{Tariff}_{ijkt})$, and

$$Z_{MRTij} = Z_{ij} - \left[\frac{1}{N_j} \sum_{m=1}^{N_j} Z_{im} + \frac{1}{N_i} \sum_{p=1}^{N_i} Z_{pj} - \frac{1}{N_j \times N_i} \sum_{m=1}^{N_j} \sum_{p=1}^{N_i} Z_{pm} \right] \tag{3}$$

for $Z_{ij} = \text{Language}_{ij}, \text{Colony}_{ij}, \text{Contiguity}_{ij}, \text{RTA}_{ijt}$

The BB method eliminates the need for country-product-year FE. Following Berger et al. (2013) and Lin et al. (2020), we include importer FE (γ_j) alongside product (γ_k) and time (γ_t) FE to capture trade regime (e.g. non-tariff barriers) and other unobservable effects that are importer, product or time specific.

The specification in equation (1) may suffer from endogeneity due omitted to variables and/or reverse causality. We include importer-exporter FE to absorb time-invariant bilateral cost variables and limit bias from omitted bilateral trade cost variables (Egger & Nigai, 2015). VSS might promote exports while export performance might stimulate VSS adoption in producing countries (Herzfeld et al., 2011). We use a one-year lag of the VSS variable in the FE and BB PPML estimations to limit endogeneity bias on the premise that past and current certification coverage are highly correlated and that current export flows cannot affect past certification adoption decisions (Ferro et al., 2015). Yet, endogeneity of the one-year lagged VSS variable cannot be rejected based on a Wooldridge test for serial correlation (Wooldridge, 2002). We therefore, additionally, use an instrumental variable (IV) approach. Inspired by Ehrich and Mangelsdorf (2018), we instrument VSS coverage using the sum of the crop-specific maximum share of certified production area of all countries neighboring the export country i as instrument. VSS coverage in neighboring countries might promote certification uptake in a particular country, e.g. due to knowledge transfers and cost sharing mechanisms (Ehrich & Mangelsdorf, 2018), and is likely less strongly affected by the export performance of that country, making the IV relevant and plausibly exogenous. Similar instruments have been adopted in gravity models to study the trade impact of certification (Ehrich & Mangelsdorf, 2018; Fiankor et al., 2020).

3.2. Heterogeneous trade effects

We study potential sources of heterogeneity in trade effects of VSS. First, we test for crop heterogeneity by adding interaction terms between VSS coverage and crop dummy variables. Second, we investigate how VSS trade effects vary with the income level of the exporter and importer country, and with the income gap between trading partners. We estimate three different sets of models including interactions between VSS coverage, on the one hand, and respectively importer’s income, exporter’s income and income gap, on the other hand, using for each of these specifications the three different estimation techniques summarized in Table 1. We use GDP per capita as income indicator and the ratio of importer’s over exporter’s GDP per capita as income gap measure. We use the log transformed value of GDP per capita and center the logarithmic transformation around the minimum value of GDP per

⁸ While the theoretical derivation originally includes GDP weights in the first-order log-linear Taylor-series approximation of MRT, we use simple averages for endogeneity reasons, as recommended by Baier and Bergstrand (2009) and Egger and Nelson (2011).

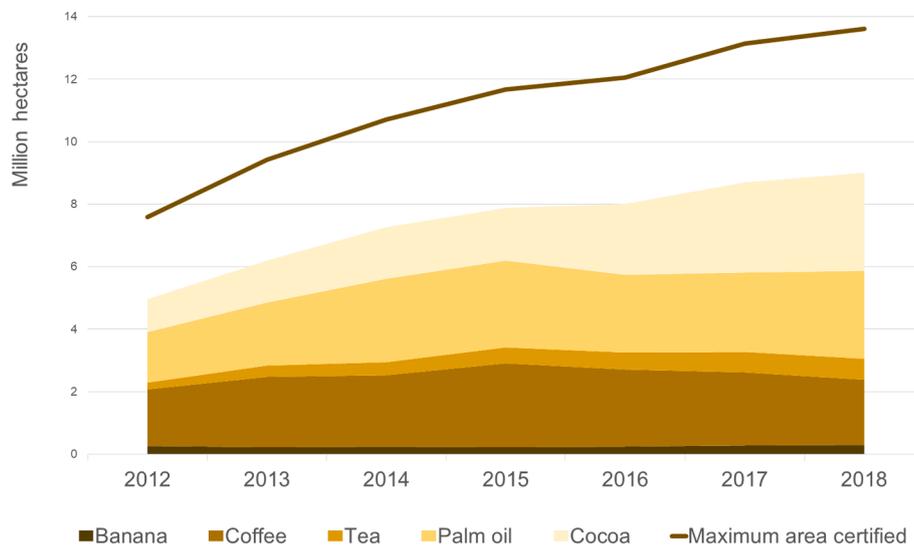


Fig. 1. Global certified production area represented by minimum certified production area by crop and maximum certified production area over all crops, 2012 to 2018.

Table 3
VSS coverage (minimum share of certified production area) for different crops.

	Full sample				VSS sample			
	N	Number of countries	Share of certified production area (%)		N	Number of countries	Share of certified production area (%)	
			Mean	St. dev.			Mean	St. dev.
Banana	714	102	7.67	21.66	206	43	26.57	33.57
Coffee	508	73	11.72	19.13	280	45	21.26	21.48
Tea	287	41	18.06	28.47	186	31	27.86	31.28
Palm oil	264	44	9.50	22.37	92	21	27.25	30.94
Cocoa	383	55	12.99	24.29	206	34	24.15	28.78
Total	2,156	110	11.17	22.93	970	75	24.83	28.81

Notes: N = number of observations, varying at exporter-crop-year level. The full sample includes all producing countries over time; the VSS sample includes countries with non-zero VSS coverage in at least one year.

Table 4
Summary statistics, based on BB sample (N = 923,018).

	Mean	St. dev.	Min	Max
Share minimum area certified (lag, %)	13.15	23.42	0	100
Export value (million USD)	0.472	13.972	0	3,138.18
Importer GDP (million USD)	328,473	1,108,192	35.49	14,279,937
Exporter production (1,000 tonnes)	335.58	2,110	0.003	40,567
World production (1,000 tonnes)	18,798,016	29,536,409	4,484,825	1.17e+08
RTA (0/1)	0.20		0	1
Tariff	12.56	19.20	0	513.60
Distance (weighted, km)	8,797	4,631	94.27	19,735
Common language (0/1)	0.19		0	1
Colonial history (0/1)	0.01		0	1
Contiguity (0/1)	0.02		0	1
Crop (0/1)				
Banana	0.07		0	1
Coffee	0.35		0	1
Tea	0.20		0	1
Palm oil	0.09		0	1
Cocoa	0.30		0	1
Exporter GDP/capita (USD)	4,921	5,428	228	44,740
Importer GDP/capita (USD)	13,113	18,778	228	123,514
Ratio importer / exporter GDP/capita	7.78	19.35	0.01	513.11

Note: Monetary values in current USD.

capita to reduce multicollinearity and ease coefficient interpretation of the main VSS effect (Iacobucci et al., 2016). We interact the logarithmic transformation of the income gap measure without centering this variable. In all models, we additionally include the main effects of the income variables⁹.

3.3. Data

3.3.1. Certification data

Availability of country-level data on VSS coverage is limited. We identified 31 VSS that are active in at least one of the selected sectors (coffee, cocoa, tea, banana and palm oil) from two online directories, the Ecolabel Index and the ITC Standards Map, which provide an exhaustive list of VSS. Over the period December 2019 - July 2020, we contacted the standard-setting organizations behind the identified VSS, as well as other related organizations, to obtain yearly coverage data for all 31 VSS, but obtained adequate data for only seven VSS. Data were aggregated and processed, and compiled in a novel dataset that comprises country-level data on certified area for seven VSS and five commodities for the period 2012–2018. Data access problems for other VSS organizations mainly relate to lack of record-keeping, unwillingness to share data, and privacy reasons. Nonetheless, our dataset includes major VSS for all five sectors (Meier et al., 2020). Since we work with minimum

⁹ Main effects of GDP per capita are absorbed by country-time FE in FE and IV estimations, which is not problematic as our interest is in the VSS-interaction effect. We drop the main effect of importer GDP per capita in the BB estimation due to high collinearity with importer-FE.

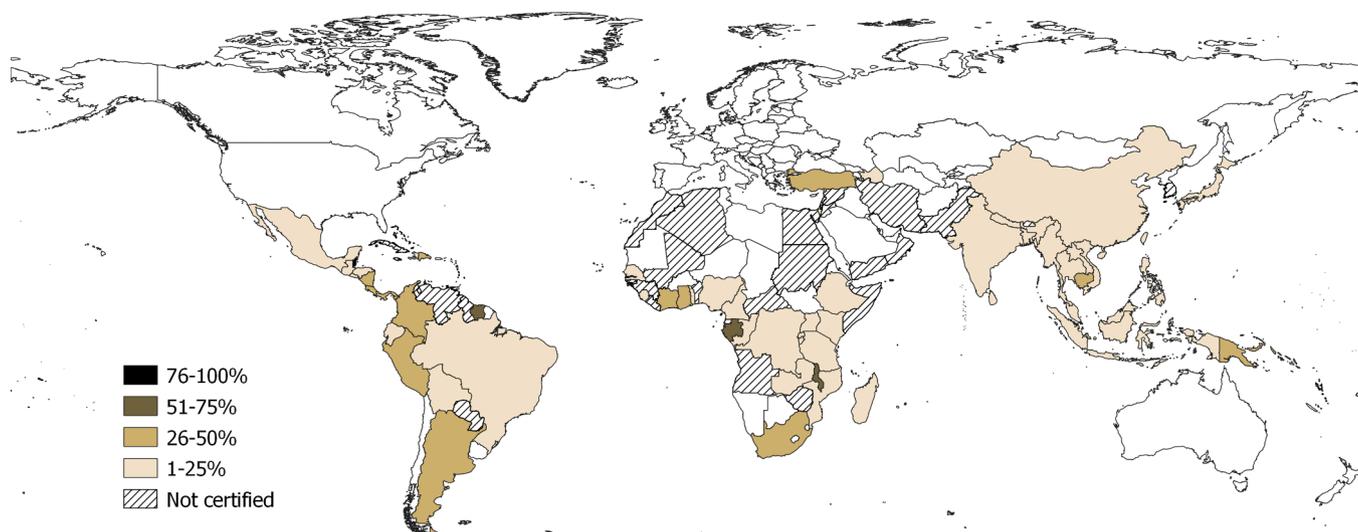


Fig. 2. Geographical spread of VSS certification (share of certified coffee, cocoa, tea, palm oil and banana production area) in 2018.

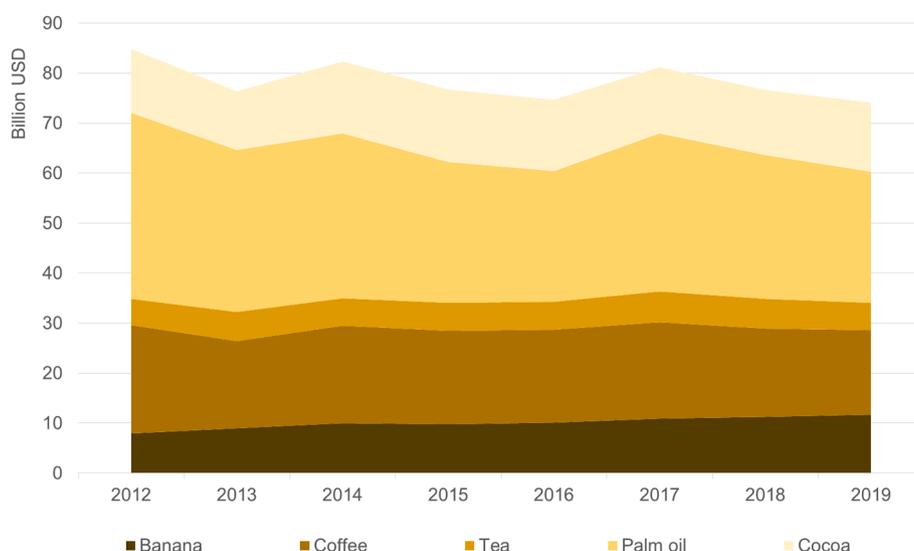


Fig. 3. Total export values (in million USD) from producing countries by crop, 2012 to 2019.

level of certification, introducing additional, less eminent VSS would not change the VSS coverage variable much. Using FAOstat crop acreage data, we calculate the share of minimum certified area over total harvested area at crop-country level¹⁰.

3.3.2. Trade flow data

We use BACI bilateral trade data at HS6-digit level (Table 2). This product level eases the interpretation of trade effects as product-lines within the same sector (e.g., cocoa beans and cocoa paste) represent different levels of processing, and product values. At a more aggregated product level, differences in trade value would capture both differences in trade-flow magnitudes and in product composition. We include all product lines that correspond to one of the five crops; either raw or with primary processing. We do not include coffee and cocoa waste-products because waste streams are unlikely to carry a sustainability label. We neither include chocolate-related products to avoid capturing large re-

exports by high-income countries that produce chocolate (Grassnick & Brümmer, 2021).

We restrict the sample of exporting countries for each crop to producing countries such that non-informative zeros and re-exports are excluded from the analysis. We consider all countries in the world as importing countries but need to exclude some due to lack of data. Other observations are dropped when they are either singletons or separated by a fixed effect, e.g., observations for countries that never import any of the considered product-lines. Table A1 in appendix lists all exporting and importing countries included in the analysis. Zero-trade flows represent 80% of the sample for the FE and IV estimations, and just over 90% for the BB estimation¹¹.

¹⁰ Calculated shares exceeding 100% were adjusted to 100. A re-estimation of all models excluding adjusted observations results in robust estimates that differ maximum 25% from the original estimates and have the same sign.

¹¹ We test whether results hold when dropping zero flows by analyzing the trade-effect of VSS on the extensive and intensive margin of trade. These results, reported in Table A2 in appendix, show that trade-enhancing effect of VSS is predominantly driven by their effect on trade magnitudes (once exporting) rather than on the probability to trade, justifying our main estimation approach.

Table 5
PPML estimation results of main effects.

	(1) FE	(2) BB	(3) IV
VSS _{ikt-1}	0.023*** (0.002)	0.018*** (0.002)	
VSS _{ikt}			0.033*** (0.006)
Log (1 + Tariff _{ijkt})	-0.159*** (0.058)	-0.256*** (0.065)	-0.135*** (0.040)
RTA _{ijt}	0.218** (0.098)	0.443** (0.119)	0.218*** (0.070)
Log (Production _{ikt})	0.846*** (0.042)	0.944*** (0.027)	0.908*** (0.041)
Log (World production _{kt})		-1.737*** (0.312)	
Log (GDP _{jt})		0.096 (0.123)	
Log (Distance _{ij})		-0.644*** (0.106)	
Contiguity _{ij}		-0.282 (0.219)	
Colony _{ij}		0.115 (0.231)	
Language _{ij}		0.227 (0.177)	
Constant	-1.933*** (0.631)	19.720*** (6.388)	-3.103*** (0.731)
Observations	393,604	923,018	350,748

Notes: Dependent variable is value of export of product *k* from producing country *i* to importing country *j* at time *t*. Columns (1) and (3) include importer-time, exporter-time, time-product and bilateral FE. Column (2) includes importer, product and time FE. Robust country-pair-product clustered standard errors in parentheses. *** *p* < 0.01, ** *p* < 0.05, * *p* < 0.1. The IV-PPML estimation does not allow to check the identification assumption of the instrument. As a next-best option, the first stage of a two-stage least squares (2SLS) estimation confirms the validity of our instrument (F(1,18594) = 19.44; p-value = 0.0000). Estimation results of the 2SLS are found in Table A9 in appendix.

Table 6
Summary of PPML estimation results of crop-specific model specifications.

	(1) FE	(2) BB
VSS _{ikt-1} ×		
Banana	0.034*** (0.003)	0.031*** (0.003)
Coffee	0.026*** (0.006)	0.011*** (0.004)
Tea	0.010** (0.005)	0.018*** (0.005)
Palm oil	0.009 (0.006)	0.008 (0.005)
Cocoa	0.006 (0.005)	0.000 (0.004)
Observations	393,604	923,018

Notes as Table 5. Control variables included (as in Table 5) but not reported.

3.4. Control variables

To control for tariffs, we use applied tariff rates at the HS6-level, obtained from the UNCTAD Trade Analysis Information System (TRAINS). Disaggregated tariff data suffer from a large number of missing observations, and we follow Fernandes et al. (2019) to impute these. We obtain production data from FAOstat. We use GDP (per capita) data from the World Bank complemented with data from the United Nations Common Database (UNCDB), after which we inter-and extrapolate values to obtain missing observations. RTA data was retrieved from Mario Larch's Regional Trade Agreements Database (Egger & Larch, 2008), and time-invariant gravity variables (population-weighted distance, common official language, contiguity and colonial history) from CEPII.

4. Results

4.1. Descriptive statistics

VSS have proliferated in the last decades (UNFSS, 2022). For the five selected crops, the VSS-certified area increased from 5 to 7.6 million hectares in 2012 to 9 to 13.6 million hectares in 2018 (Fig. 1). While coffee represented the largest certified area in 2012, cocoa took over since 2018. There is a geographical divide in certification (Fig. A2 in appendix): VSS coverage in Asia is mostly driven by palm oil certification, comprising over two thirds of total certified production area. In South-America, coffee certification is most widespread while in Africa, cocoa certification is dominating. Banana certification is mostly restricted to South-America, and tea certification is evenly spread over Asia and Africa.

The summary statistics in Table 3 reveal that, on average across all producing countries, about 11% of the crop-specific production area is certified. When only considering countries with VSS certification, almost 25% of the production area is certified. VSS coverage is most intense in the tea sector with on average, across producing countries, 18% of the production area certified and with three quarters of all producing countries adopting VSS. About 60% of coffee and cocoa producing countries adopt VSS but the share of certified area is slightly lower for these crops. VSS coverage is <10% on average across countries in the banana and palm oil sectors, mainly because only around 45% of producing countries adopt VSS¹². Table 4 displays summary statistics of all other variables used in the analysis, based on the BB sample¹³.

We map the geographical spread of country-level VSS coverage, combined over all five crops, in Fig. 2. Almost all Asian and South-American commodity-producing countries have adopted VSS by 2018 while most non-adopters are in Africa. VSS coverage is somewhat larger in South-America compared to Asia. Crop-specific maps are provided in Fig. A3 in appendix. These largely confirm the general trend with less certified countries in Africa and for banana also in Asia.

Fig. 3 graphs the crop-specific export value from producing countries by crop over the period between 2012 and 2019. Equivalent graphs by continent are provided in Fig. A4 in appendix. These graphs show that global commodity exports decreased slightly over this time period, mainly stemming from decreases in palm oil exports in Asia. Globally, palm oil is the most important export commodity in terms of export value, followed by coffee. While palm oil dominates in commodity export values in Asia, this is cocoa in Africa and coffee and banana in South-America. There is a geographical similarity between export sector importance and VSS coverage by crop, that appears from a comparison between Figs. A2 and A4 in appendix.

4.2. Econometric results

Table 5 presents the main PPML estimation results of the FE model (column 1), the BB estimation (column 2), and the IV estimation (column 3). We find a significant and robust positive effect of VSS coverage on export values across all specifications, signaling an export-facilitating effect of VSS adoption in tropical commodity sectors. Coefficient estimates for VSS coverage can be interpreted as semi-elasticities. The estimations reveal that a one percentage point (pp) increase in the share of certified production area increases commodity export values with on average 1.8 to 3.3%, *ceteris paribus*. The signs and magnitudes of the coefficient estimates for the traditional gravity variables are in line with expectations, except for contiguity where we find that sharing a border does not affect trade. This likely relates to the focus on tropical commodities, of which an important share is destined for non-tropical

¹² Table A3 in appendix provides coverage statistics by VSS.

¹³ Summary statistics based on the FE and IV samples can be found in Table A4 in appendix.

Table 7
Summary of PPML estimation results of exporter and importer heterogeneous model specifications.

	Exporter heterogeneity			Importer heterogeneity		
	(1) FE	(2) BB	(3) IV	(4) FE	(5) BB	(6) IV
VSS _{ikt-1}	0.020*** (0.008)	0.016*** (0.004)		0.003 (0.008)	-0.005 (0.012)	
VSS _{ikt}			0.035*** (0.009)			0.017 (0.011)
Log (expGDP/cap) _{it}		0.070 (0.077)				
Log (impGDP/cap) _{jt}					0.011 (0.301)	
VSS						
x Log (expGDP/cap) _{it}	0.001 (0.003)	0.000 (0.001)	-0.001 (0.001)			
x Log (impGDP/cap) _{jt}				0.004** (0.002)	0.005** (0.003)	0.004*** (0.001)
Observations	393,604	923,018	350,748	393,604	923,018	350,748

Notes as Table 5. Columns (1), (3), (4) and (6) include importer-time, exporter-time, time-product and bilateral FE. Columns (2) and (5) include importer, product and time FE. Control variables included (as in Table 5) but not reported.

Table 8
Summary of PPML estimation results for income gap heterogeneous model specification.

	Income gap heterogeneity		
	(1) FE	(2) BB	(3) IV
VSS _{ikt-1}	0.017*** (0.003)	0.012*** (0.004)	
VSS _{ikt}			0.029** (0.011)
Log [$\frac{imp\ GDP/cap}{exp\ GDP/cap}$] _{ijt}		-0.167** (0.078)	0.023 (0.164)
VSS × Log [$\frac{imp\ GDP/cap}{exp\ GDP/cap}$] _{ijt}	0.003** (0.002)	0.004** (0.001)	0.002 (0.007)
Observations	393,604	923,018	350,748

Notes as Table 5. Control variables included (as in Table 5) but not reported.

countries. We note that the magnitude of the trade effect of tariffs and RTAs is larger in the BB method due to the BB-correction on the bilateral variables in this estimation.

Table 6 reports a summary of the main results for the crop-specific models¹⁴. Coefficient estimates of gravity control variables are in line with the baseline estimation in Table 5 and are not reported. We find that VSS coverage is associated with increased export values in the banana, coffee and tea sectors but we find no significant effects in the palm oil and cocoa sectors. Wald tests confirm that for the FE estimation the VSS impact is larger in the banana and coffee sectors than in the tea sector, and for the BB estimation larger in the banana sector than in the coffee and tea sectors. The estimates suggest that a one pp increase in the share of certified banana production area increases the value of banana exports with 3.1 to 3.4%. This corresponds to an average increase of about 3.1 to 3.4 million USD a year for all producing countries, and of about 2 to 2.2 million USD for low and lower-middle income countries. A one pp increase in VSS coverage results in an average increase in export value of 1.1 to 2.6% in the coffee sector, and of 1 to 1.8% in the tea sector. Economic export gains range on average between 1.3 and 6.7 million USD for all producing countries, and between 1.5 and 5.1 million USD for low- and lower middle income producing countries. The export effects of VSS certification are not only statistically but also economically significant in the banana, coffee and tea sectors.

Table 7 reports the main results on exporter (columns (1) to (3)) and importer (columns (4) to (6)) heterogeneity in VSS impact. Coefficient

estimates of gravity control variables are in line with the baseline estimation in Table 5 and are not reported. We find no significant interaction effects between VSS coverage and exporter GDP per capita but we do find significantly positive interaction effects between VSS coverage and importer GDP per capita in all three models. These results indicate that the trade-facilitating effect of VSS adoption does not vary with the income level of the exporting country but increases with the income level of the importing country. We note that the main VSS coefficients are not significant in columns (4) to (6). Given that GDP per capita is centered around its minimum value, this implies that VSS do not have trade implications for exports to countries with the lowest income level, and only have a trade-enhancing effect when exporting to countries with higher income levels.

Table 8 presents the main results for the models including the log-transformed measure of income gap between exporter and importer. The main effect of the income gap on trade is negative in the BB estimation – and omitted in the FE estimation due to high collinearity with the bilateral FE – which confirms a negative relationship between income gap and trade due to for example institutional distance and related transaction costs. We find significantly positive coefficients for VSS coverage in all three models, suggesting a positive trade impact of VSS for trade partners with the same GDP per capita level. Moreover, we find a significantly positive coefficient for the interaction term in the FE and BB estimations, and a similar coefficient in the IV estimation that is, likely due to inefficiency, not significant. This suggests that the export-increasing effect of VSS adoption is largest for trade between lower-income exporting and higher-income importing countries. The estimates imply that VSS adoption off-sets the negative effect related to the income gap between trading partners at a certification coverage of about 40%, which applies to just over 10% of the country-crop-year observations in the sample.

5. Discussion

Our results confirm that VSS adoption can have a positive effect on countries' commodity exports and show that these export-enhancing effects differ between sectors, which justifies our multi-sector approach. We find the strongest effect for banana, followed by coffee and tea, and no significant effect in the cocoa and palm oil sector. The strong effect for banana might relate to a lower VSS coverage in that sector and possible first-mover advantages, as observed by Henson and Humphrey (2010). In addition, banana exports might be more affected by VSS through quality improvements than other studied crops because of the higher perishability. Moreover, it is the only sector in our sample that comprises GlobalGAP, one of the two B2B standards in our analysis. Retailers in high-income countries often rely on B2B standards to assure

¹⁴ The IV-PPML estimation for the crop-specific models does not converge. Reported FE and BB estimates might be biased downward, given that IV estimates are larger than FE and BB estimates in Table 5.

quality in the supply chain, and have extended transnational food sourcing networks (Andersson, 2019; Wrigley & Lowe, 2010). The observed strong trade effects of VSS in the banana sector could point to network effects or certified suppliers benefitting from established retailer networks in multiple countries, as disclosed by Cheptea, Emlinger and Latouche (2019). Additionally, because of its focus on good agricultural practices, GlobalGAP might have a larger impact through production channels than other studied VSS.

The estimated trade-enhancing effect of coffee certification surprises as the market for VSS-certified coffee is argued to be saturated. As asserted based on micro-economic insights (e.g. Oya et al., 2018; Tayleur et al., 2018; Vanderhaegen et al., 2018) the estimated effects may relate to price and quality effects rather than volume effects. We test this with the same crop-specific gravity model estimating trade volumes instead of values. This results in insignificant trade volume effects of VSS in the coffee sector, confirming this hypothesis. Coffee certification is especially important in high-value specialty market segments, which further explains the effect of VSS adoption on coffee export values.

Despite the similarity between coffee and cocoa supply chains (both characterized by smallholder production, high degrees of processing, product and quality differentiation possibilities, and dominance of few large multinational companies), we find no significant effect in the cocoa sector. Unlike coffee which is mainly exported as unroasted coffee beans, cocoa beans are increasingly processed into higher-value products (cocoa butter, powder and paste) within the countries of origin (CEPII, 2022). To better understand how this affects the trade implications of VSS, we follow Grassnick and Brümmer (2021), and estimate trade effects of cocoa certification in a reduced sample of cocoa exports, distinguishing 6-digit cocoa product lines. Estimation results are reported in Table A10 in appendix. We find an export-enhancing effect of VSS for cocoa beans, but an insignificant effect for cocoa paste, and even a trade-reducing effect for cocoa butter and powder. These effects cancel out in the overall estimation for cocoa, and are in line with the impact of UTZ certification observed by Grassnick and Brümmer (2021). The magnitude of the effect for cocoa beans is similar to that of coffee and tea, with a one pp increase in VSS coverage resulting in a one percent increase in export value.

We find no trade effect of VSS adoption in the palm oil sector. Many food processing and manufacturing companies in high-income countries have committed to sustainable sourcing practices for palm oil, and consumer awareness on sustainable palm oil production is increasing. However, the largest destination market for palm oil exports are middle-income countries in South- and Southeast Asia where it is mainly used as a common cooking oil. Consumer demand for sustainably sourced palm oil in these importing countries is low, limiting the demand for VSS compliant palm oil exports (Voora et al., 2020).

Further, we show that the trade-enhancing effect of VSS certification does not vary with the income level of the exporter country but increases with the income level of the importer country and with the income gap between the trading partners. These results corroborate the finding of Fiankor et al. (2020) that GlobalGAP certification of fruits has a larger effect on exports to OECD countries, and generalizes that this holds in other sectors and for VSS more generally. Yet, our results contradict the findings of Ehrich and Mangelsdorf (2018) that IFS certification only enhances exports from high- and middle-income countries; as well as those from Andersson (2019) and Fiankor et al. (2020) that the export-enhancing effect of GlobalGAP is strongest for developing countries. Our results confirm that the trade effects of VSS adoption are importantly driven by the demand for sustainably-sourced food products in high-income countries and the need to overcome stringent public food-quality and -safety regulations to export to these countries. Our results

imply that VSS adoption is beneficial for low-income countries, and that even small increases in certification coverage lead to substantial improvements in the export performance of these countries. Our finding that VSS are particularly trade-enhancing when the income gap between importer and exporter countries is large supports the hypothesis that VSS reduce information asymmetries and allow to overcome the trade-inhibiting effect of governance distance between countries. This hypothesis was already confirmed for GlobalGAP certification in the fruit sector (Fiankor et al., 2019) and for ISO-certification at firm-level (Goedhuys & Sleuwaegen, 2016), and is now confirmed for VSS more generally instead of B2B standards only.

Our findings are relevant in light of three specific policy issues. First, VSS adoption can substantially improve the export performance of low-income countries, with potentially large trade gains from small increases in commodity certification coverage. This suggests that VSS can play a role in development programs to strengthen specific export sectors in low-income countries and that, even small, donor-funded certification programs can deliver economy-wide benefits in terms of trade gains. Yet, not in all sectors. It remains important to also consider the demand side when expanding VSS coverage in development programs.

Second, VSS can help to overcome trade barriers. While the governance distance between trading partners strongly limits South-North trade, especially for agricultural products (de Mendonça et al., 2014; Fiankor et al., 2019; Goedhuys & Sleuwaegen, 2016), VSS adoption is particularly trade-enhancing when the income or governance gap is large. Yet, VSS coverage is strongly biased towards countries with stronger governance systems, where they build on strong private sector development policies and well-functioning regulatory institutions (Herzfeld et al., 2011; UNFSS, 2020; Yadav et al., 2021). Also, the environmental and social sustainability gains from VSS adoption are largest in good institutional settings, in particular well-functioning vertical and horizontal coordination systems (Oya et al., 2018). There is a danger that VSS are strengthening and greening existing trade patterns while reinforcing market access barriers for the poorest countries. For VSS to effectively reconcile international food trade with environmental and social sustainability, policy attention is needed to VSS adoption and impact in the poorest countries. Such policies can constitute financial and technical support for producers to overcome (direct and indirect) certification costs, attention to an enabling institutional environment for value chain upgrading and private sector development, and investment in local auditing and internationally acknowledged accreditation bodies (Ehrich & Mangelsdorf, 2018; Fiankor et al., 2020; Grabs et al., 2021).

Third, findings suggest that VSS adoption stimulates trade in raw products such as green coffee beans, dried tea leaves and cocoa beans but inhibit trade in higher-value processed products such as cocoa butter and powder. This might relate to food processing companies in high-income countries wishing to control the value added during processing; which is especially important for certified products.. If VSS hamper exports of value-added cocoa products, they might discourage investments in cocoa grinding facilities and divert revenues from cocoa processing to importing countries. This implies that the further expansion of VSS and their integration in public sustainability and trade policies, entails the danger of confirming LMICs in the role of lower value primary produce exporters.

A main limitation in our study is the lack of more accurate yearly VSS coverage data at country level, including data on multiple certification. We include only seven of the 31 active VSS in the five included sectors. A focus on the minimum and maximum VSS coverage (representing the range of possible true VSS coverage) proved to be robust and adding less widespread VSS would likely not change results – as this would have

no or only a small impact on the minimum VSS coverage variable. We were able to include only seven years of observation for the period 2012 – 2018, during which VSS adoption trends varied across sectors and VSS. Expanding the VSS coverage database to include a longer period of time might nuance findings, and might allow for difference-in-difference identification strategies.

The focus in this paper is on understanding the overall trade effects of VSS adoption. We do not focus on the mechanisms behind these effects, nor on heterogeneity across VSS. Trade effects of VSS adoption may emerge through price, quality and volume effects, and through demand- and supply-side effects. Moreover, VSS vary largely in terms of production requirements, price support mechanisms and governance systems, which may result in varying trade effects. For example, VSS with a focus on good agricultural practices may have different supply-side effects than VSS with a focus on social requirements; VSS that stipulate minimum prices may carry very different trade effects than VSS that apply price premia; and B2B standards may bear different demand-side effects than B2C standards. Understanding how VSS affect the export performance of LMICs, and how and why trade effects vary across VSS, are research questions that open up interesting avenues for future research, and entail a high policy relevance, especially in light of the increased reference to VSS in general, without distinction or differentiation among VSS, in trade and preferential market access agreements.

6. Conclusion

Our results confirm that VSS adoption in tropical commodities sectors has an economically relevant impact on the export performance of producing countries - yet, not for all commodities. We find a trade-enhancing effect in the banana, tea and coffee sector but not in the cocoa and palm oil sector, which has geospatial implications. South-America mostly reaps the export gains from VSS adoption in the banana and coffee sector, while VSS do not contribute to the export performance of the palm oil sector, that is dominant in Asia. VSS adoption in the cocoa sector is most important in Africa and has more ambiguous implications. Cocoa certification enhances exports of raw cocoa beans but impedes exports of higher-value processed cocoa products, which may confirm LMICs, in Africa in particular, in their role of primary produce exporters.

We show that the export-enhancing effect of VSS adoption increases with the income gap between the importer and exporter country. This

confirms that VSS adoption can strengthen trade relations of LMICs with high-income countries, and help to overcome the trade-inhibiting impact of governance distance – for example in public food-quality and -safety regulations – between trading partners. While there are potentially large trade gains from VSS adoption for the poorest countries, certification coverage as well as its sustainability impacts remain lowest in these countries. Without targeted support, the ongoing integration of VSS in trade policy might strengthen and green existing trade patterns while reinforcing market access barriers for the poorest countries. For VSS to effectively reconcile international food trade with environmental and social sustainability, policy attention is needed to VSS adoption and impact in the poorest countries.

CRedit authorship contribution statement

Janne Bemelmans: Conceptualization, Methodology, Formal analysis, Investigation, Data curation, Writing – original draft, Visualization. **Daniele Curzi:** Methodology, Validation, Resources, Writing – review & editing. **Alessandro Olper:** Validation, Resources, Writing – review & editing. **Miet Maertens:** Conceptualization, Validation, Writing – review & editing, Supervision, Project administration, Funding acquisition.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Acknowledgements

This work was supported by an KU Leuven internal research fund [grant number C24M/19/031], and a PhD Fellowship fundamental research granted by FWO (Research Foundation - Flanders) [grant number 11J6123N].

Appendix A

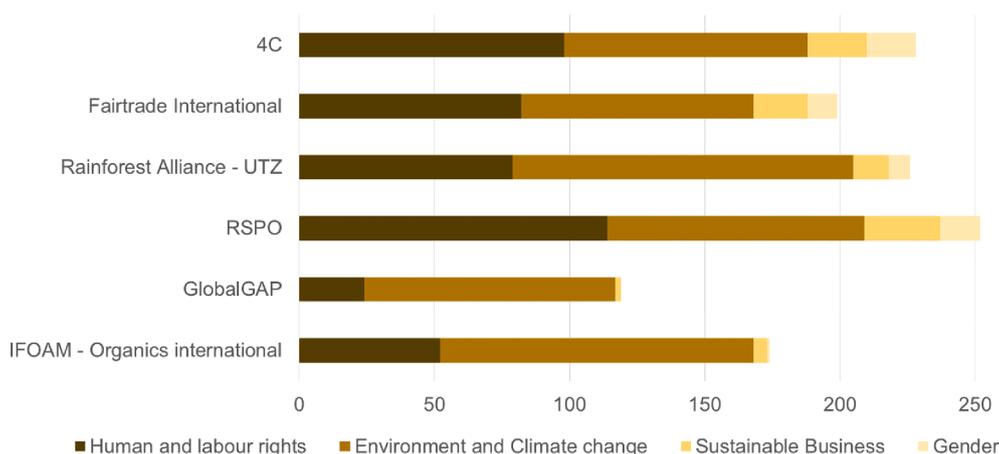


Fig. A1. Number of requirements by sustainability metrics included by VSS. Data source: ITC (2021). Note: At the time of writing Rainforest Alliance and UTZ underwent a merger; and sustainability metrics are only available for current standards.

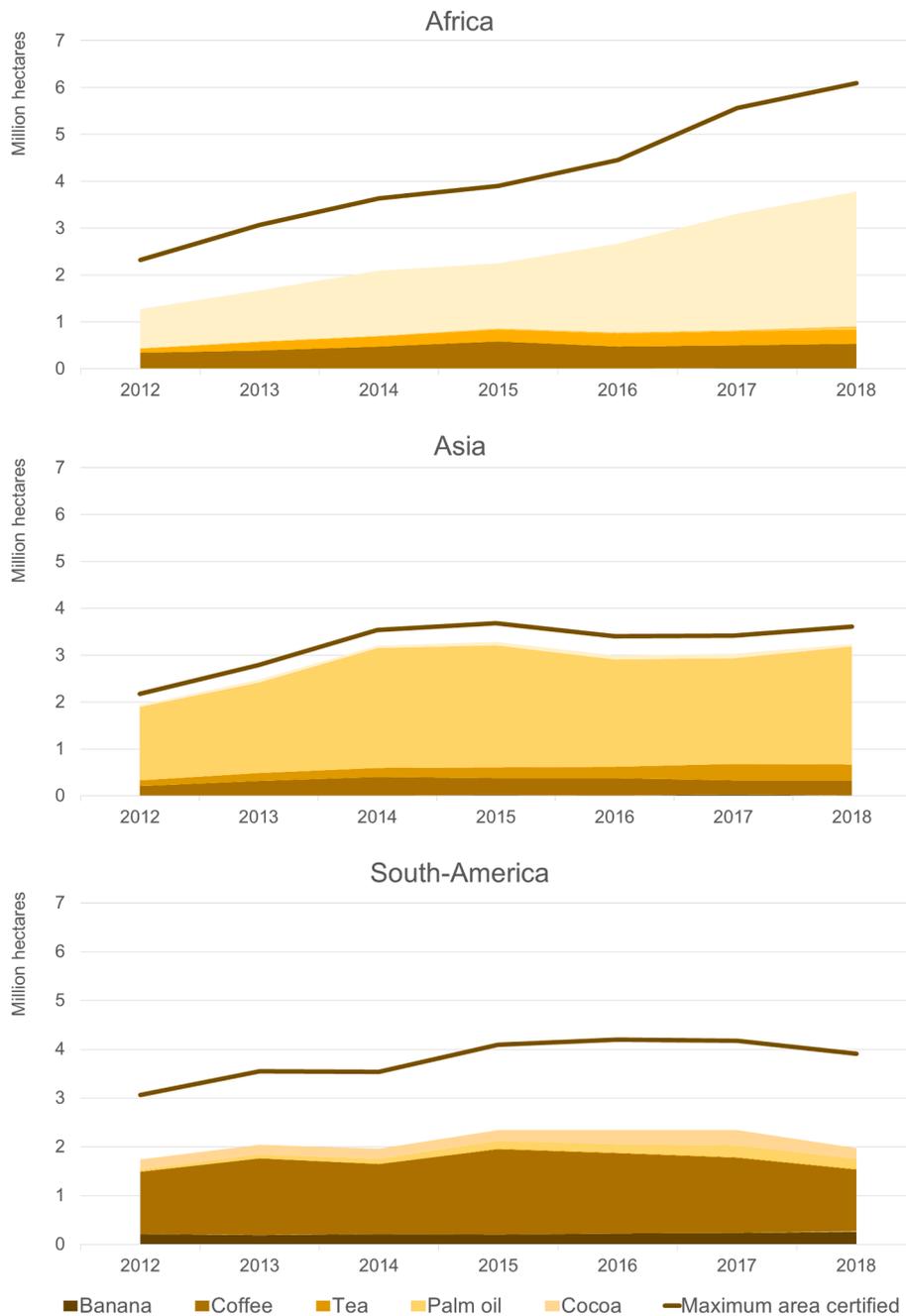


Fig. A2. Certified production area by continent represented by minimum certified production area by crop and maximum certified production area over all crops, 2012 to 2018.

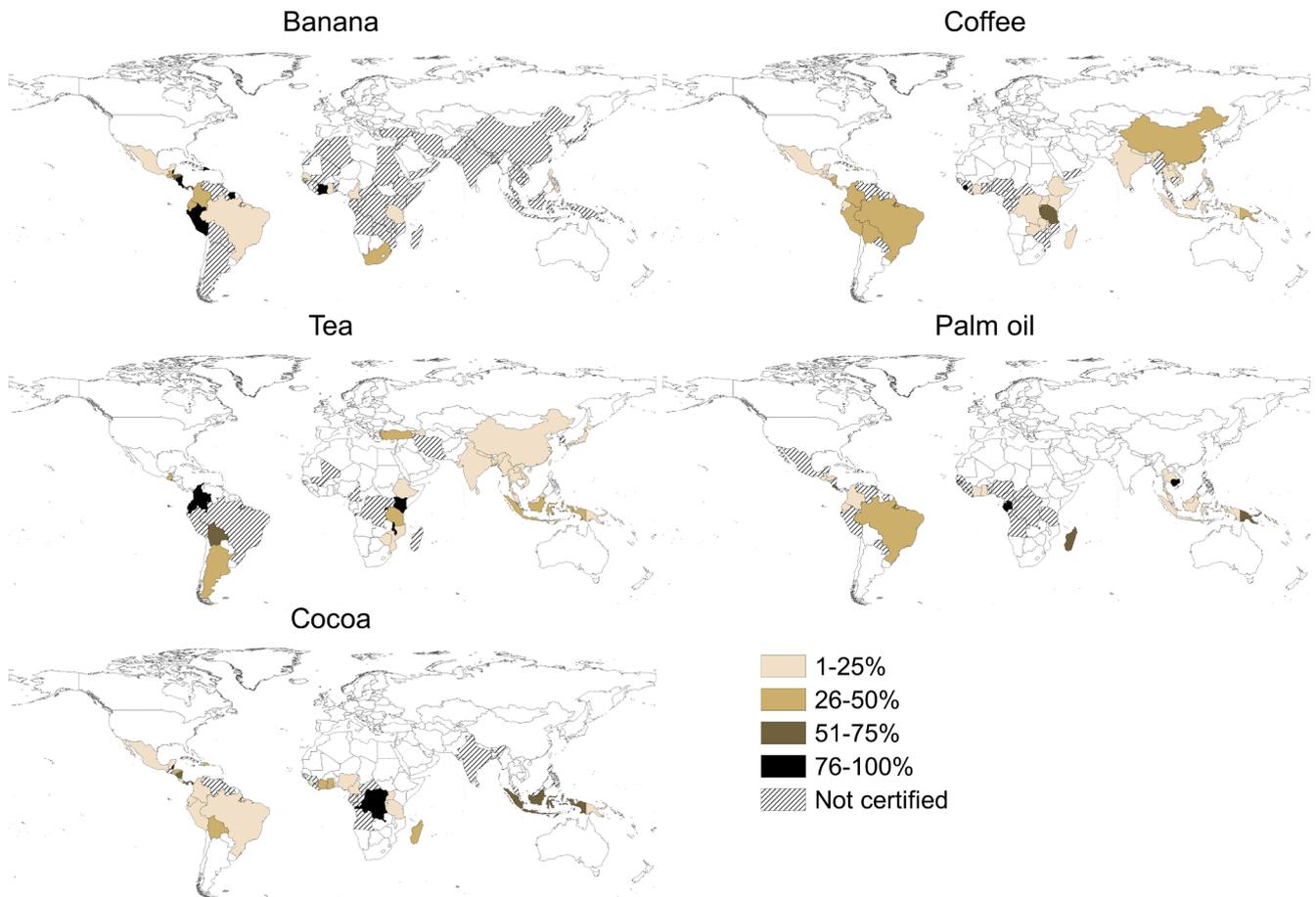


Fig. A3. Crop-specific geographical spread of VSS certification in 2018, in terms of the share of total production area certified.

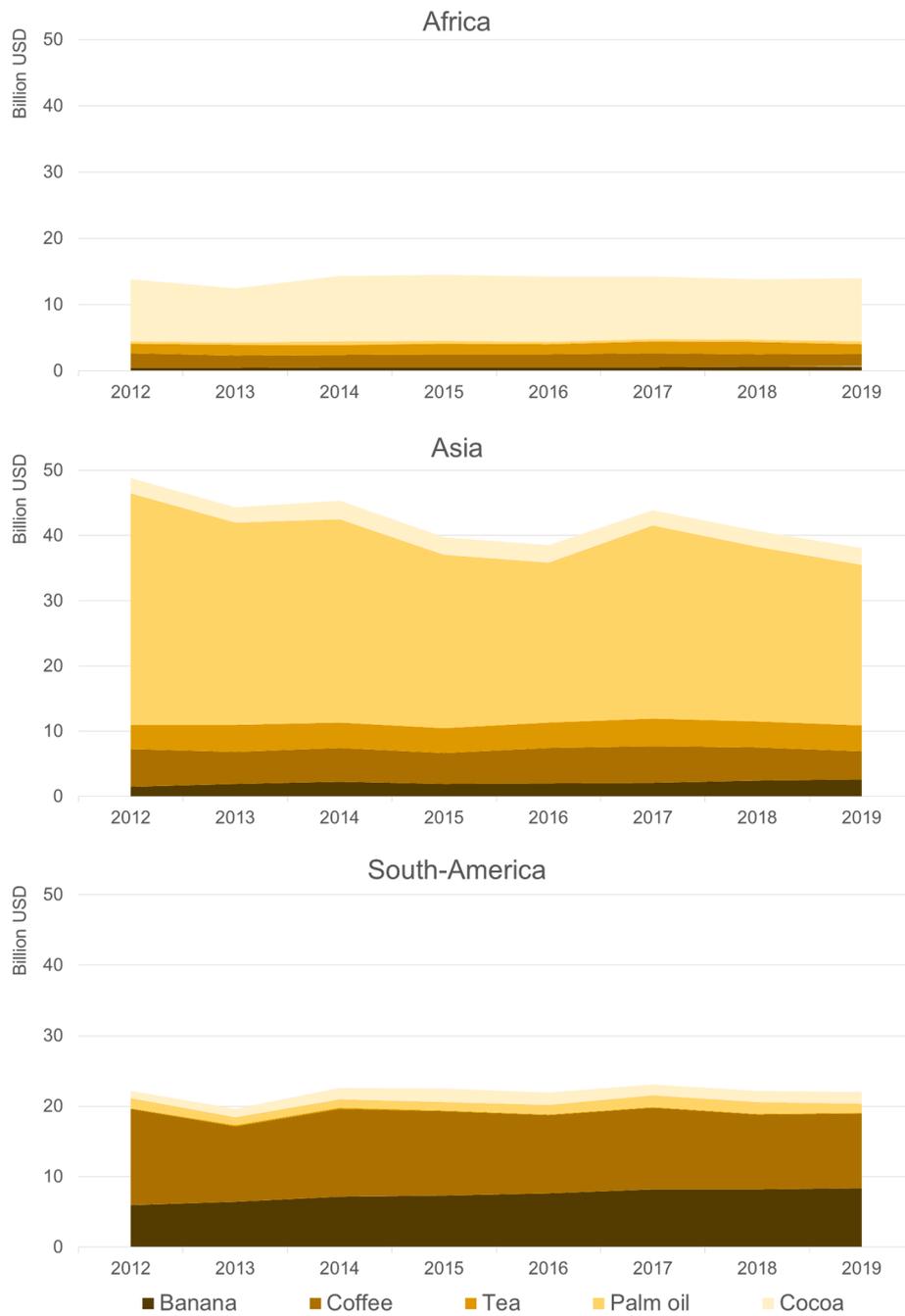


Fig. A4. Export values (in million USD) by crop and continent, 2012 to 2019.

Table A1
List of exporting and importing countries.

Country	Exp	Imp	Country	Exp	Imp	Country	Exp	Imp
Afghanistan	0	1	Gabon	1	1	Panama	1	1
Albania	0	1	Gambia	1	1	Papua New Guinea	1	1
Algeria	1	1	Georgia	0	1	Paraguay	1	1
Angola	1	1	Germany	0	1	Peru	1	1
Antigua and Barbuda	1	1	Ghana	1	1	Philippines	1	1
Argentina	1	1	Greece	0	1	Plurinational State of Bolivia	1	1
Armenia	0	1	Grenada	1	1	Poland	0	1
Aruba	0	1	Guatemala	1	1	Portugal	0	1
Australia	0	1	Guinea	1	1	Qatar	0	1
Austria	0	1	Guinea-Bissau	1	1	Republic of Korea	1	1
Azerbaijan	1	1	Guyana	1	1	Republic of Moldova	0	1
Bahamas	1	1	Haiti	1	1	Romania	0	1
Bahrain	1	1	Honduras	1	1	Russian Federation	0	1
Bangladesh	1	1	Hungary	0	1	Rwanda	1	1
Barbados	1	1	Iceland	0	1	Saint Kitts and Nevis	0	1
Belarus	0	1	India	1	1	Saint Lucia	1	1
Belgium	0	1	Indonesia	1	1	Saint Vincent and the Grenadines	1	1
Belize	1	1	Iran	1	1	Samoa	1	1
Benin	1	1	Ireland	0	1	Sao Tome and Principe	1	1
Bermuda	0	1	Israel	1	1	Saudi Arabia	0	1
Bhutan	1	1	Italy	0	1	Senegal	1	1
Bosnia and Herzegovina	0	1	Jamaica	1	1	Seychelles	1	1
Botswana	0	1	Japan	1	1	Sierra Leone	1	1
Brazil	1	1	Jordan	1	1	Singapore	0	1
Brunei Darussalam	1	1	Kazakhstan	0	1	Slovakia	0	1
Bulgaria	0	1	Kenya	1	1	Slovenia	0	1
Burkina Faso	0	1	Kuwait	0	1	Solomon Islands	1	1
Burundi	1	1	Kyrgyzstan	0	1	Somalia	1	0
Cabo Verde	1	1	Lao People's Dem. Rep.	1	1	South Africa	1	1
Cambodia	1	1	Latvia	0	1	Spain	0	1
Cameroon	1	1	Lebanon	1	1	Sri Lanka	1	1
Canada	0	1	Lesotho	0	1	State of Palestine	1	1
Cayman Islands	0	1	Liberia	1	1	Sudan	1	1
Central African Republic	1	1	Libya	0	1	Suriname	1	1
Chad	0	1	Lithuania	0	1	Swaziland	1	1
Chile	0	1	Luxembourg	0	1	Sweden	0	1
China	1	1	Madagascar	1	1	Syria	1	1
Hong Kong (HK SAR)	0	1	Malawi	1	1	Tajikistan	0	1
Colombia	1	1	Malaysia	1	1	Thailand	1	1
Comoros	1	1	Maldives	1	1	Republic of Macedonia	0	1
Congo	1	1	Mali	1	1	Timor-Leste	1	1
Costa Rica	1	1	Malta	0	1	Togo	1	1
Croatia	0	1	Mauritania	0	1	Tonga	1	1
Cuba	1	1	Mauritius	1	1	Trinidad and Tobago	1	1
Cyprus	0	1	Mexico	1	1	Tunisia	0	1
Czech Republic	0	1	Mongolia	0	1	Turkey	1	1
Côte d'Ivoire	1	1	Montenegro	0	1	Turkmenistan	0	1
DR Congo	1	1	Morocco	1	1	Tuvalu	0	1
Denmark	0	1	Mozambique	1	1	Uganda	1	1
Djibouti	0	1	Myanmar	1	1	Ukraine	0	1
Dominica	1	1	Namibia	0	1	United Arab Emirates	0	1
Dominican Republic	1	1	Nauru	0	1	United Kingdom	0	1
Ecuador	1	1	Nepal	1	1	United Republic of Tanzania	1	1
Egypt	1	1	Netherlands	0	1	Uruguay	0	1
El Salvador	1	1	New Zealand	0	1	Uzbekistan	0	1
Equatorial Guinea	1	1	Nicaragua	1	1	Vanuatu	1	1
Estonia	0	1	Niger	0	1	Venezuela	1	1
Ethiopia	1	1	Nigeria	1	1	Viet Nam	1	1
Fiji	1	1	Oman	1	1	Yemen	1	1
Finland	0	1	Pakistan	1	1	Zambia	1	1
Monaco	0	1	Palau	0	1	Zimbabwe	1	1
French Polynesia	1	1						

Table A2

Robustness check inclusion zero-flows: Baseline model specification for extensive (LPM estimation) and intensive margin of trade (OLS and PPML estimation).

	Extensive margin		Intensive margin			
	(0/1)		Log Value		Value	
	(1) FE-LPM	(2) BB-LPM	(3) FE-OLS	(4) BB-OLS	(5) FE-PPML	(6) BB-PPML
VSS _{ikt-1}	0.001*** (0.000)	0.000 (0.000)	0.019*** (0.001)	0.009*** (0.001)	0.021*** (0.002)	0.015*** (0.002)
Log (1 + Tariff _{ijkt})	-0.039*** (0.001)	-0.043*** (0.002)	-0.328*** (0.026)	-0.294*** (0.031)	-0.067 (0.057)	-0.133** (0.062)
RTA _{ijt}	-0.005 (0.007)	0.024*** (0.002)	0.188* (0.097)	0.518*** (0.060)	0.193* (0.105)	0.256** (0.122)
Log (Production _{ikt})	0.051*** (0.001)	0.024*** (0.000)	0.598*** (0.014)	0.512*** (0.010)	0.688*** (0.044)	0.726*** (0.032)
Log (World production _{kt})		-0.004 (0.006)		-1.430*** (0.354)		-1.402*** (0.328)
Log (GDP _{jt})		-0.002 (0.002)		0.288*** (0.103)		0.083 (0.135)
Log (Distance _{ij})		-0.039*** (0.001)		-0.549*** (0.043)		-0.616*** (0.099)
Contiguity _{ij}		0.121*** (0.007)		0.458*** (0.115)		-0.449** (0.200)
Colony _{ij}		0.079*** (0.018)		-0.108 (0.178)		0.045 (0.237)
Language _{ij}		0.027*** (0.018)		-0.008 (0.081)		0.173 (0.197)
Constant	-0.269*** (0.007)	-0.210* (0.113)	-3.707*** (0.174)	10.105 (6.286)	0.508 (0.662)	18.320*** (6.641)
Observations	393,604	923,018	80,004	80,706	80,004	80,706

Notes: The dependent variable in columns (1) and (2) is a dummy equaling 1 for non-zero flows of product *k* from producing country *i* to importing country *j* at time *t*, and 0 for zero flows. The dependent variable in columns (3) and (4) is the log value of export flows of product *k* from producing country *i* to importing country *j* at time *t*; in columns (5) and (6) it is the value for these export flows. Columns (1), (3) and (5) include importer-time, exporter-time, time-product and bilateral fixed effects. Columns (2), (4) and (6) include importer, product and time fixed effects. Robust country-pair-product clustered standard errors in parentheses. *** *p* < 0.01, ** *p* < 0.05, * *p* < 0.1.

Table A3

VSS descriptions: Marketing type; number of certified countries; global coverage by crop, and regional coverage over the selected crops (latter two in terms of share of production area certified).

	Marketing	Certified countries	Sectorial coverage (%)					Regional coverage (%)			
			Coffee	Cocoa	Tea	Banana	Palm oil	Global	Africa	S-America	Asia
4C	B2B	28	11.77					11.77	3.99	18.50	8.24
Fairtrade Int.	B2C	24	7.62	9.94	2.75	0.70		6.65	9.45	10.16	0.59
Rainforest Alliance	B2C	44	3.02	6.37	12.18	3.31	0.13	3.09	5.20	5.40	1.12
UTZ	B2C	41	6.83	26.02	1.53			13.90	25.28	9.41	2.48
RSPO	B2C	17					10.10	10.10	1.42	13.13	12.16
GlobalGAP	B2B	28				4.74		4.74	0.43	17.50	0.01
IFOAM – Organics Int.	B2C	59	6.18	2.75	2.14	1.47	0.03	1.99	2.81	4.56	0.70

Notes: Coverage statistics based on 2018 data. Empty cells in crop coverage indicate that the VSS is not active in this sector.

Table A4

Descriptive statistics: FE and IV sample (FE: N = 393,604; IV: N = 350,748).

	FE sample				IV sample			
	Mean	St. dev.	Min	Max	Mean	St. dev.	Min	Max
Share minimum area certified (lag)	15.90	23.17	0	100	17.40	23.90	0	100
Export value (million USD)	1.112	21.388	0	3,138	1.291	24.914	0	3,470
Exporter production (1,000 tonnes)	665.70	3,143	0.003	40,567	771.02	3,442	0.004	40,567
RTA (0/1)	0.31		0	1	0.30		0	1
Tariff	11.00	23.42	0	513.60	11.19	23.54	0	513.60
Crop (0/1)								
Banana	0.06		0	1	0.06		0	1
Coffee	0.33		0	1	0.32		0	1
Tea	0.25		0	1	0.25		0	1
Palm oil	0.09		0	1	0.11		0	1
Cocoa	0.28		0	1	0.26		0	1
Exporter GDP/capita (USD)	5,288	5,671	228	42,063	4,922	4,535	239	42,063
Importer GDP/capita (USD)	17,789	20,755	228	123,514	17,261	20,401	239	123,514
Ratio importer / exporter GDP/capita	9.31	20.34	0.01	354.43	9.52	20.70	0.02	338.48

Note: all monetary values are in current USD.

Table A5

Robustness check VSS variable: Baseline model specification with maximum level of certified production area as measure of VSS intensity.

	(1) FE	(2) BB	(3) IV
VSS _{ikt-1}	0.020*** (0.002)	0.014*** (0.002)	
VSS _{ikt}			0.025*** (0.003)
Log (1 + Tariff _{ijkt})	-0.155*** (0.058)	-0.261*** (0.065)	-0.126*** (0.039)
RTA _{ijt}	0.214** (0.099)	0.387*** (0.121)	0.210*** (0.070)
Log (Production _{ikt})	0.801*** (0.043)	0.933*** (0.027)	0.851*** (0.032)
Log (World production _{kt})		-1.531*** (0.308)	
Log (GDP _{jt})		0.106 (0.123)	
Log (Distance _{ij})		-0.668*** (0.106)	
Contiguity _{ij}		-0.299 (0.218)	
Colony _{ij}		0.131 (0.239)	
Language _{ij}		0.211 (0.177)	
Constant	-1.399** (0.635)	15.968** (6.320)	-2.286*** (0.565)
Observations	393,604	923,018	350,748

Notes: The dependent variable is the value of export flows of product *k* from producing country *i* to importing country *j* at time *t*. Columns (1) and (3) include importer-time, exporter-time, time-product and bilateral fixed effects. Column (2) includes importer, product and time fixed effects. Robust country-pair-product clustered standard errors in parentheses. *** *p* < 0.01, ** *p* < 0.05, **p* < 0.1.

Table A6

Robustness check VSS variable: Crop heterogeneity model specification with maximum level of certified production area as measure of VSS intensity.

	(1) FE	(2) BB
VSS _{ikt-1} ×		
Banana	0.029*** (0.003)	0.025*** (0.003)
Coffee	0.019*** (0.004)	0.008*** (0.002)
Tea	0.012*** (0.004)	0.017*** (0.004)
Palm oil	0.010* (0.005)	0.008* (0.005)
Cocoa	0.005 (0.004)	0.001 (0.003)
Observations	393,604	923,018

Notes: The dependent variable is the value of export flows of product *k* from producing country *i* to importing country *j* at time *t*. Column (1) includes importer-time, exporter-time, time-product fixed effects and bilateral fixed effects. Column (2) includes importer, product and time fixed effects. Control variables are included (as in Table A5) but are not reported. Robust country-pair-product clustered standard errors in parentheses. *** *p* < 0.01, ** *p* < 0.05, **p* < 0.1.

Table A7

Robustness check VSS variable: Income heterogeneity model specification with maximum level of certified production area as measure of VSS intensity.

	Exporter heterogeneity			Importer heterogeneity		
	(1) FE	(2) BB	(3) IV	(4) FE	(5) BB	(6) IV
VSS _{ikt-1}	0.017** (0.007)	0.015*** (0.004)		-0.015* (0.007)	-0.020** (0.009)	
VSS _{ikt}			0.023*** (0.006)			-0.007 (0.009)
Log (GDP/cap _{it})		0.105 (0.090)				
Log (GDP/cap _{jt})					-0.229 (0.297)	
VSS _{ikt-1} / VSS _{ikt}						
x Log (GDP/cap _{it})	0.001 (0.002)	-0.001 (0.001)	0.001 (0.001)			
x Log (GDP/cap _{jt})				0.008*** (0.002)	0.008*** (0.002)	0.007*** (0.001)
Observations	393,604	923,018	350,748	393,604	923,018	350,748

Notes: The dependent variable is the value of export flows of product *k* from producing country *i* to importing country *j* at time *t*. Columns (1), (3), (4) and (6) include importer-time, exporter-time, time-product and bilateral fixed effects. Columns (2) and (5) include importer, product and time fixed effects. Control variables are included (as in Table A5) but are not reported. Robust country-pair-product clustered standard errors in parentheses. *** *p* < 0.01, ** *p* < 0.05, **p* < 0.1.

Table A8

Robustness check VSS variable: Income gap heterogeneity model specification with maximum level of certified production area as measure of VSS intensity.

	Income gap heterogeneity		
	(1) FE	(2) BB	(3) IV
VSS _{ikt-1}	0.011*** (0.003)	0.005* (0.003)	
VSS _{ikt}			0.017*** (0.006)
Log [$\frac{imp\ GDP/cap}{exp\ GDP/cap}$] _{ijt}	0.	-0.279*** (0.080)	0.040 (0.116)
VSS × Log [$\frac{imp\ GDP/cap}{exp\ GDP/cap}$] _{ijt}	0.006*** (0.001)	0.006*** (0.001)	0.004 (0.004)
Observations	393,604	923,018	350,748

Notes: The dependent variable is the value of export flows of product *k* from producing country *i* to importing country *j* at time *t*. Columns (1), (3), (4) and (6) include importer-time, exporter-time, time-product and bilateral fixed effects. Columns (2) and (5) include importer, product and time fixed effects. Control variables are included (as in Table A5) but are not reported. Robust country-pair-product clustered standard errors in parentheses. *** *p* < 0.01, ** *p* < 0.05, **p* < 0.1.

Table A9

Estimation results 2SLS.

	First stage (1) VSS	Second stage (2) Ln value
IV _{ikt}	0.020*** (0.004)	
VSS _{ikt}		0.319*** (0.076)
Log (1 + Tariff _{ijkt})	0.533*** (0.149)	-0.491*** (0.066)
RTA _{ijt}	-0.265 (0.463)	0.223 (0.167)
Log (Production _{ikt})	1.276*** (0.098)	0.162 (0.106)
Observations	71,158	71,158

Notes: The dependent variable in column (1) is the minimum share of certified production area of product *k* in producing country *i* at time *t*. In column (2) the dependent variable is the logarithm of export values of product *k* from producing country *i* to importing country *j* at time *t*. Importer-time, exporter-time, time-product and bilateral fixed effects are included. Robust country-pair-product clustered standard errors in parentheses. *** *p* < 0.01, ** *p* < 0.05, **p* < 0.1. F(1,18594) = 19.44. AR-test: F(1,18594) = 84.95.

Table A10

Export impact of VSS in cocoa sector: Heterogeneity by 6-digit product line.

	(1) FE	(2) BB
VSS _{it-1} × Cocoa _{izt-1}		
Beans	0.010*** (0.004)	0.010*** (0.003)
180100		0.004 (0.005)
Paste [Not defatted]	0.004 (0.007)	
180310		-0.011 (0.011)
Paste [(Partly) defatted]	-0.025 (0.019)	
180320		-0.029*** (0.010)
Butter	-0.053*** (0.010)	
180400		-0.081*** (0.016)
Powder [No additions]	-0.100*** (0.013)	
180500		-0.614*** (0.082)
Log (1 + Tariff _{ijt})	-0.444*** (0.079)	-0.127 (0.141)
RTA _{ijt}	0.061 (0.073)	0.760*** (0.045)
Log (Production _{it})	0.487*** (0.092)	0.191 (0.214)
Log (GDP _{jt})		

Table A10 (continued)

	(1) FE	(2) BB
Log (Distance _{ij})		-0.617*** (0.139)
Contiguity _{ij}		0.272 (0.587)
Colony _{ij}		-0.123 (0.337)
Language _{ij}		0.460* (0.277)
Constant	4.475*** (1.185)	-8.688 (5.964)
Observations	60,402	264,586

Notes: The dependent variable is the value of export flows of cocoa 6-digit product-line *k* from producing country *i* to importing country *j* at time *t*. Column (1) includes importer-time, exporter-time, time-product fixed effects and bilateral fixed effects. Column (2) includes importer, product and time fixed effects. Robust country-pair-product clustered standard errors in parentheses. *** *p* < 0.01, ** *p* < 0.05, **p* < 0.1.

References

Anderson, J.E., 1979. Theoretical foundation for the gravity equation. *Am. Econ. Rev.* 69 (1), 106–116.

Anderson, J.E., van Wincoop, E., 2003. Gravity with gravitas: a solution to the border puzzle. *Am. Econ. Rev.* 93 (1), 170–192. <https://doi.org/10.1257/000282803321455214>.

Anderson, J.E., van Wincoop, E., 2004. Trade costs. *J. Econ. Lit.* 42 (3), 691–751. <https://doi.org/10.1257/0022051042177649>.

Andersson, A., 2019. The trade effect of private standards. *Eur. Rev. Agric. Econ.* 46 (2), 267–290. <https://doi.org/10.1093/erae/jby027>.

Baier, S.L., Bergstrand, J.H., 2009. Bonus vetus OLS: a simple method for approximating international trade-cost effects using the gravity equation. *J. Int. Econ.* 77 (1), 77–85. <https://doi.org/10.1016/j.jinteco.2008.10.004>.

Berger, D., Easterly, W., Nunn, N., Satyanath, S., 2013. Commercial imperialism? Political influence and trade during the cold war. *Am. Econ. Rev.* 103 (2), 863–896. <https://doi.org/10.1257/aer.103.2.863>.

CEPII, 2022. BACI dataset - 202201 version. Available from: <http://www.cepii.fr/CEPII/en/bdd_modele/bdd_modele_item.asp?id=37>.

Cheptea, A., Emlinger, C., Latouche, K., 2019. Exporting firms and retail internationalization: evidence from France. *J. Econ. Manag. Strateg.* 28 (3), 561–582. <https://doi.org/10.1111/jems.12294>.

de Mendonça, T.G., Lirio, V.S., Braga, M.J., da Silva, O.M., 2014. Institutions and bilateral agricultural trade. *Procedia Econ. Finance* 14, 164–172. [https://doi.org/10.1016/S2212-5671\(14\)00699-6](https://doi.org/10.1016/S2212-5671(14)00699-6).

DeFries, R.S., Fanzo, J., Mondal, P., Remans, R., Wood, S.A., 2017. Is voluntary certification of tropical agricultural commodities achieving sustainability goals for small-scale producers? A review of the evidence. *Environ. Res. Lett.* 12, 33001. <https://doi.org/10.1088/1748-9326/aa625e>.

Egger, P., Larch, M., 2008. Interdependent preferential trade agreement memberships: an empirical analysis. *J. Int. Econ.* 76 (2), 384–399. <https://doi.org/10.1016/j.jinteco.2008.08.003>.

Egger, P., Nelson, D., 2011. How bad is antidumping? Evidence from panel data. *Rev. Econ. Stat.* 93 (4), 1374–1390. https://doi.org/10.1162/REST_a_00132.

Egger, P.H., Nigai, S., 2015. Structural gravity with dummies only: constrained ANOVA-type estimation of gravity models. *J. Int. Econ.* 97 (1), 86–99. <https://doi.org/10.1016/j.jinteco.2015.05.004>.

Ehrich, M., Mangelsdorf, A., 2018. The role of private standards for manufactured food exports from developing countries. *World Dev.* 101, 16–27. <https://doi.org/10.1016/j.worlddev.2017.08.004>.

Fernandes, A.M., Ferro, E., Wilson, J.S., 2019. Product standards and firms' export decisions. *World Bank Econ. Rev.* 33 (2), 353–374. <https://doi.org/10.1093/wber/lhw071>.

Ferro, E., Otsuki, T., Wilson, J.S., 2015. The effect of product standards on agricultural exports. *Food Policy* 50, 68–79. <https://doi.org/10.1016/j.foodpol.2014.10.016>.

Fiankor, D.-D.-D., Martínez-Zarzoso, I., Brümmer, B., 2019. Exports and governance: the role of private voluntary agrifood standards. *Agric. Econ.* 50 (3), 341–352. <https://doi.org/10.1111/agec.12488>.

Fiankor, D.-D.-D., Flachsbarth, I., Masood, A., Brümmer, B., 2020. Does GlobalGAP certification promote agrifood exports? *Eur. Rev. Agric. Econ.* 47 (1), 247–272. <https://doi.org/10.1093/erae/jbz023>.

Goedhuys, M., Sleguwaegen, L., 2016. International standards certification, institutional voids and exports from developing country firms. *Int. Bus. Rev.* 25 (6), 1344–1355. <https://doi.org/10.1016/j.ibusrev.2016.04.006>.

Grabs, J., Cammelli, F., Levy, S.A., Garrett, R.D., 2021. Designing effective and equitable zero-deforestation supply chain policies. *Glob. Environ. Chang.* 70, 102357. <https://doi.org/10.1016/j.gloenvcha.2021.102357>.

Grassnick, N., Brümmer, B., 2021. Do voluntary sustainability standards increase countries' access to cocoa export markets? *GlobalFood Discussion Paper No. 150*. University of Goettingen. <https://doi.org/10.22004/ag.econ.310535>.

- Helpman, E., Melitz, M., Rubinstein, Y., 2008. Estimating trade flows: trading partners and trading volumes. *Q. J. Econ.* 123 (2), 441–487. <https://doi.org/10.1162/qjec.2008.123.2.441>.
- Henson, S., Humphrey, J., 2010. Understanding the complexities of private standards in global agri-food chains as they impact developing countries. *J. Dev. Stud.* 46 (9), 1628–1646. <https://doi.org/10.1080/00220381003706494>.
- Henson, S., Masakure, O., Cranfield, J., 2011. Do fresh produce exporters in sub-Saharan Africa benefit from GlobalGAP certification? *World Dev.* 39 (3), 375–386. <https://doi.org/10.1016/j.worlddev.2010.06.012>.
- Herzfeld, T., Drescher, L.S., Grebitus, C., 2011. Cross-national adoption of private food quality standards. *Food Policy* 36 (3), 401–411. <https://doi.org/10.1016/j.foodpol.2011.03.006>.
- Iacobucci, D., Schneider, M.J., Popovich, D.L., Bakamitsos, G.A., 2016. Mean centering helps alleviate “micro” but not “macro” multicollinearity. *Behav. Res. Methods* 48 (4), 1308–1317. <https://doi.org/10.3758/s13428-015-0624-x>.
- Latouche, K., Chevassus-Lozza, E., 2015. Retailer supply chain and market access: evidence from French agri-food firms certified with private standards. *World Econ.* 38 (8), 1312–1334. <https://doi.org/10.1111/twec.12191>.
- Lin, J., Flachsbarth, I., Cramon-Taubadel, S., 2020. The role of institutional quality on the performance in the export of coconut products. *Agric. Econ.* 51 (2), 237–258. <https://doi.org/10.1111/agec.12552>.
- Mangelsdorf, A., Portugal-Perez, A., Wilson, J.S., 2012. Food standards and exports: evidence for China. *World Trade Rev.* 11 (3), 507–526. <https://doi.org/10.1017/S1474745612000195>.
- Marx, A., Depoorter, C., 2021. Voluntary sustainability standards. In: Delimatsis, P., Reins, L. (Eds.), *Elgar Encyclopedia of Environmental Law Series - Volume XI: Trade and Environmental Law*. Edward Elgar Publishing, Cheltenham, pp. 704–714.
- Marx, A., Sharma, A., Bécault, E., 2015. Voluntary Sustainability Standards: An Overview. Available from <https://ees.kuleuven.be/eng/klimos/papers/marx_2015_voluntary_sustainability_standards.pdf>.
- Masood, A., Brümmer, B., 2014. Impact of GlobalGAP Certification on EU Banana Imports: A Gravity Modeling Approach. *GlobalFood Discussion Paper No. 49*. University of Goettingen. <https://doi.org/10.22004/ag.econ.187539>.
- Meemken, E.-M., Barrett, C.B., Michelson, H.C., Qaim, M., Reardon, T., Sellare, J., 2021. Sustainability standards in global agrifood supply chains. *Nature Food* 2, 758–765. <https://doi.org/10.1038/s43016-021-00360-3>.
- Meemken, E.-M., Qaim, M., 2018. Organic agriculture, food security, and the environment. *Ann. Rev. Resour. Econ.* 10 (1), 39–63. <https://doi.org/10.1146/annurev-resource-100517-023252>.
- Meier, C., Sampson, G., Larrea, C., Schlatter, B., Voora, V., Dang, D., ... Willer, H., 2020. *The State of Sustainable Markets 2020: Statistics and Emerging Trends*. Geneva.
- Oya, C., Schaefer, F., Skolidou, D., 2018. The effectiveness of agricultural certification in developing countries: a systematic review. *World Dev.* 112, 282–312. <https://doi.org/10.1016/J.WORLDDEV.2018.08.001>.
- Santos Silva, J.M.C., Tenreiro, S., 2006. The log of gravity. *Rev. Econ. Stat.* 88 (4), 641–658. <https://doi.org/10.1162/rest.88.4.641>.
- Santos Silva, J.M.C., Tenreiro, S., 2011. Further simulation evidence on the performance of the Poisson pseudo-maximum likelihood estimator. *Econ. Lett.* 112 (2), 220–222. <https://doi.org/10.1016/j.econlet.2011.05.008>.
- Schleifer, P., Sun, Y., 2018. Emerging markets and private governance: the political economy of sustainable palm oil in China and India. *Rev. Int. Polit. Econ.* 25 (2) <https://doi.org/10.1080/09692290.2017.1418759>.
- Schuster, M., Maertens, M., 2015. The impact of private food standards on developing countries' export performance: an analysis of asparagus firms in Peru. *World Dev.* 66, 208–221. <https://doi.org/10.1016/j.worlddev.2014.08.019>.
- Smith, G., 2009. *Interaction of Public and Private Standards in the Food Chain*. OECD Publishing, Paris.
- Springmann, M., Clark, M., Mason-D'Croz, D., Wiebe, K., Bodirsky, B.L., Lassaletta, L., Willett, W., 2018. Options for keeping the food system within environmental limits. *Nature* 562 (7728), 519–525. <https://doi.org/10.1038/s41586-018-0594-0>.
- Taylor, C., Balmford, A., Buchanan, G.M., Butchart, S.H.M., Ducharme, H., Green, R.E., Phalan, B., 2017. Global coverage of agricultural sustainability standards, and their role in conserving biodiversity. *Conserv. Lett.* 10 (5) <https://doi.org/10.1111/conl.12314>.
- Taylor, C., Balmford, A., Buchanan, G.M., Butchart, S.H.M., Corlet Walker, C., Ducharme, H., Phalan, B., 2018. Where are commodity crops certified, and what does it mean for conservation and poverty alleviation? *Biol. Conserv.* 217, 36–46. <https://doi.org/10.1016/j.biocon.2017.09.024>.
- UNCTAD, 2021. *Better trade for Sustainable Development: The Role of Voluntary Sustainability Standards*. Geneva.
- UNFSS, 2020. *Scaling up Voluntary Sustainability Standards through Sustainable Public Procurement and Trade Policy: 4th Flagship Report of the UNFSS*. Geneva.
- UNFSS, 2022. *Voluntary Sustainability Standards - Sustainability Agenda and Developing Countries: Opportunities and Challenges : 5th Flagship Report of the UNFSS*. Available from: <https://unfss.org/wp-content/uploads/2022/10/UNFSS-5th-Report_14Oct2022_rev.pdf>.
- Vanderhaegen, K., Akoyi, K.T., Dekoninck, W., Jocqué, R., Muys, B., Verbist, B., Maertens, M., 2018. Do private coffee standards ‘walk the talk’ in improving socio-economic and environmental sustainability? *Glob. Environ. Chang.* 51, 1–9. <https://doi.org/10.1016/j.gloenvcha.2018.04.014>.
- Voora, V., Larrea, C., Bermúdez, S., Baliño, S., 2020. *Global Market Report: Palm oil. Sustainable Commodities Marketplace Series 2019*. Winnipeg.
- Wooldridge, J.M., 2002. *Econometric Analysis of Cross Section and Panel Data*. MIT, Cambridge.
- Wrigley, N., Lowe, M., 2010. *The Globalization of Trade in Retail Services - Report commissioned by OECD trade policy linkages and services division for the OECD experts meeting on distribution services*. Paris.
- Yadav, D., Dutta, G., Kumar, S., 2021. Food safety standards adoption and its impact on firms' export: a systematic literature review. *J. Clean. Prod.* 329 <https://doi.org/10.1016/j.jclepro.2021.129708>.