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Abstract

The increasing interest of policymakers and academics on non-tariff measures (NTMs) has stimulated a growing literature on their effects on agri-food trade of African countries. The empirical evidence, however, are ambiguous: some studies suggest that NTMs are trade barriers, others suggest they have a catalyst role for trade. Understanding the drivers of these contrasting effects and the prevailing one would allow to draw important conclusions.
We review, through a meta-analytical approach, a set of empirical studies that quantify the effects of NTMs on African agri-food trade. We find a prevalence of the trade-impeding effects. Our results also help explaining differences in NTMs' effects due to methodological and structural heterogeneity. Moreover the effects of NTMs vary across types of NTMs and analysed commodities.
We conclude by comparing our findings with existing literature and emphasize which research areas deserve further investigation such as intra-Africa trade or trade effects of technical NTMs.

Keywords: Non-tariff measures; African trade; Trade barrier; Trade catalyst; Literature review.

JEL Codes: F13 ; N57 ; Q17; Q18

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Introduction

The integration of African countries in the world trading system strongly depends on opportunities of market access at favourable conditions (i.e., lower trade costs) (Henson and Loader 2001). Border-related trade costs are high for agri-food commodities, and appear to be greater for Africa (Porteous 2017). The progressive liberalisation of agri-food trade, through the negotiations of the World Trade Organisation (WTO), has increased opportunities of market access and lowered traditional barriers to trade (i.e., tariffs) (Santeramo, Guerrieri, and Lamonaca, 2019). Contemporaneously, concerns have been raised on the proliferation of non-tariff measures (NTMs) and on their impacts on trade (Fernandes, Ferro, and J.S. Wilson 2017; Santeramo and Lamonaca, 2018). Although the main scope of NTMs is to correct market inefficiencies, they may have a two-fold role: trade catalysts or trade barriers (Nimenya, Ndimiraand and de Frahan 2012; Santeramo 2017). Facing NTMs may be particularly challenging for African countries, whose comparative advantages in the agri-food products may be undermined, due to the lack of adequate financial and technical capacity to comply with changing, and more stringent, requirements (Jaffee and Henson 2004; Martin 2018).

Several studies investigate the impacts of NTMs on African agri-food trade (e.g., Henson, Brouder, and Mitullah 2000; Henson and Loader 2001; Otsuki, J.S. Wilson, and Sewadeh 2001a, b; J.S. Wilson and Otsuki 2004; Anders and Caswell 2009; Jongwanich 2009; Xiong and Beghin 2011; Nimenya, Ndimira and de Frahan 2012; Shepherd and N.L. Wilson 2013). The vast majority of these studies are product-, country-, or NTM-specific, which imply heterogeneous estimates and make difficult to draw general conclusions. We aim at answering two enquiries: what is the prevailing effect of NTMs on African agri-food trade in literature? Which factors affect the heterogeneity in the estimated effects of NTMs?

The importance of these issues is attested by an increasing number of related review articles, published in top journals, on the effects NTMs on global trade. Few reviews are quantitative (e.g., Li and Beghin, 2012; Santeramo and Lamonaca, 2019); the vast majority are qualitative (e.g., Beghin, Maertens, and Swinnen 2015), focused on specific categories of NTMs (e.g., Cipollina and Salvatici 2008) or on particular geographic areas (e.g., Salvatici, Matthews, and Scoppola 2017). Differently a review on the influence of NTMs on trade performances of African agri-food sector is currently lacking.

We review, through a meta-analytical approach, a set of empirical studies that quantify the effects of NTMs on African agri-food trade, in order to disentangle the prevailing effect and potential determinants of heterogeneity across studies.

The paper is organised as follows: section 2 provides details on exports and NTMs in the African agri-food sector. Sections 3 and 4 describes theoretical and empirical issues: in particular, the former deepens on the rationale of NTMs as trade barriers or catalysts; the latter provides information on sources of data and econometric procedures. Qualitative and quantitative results are presented and discussed in section 5, whereas the last section concludes providing empirical and policy implications.

Trade and non-tariff measures in African agri-food sector

The agri-food trade from developing countries has progressively expanded since the mid-1990s (Martin 2018): emblematic is the case of Africa. African exports grew exponentially during the period 1995-2013, but suffered a setback since 2014 (UN Comtrade 2017). Along with the increase in exports, the number of non-tariff measures (NTMs), and in particular of Sanitary and Phytosanitary Standards (SPSs), against Africa has increased as well (UNCTAD 2017) (figure 1).

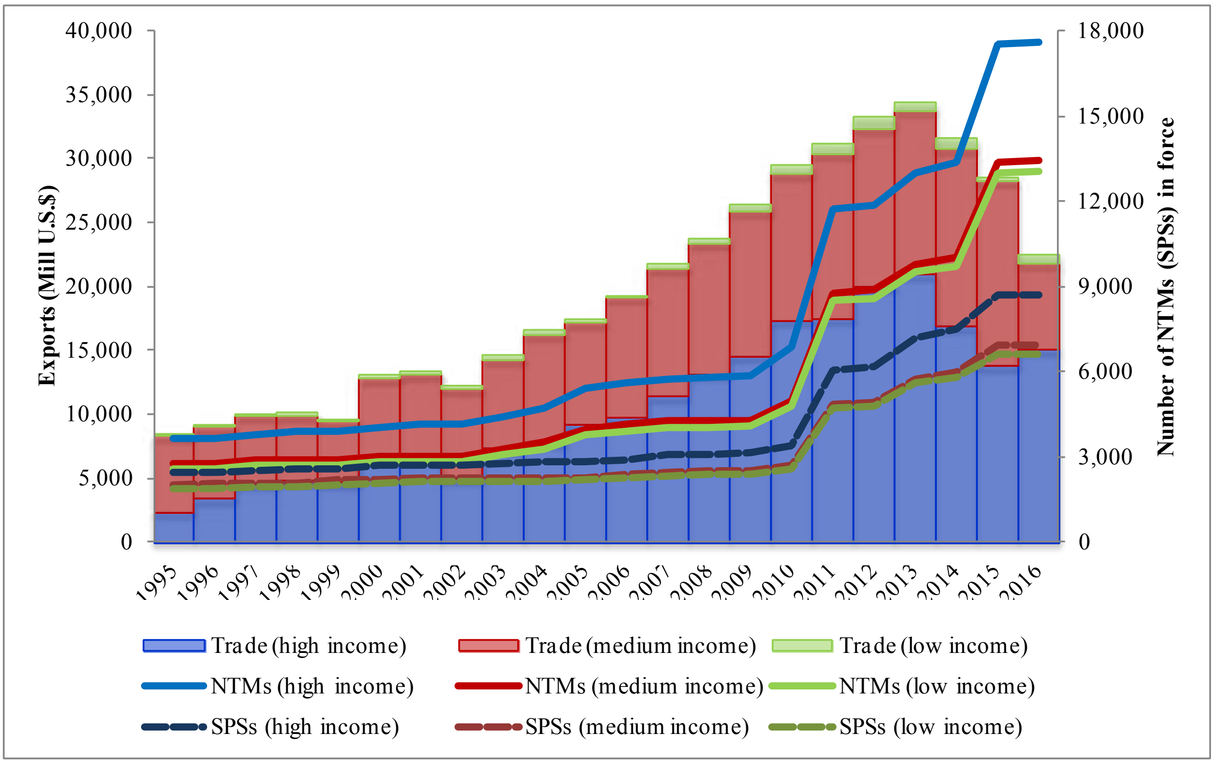


Figure 1. Exports and non-tariff measures (NTMs), with a focus on Sanitary and Phytosanitary Standards (SPSs) in the African agri-food sector, 1995-2016.

Source: elaboration on UN Comtrade (2017) and UNCTAD (2017).

Notes: The number of NTMs in force, classified according to countries' income levels, is normalised by the number of countries for each group. The list of African countries analysed and classified by income categories is in Appendix.

The rapid growth of exports may be due to the economic globalisation in commodity chains, and to structural changes in the composition of agri-food trade (Henson, Brouder, and Mitullah 2000; Maertens and Swinnen 2009): African countries have became export-oriented economies, and moved the composition of exports from traditional (e.g., coffee, tea, sugar, cocoa) to non-traditional, high value commodities (e.g., fruit and vegetables, poultry, fish) (Okello and Roy 2007; Rios et al. 2009). In twenty years exports have doubled for seafood products and vegetables, and decoupled for meat, to the detriment of traditional exports (-43% for coffee and tea, -33% for cocoa) (UN Comtrade 2017). It is worth noting that NTMs are more frequent on non-traditional than on traditional commodities: total NTMs account for

26% for fish, 15% for fruits and vegetables, and 11% for meat, whereas only 3% of total NTMs affect traditional commodities (UNCTAD 2017).

The recent reduction of exports from Africa raises the question of potential marginalisation of African countries in international trade. However, according to Bouet, Mishra, and Roy (2008), African exports performances depend on income levels: the lower the income, the lower the traded values and the higher the average level of NTMs and SPSs (figure 1). The increased NTMs may be related to a higher demand for safe food from high income countries (Okello and Roy 2007): measures intended to protect human health (i.e., SPSs) account for 52% of total NTMs. The remaining 48% are export-related measures (17%), price control measures (12%), Technical Barriers to Trade (12%), and pre-shipment inspections (7%) (UNCTAD 2017).

The growing and more stringent NTMs may challenge exports of African countries (Broberg, 2009). A limited number of developed countries and emerging economies account for 96% of total NTMs set against Africa: the United States (22%), Indonesia (21%), Canada (12%), and Russian Federation (11%) implement more than the half of total NTMs, followed with lower contribution by Japan (8%), New Zealand (6%), Liberia (5%), Guinea (4%), Gambia (4%), and Philippines (2%) (UNCTAD 2017).

The rationale of non-tariff measure

The United Nations Conference on Trade and Development (UNCTAD 2012, 1) defines non-tariff measures (NTMs) as *"policy measures other than ordinary customs tariffs that can potentially have an economic effect on international trade in goods, changing quantities traded, or prices or both"*. Such a definition highlights two features of NTMs. First, NTMs differ from tariffs (which are protectionist if discriminate against foreign or domestic goods) and cannot be directly compared with them (Swinnen 2016). Second, NTMs may have a corrective role in the marketplace, by reducing asymmetric information (Technical Barriers to Trade, TBTs), mitigating risks in consumption (Sanitary and Phytosanitary Standards, SPSs), influencing competition and decisions to import or export (non-technical NTMs[1]). However, the UNCTAD's definition does not specify if NTMs are catalyst or barriers to trade. The vagueness of the definition is not accidental: the term "non-tariff measures" has recently overcame the term "non-tariff barriers" in order to emphasise that non-tariff policies may either friction or facilitate trade (Grant and Arita 2017).

The trade effects of NTMs may differ according to the economic relevance of country affected by the measure. Differently from large open economies (e.g. the EU, the US), small open economies (e.g. African countries) are unable to alter world prices (price-taker) and, thus, trends in international trade. The effects of NTMs on trade performances of small open economies depend on the relative economic relevance of countries implementing NTMs.

In order to analyse the catalyst and barrier effects of NTMs, we assume that a large open economy (i.e., the importing country) sets a non-discriminatory NTM, equivalent in its effect to the domestic regulation, against exports of a product from a small open economy (i.e., the exporting country) to maximise domestic welfare (consumers' surplus and producers' profits).

1 According to the international classification (UNCTAD 2012), non-technical measures include: contingent trade-protective measures (D); non-automatic licensing, quotas, prohibitions and quantity-control measures other than for SPS or TBT reasons (E); price-control measures, including additional taxes and charges (F); finance measures (G); measures affecting competition (H); trade-related investment measures (I); distribution restrictions (J); restrictions on post-sales services (K); subsidies (L); government procurement restrictions (M); intellectual property (N); rules of origin (O); export-related measures (P).

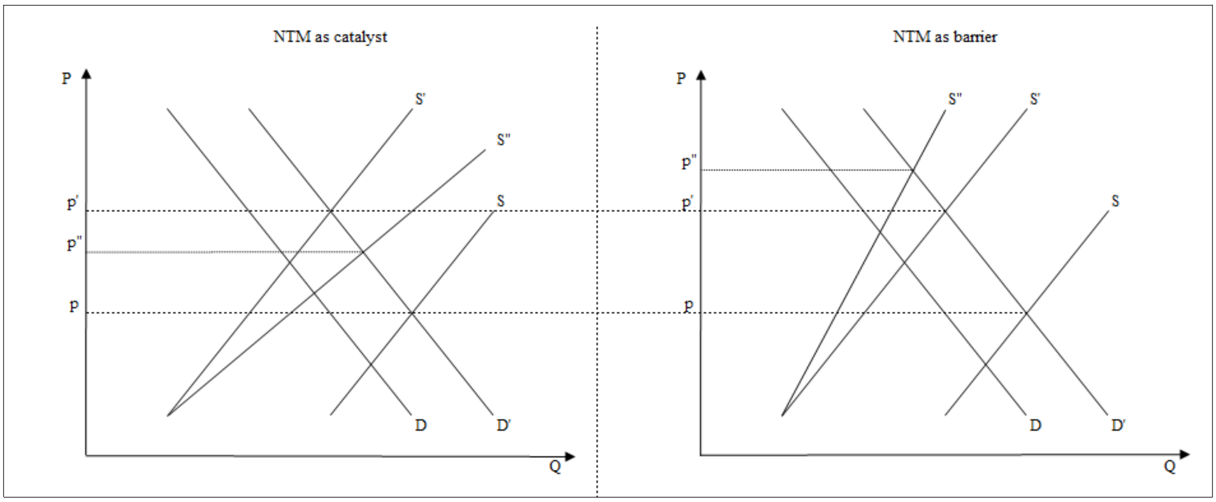


Figure 2. "Catalyst" vs. "barrier" role of non-tariff measures (NTMs): a theoretical framework.

Notes: D and D' are domestic market demand pre- and post-NTM; S, S', and S" are domestic market supply pre-NTM, post-NTM without foreign competition, and post-NTM with foreign competition; p, p', and p" are equilibrium price in domestic market pre-NTM, post-NTM without foreign competition, and post-NTM with foreign competition.

In domestic market, a non-discriminatory NTM shifts rightward the demand (from D to D') by reducing market failures (asymmetric information and/or externalities), and leftward the supply (from S to S') by increasing the costs of compliance (figure 2). The demand-enhancing effect (due to an increase in consumers' utility) is the consequence of greater consumers' trust in products under regulation (Xiong and Beghin 2014). The supply-contraction effect (due to a reduction in producers' marginal costs) depends on higher costs faced to implement a more stringent regulation (Crivelli and Gröschl 2016).

The new equilibrium price is higher than the pre-NTM price (from p to p') (figure 2) and increases consumers' expenditures and producers' revenue. The net effect on domestic welfare depends on the magnitude of gain in utility (for consumers) and revenue (for producers), compared to the size of (negative) effect on consumption expenditures and implementation costs: the higher the consumers' utility, the higher the willingness to pay a higher price; the lower the implementation costs, the higher the gain in revenue (Swinnen 2016).

The welfare effects of a non-discriminatory NTM in domestic market are also influenced by trading partners: NTMs may be protectionist or pro-trade (Marette and Beghin 2010; Sheldon 2012). The domestic market is more competitive (i.e., the supply is more elastic) if the NTM doesn't lock out African exporters, and vice-versa. Given the increased consumers demand for products under regulation in the destination market, changes in the elasticity of supply (from S' to S") moves the equilibrium price (from p' to p"): if the difference between domestic price pre- and post-NTM with foreign competition (p – p") is lower (greater) than the difference between domestic price pre- and post-NTM without competition (p – p'), domestic producers face greater (lower) implementation costs and obtain lower (higher) profits than foreign producers (figure 2).

(*p*− *p* right) < left (p-p' right) ⇒NTM as catalyst ## and ## left (p - p|>|*p*− *p* (1)

The NTM has a catalyst (barrier) effect on trade if determines an increase (reduction) in exports (Swinnen 2017).

The trade effects of NTMs estimated in literature, if different from zero, captures how much a NTM increases producer costs and, as a consequence, if discriminates between domestic and foreign producers. The estimated trade effect of a NTM is positive if the NTM is non-discriminatory; vice-versa it is negative if the NTM discriminates against imports.

Methodological approach

Specification of the gravity equation

The vast majority of empirical literature on the trade effects of non-tariff measures (NTMs) is based on gravity equations (Li and Beghin 2012) which explain trade flows from origin *i* to destination *j* (X_{ij}) as direct function of economic masses of *i* and *j* (i.e., GDP_i and GDP_j), mitigated by the economic distance between them (i.e., proxies of transport costs, Z_{ij}^k). A common gravity specification is as follows:

$$X_{ij}=\alpha+\sum_i \sum_j (\beta_i+\beta_j)+\sum_k \gamma^k Z_{ij}^k+\varepsilon_{ij} \quad (2)$$

where α is the constant; βi and β_j are fixed effects that proxy the multilateral resistance terms for *i* and *j* (including countries' GDPs); γ^k are *k* parameters that measure the impact of *k* bilateral trade costs (e.g. distance, tariffs, NTMs); ε_{ij} is an i.i.d. error term.

In the above specification the parameter δ^{NTM} measures the effect of NTMs on trade: the sign would reveal the trade-enhancing or trade-impeding effects of NTMs (Beghin and Bureau 2001).

Sources of heterogeneity across studies

Different studies are likely to provide different estimates of the parameter δ^{NTM}, due to methodological and structural heterogeneity across studies (Disdier and Head 2008). Methodological heterogeneity relates to differences in statistical and econometric techniques. Major differences concern the proxy used to measure NTMs: some methodologies include inventory measures (e.g., dummy or count variables, frequency index, coverage ratio, prevalence score), or *ad valorem equivalents* (AVEs) (Gourdon 2014). Relevant differences may also be due to the inclusion (or not) of fixed effects and to the treatment (or not) of zero trade flows. Baldwin and Taglioni (2006) suggest to use fixed effects to capture the effect of multilateral resistance (Anderson and van Wincoop 2001). The problem of zeros is frequent in trade data, probably due to contingent situation of absence of trade: different estimation procedures (e.g., Tobit, Heckman, Helpman-Melitz-Rubinstein, Poisson Pseudo-Maximum Likelihood) allow to incorporate zeros in a structural gravity model (Head and Mayer 2014). Other differences may be related to the functional forms of the model and to different ways to measure trade flows. The log-log and the log-level models are the most frequent: the δ^{NTM} are interpreted as elasticity and semi-elasticity, respectively; level-level and level-log models are also frequently used. Finally, while some studies sum imports and exports, others focus on uni-directional trade, some use a dependent variable in value terms, other prefer volumes of trade.

Structural heterogeneity also depends on different sub-populations of the data, in terms of types of NTMs, products, involved countries. By pursuing specific political objectives, different NTMs (e.g., Sanitary and Phytosanitary Standards, SPSs, Technical Barriers to Trade, TBTs, Maximum Residue Levels, MRLs) may have different effects on trade (Schlueter, Wieck, and Heckelei 2009). In addition, NTMs are product-specific by their nature: their effect may vary according to the level of aggregation of data (i.e., HS-2 digit, HS-4 digit, HS-6 digit).

Lastly, divergences may also emerge according to the geo-economic affinity of countries implementing and affected by NTMs: δ^{NTM} estimated for trade between countries with different level of economic development (developed-developing countries) or similar level of economic development (developed-developed or developing-developing countries) are likely to differ.

Sample selection and data collection

Following the guidelines provided by Stanley et al. (2013), we carried out an extensive search in bibliographic databases (i.e., Scopus, Web of Science, JSTOR, RePEc, IATRC, AgEcon Search, Google Scholar) during the period July-September 2017. Studies of interest were identified through the keywords "non-tariff measure/non-tariff barrier", "technical barrier to trade", "sanitary and phytosanitary standard", "maximum residue level", "specific trade concern" combined with the terms "agri-food trade" and "Africa/African". The papers that appear more than once in the same bibliographic database with different keywords are counted once (e.g., Otsuki, J.S. Wilson, and Sewadeh 2001a, b; Anders and Caswell 2009; Drogué and De Maria 2012). On the basis of information available in titles, abstracts, and full texts, we included empirical gravity-based studies that quantify the effects of non-tariff measures (NTMs) on African agri-food trade. We excluded theoretical papers and studies that provide not comparable results. A flow chart describes in detail the literature searching criteria (figure 3).

The final sample consists of 22 papers (16 published in peer-reviewed journals, 6 from grey literature[2]), 271 observations (point estimates of trade effects of NTMs), and 256 estimated t-statistics[3].

2 We refer to working papers and conference proceedings.

3 We have 15 missing values for t-statistics due to the lack, in some papers, of standards errors and t-values.

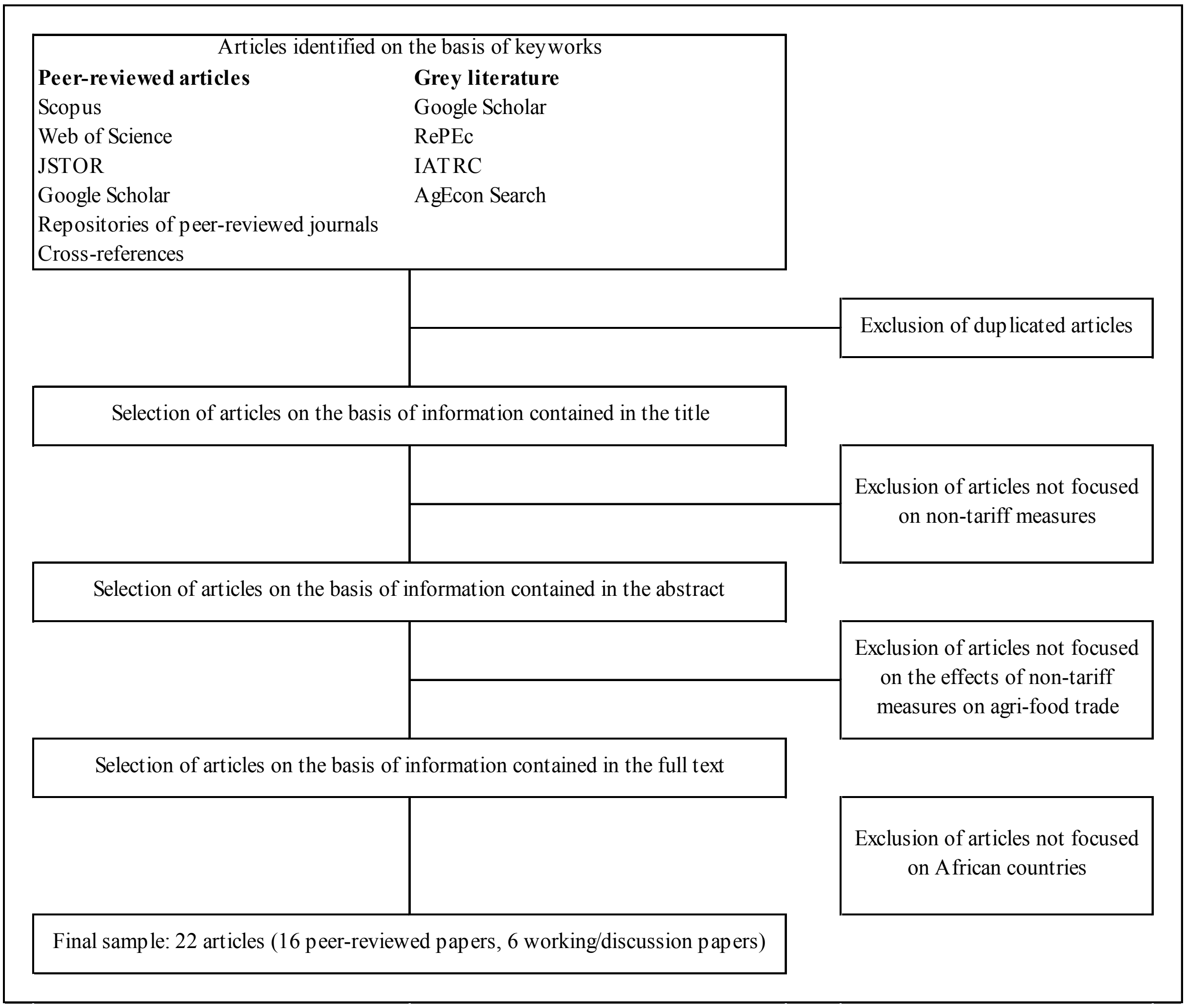


Figure 3. Literature searching criteria.

From the selected papers we compute dummy variables on methodological and structural characteristics of the studies. In line with Stanley, Doucouliagos, and Jarrell (2008), we classified variables in (a) covariates correlated with the estimates but not with the publication selection and (b) covariates correlated with the publication selection but not with the estimates. The publication selection may bias estimates and undermine the validity of inferences and policy implications (Stanley and Doucouliagos 2012). Publication bias may occur if a particular direction of results (i.e. negative or positive estimates) (type I bias) or statistically significant results (type II bias) are treated more favourably, thus are more likely to be reported in published studies (Stanley, 2005). The precision of the estimates (i.e., estimated standard errors) allows to correct for publication selection (Stanley, Doucouliagos, and Jarrell 2008). Table 1 lists and describes the covariates.

Table 1. Description of covariates and basic statistics.

Covariates	**Description**	**Type**	**Set**[*]	**Mean**
Standard error	Estimated standard error	Continuous	a	0.930
AVE	*Ad valorem equivalent* used to proxy NTMs	Dummy	a	0.048
Log-Log form	Empirical model expressed in log-log form	Dummy	a	0.690
Y-exports	Exports are the dependent variable	Dummy	a	0.646
HS-2 digit	Product aggregated at 2 digits of Harmonised System	Dummy	a	0.240
HS-4 digit	Product aggregated at 4 digits of Harmonised System	Dummy	a	0.100
Fixed effects	Inclusion of fixed effects for multilateral resistance	Dummy	b	0.852
Zero trade	Treatment of zero trade flows	Dummy	b	0.424
MRL	NTM is a Maximum Residue Level	Dummy	b	0.373
SPS	NTM is a Sanitary and Phytosanitary Standard	Dummy	b	0.373
N-S	Origin is developed (North), destination is developing (South)	Dummy	b	0.871

[*] Covariates are classified in correlated with the estimates but not with the publication selection (a) and correlated with the publication selection but not with the estimates (b).

We provide a preliminary analysis of collected through descriptive statistics, boxplots and kernel densities.

The Meta Regression Analysis

The meta-analysis (MA) is a suitable approach to explain heterogeneity: it allows us to (i) combine and summarise different but comparable empirical studies, (ii) emphasize the heterogeneity across studies, and (iii) account for potential publication bias (Stanley and Doucouliagos 2012).

In line with Santeramo and Shabnam (2015), we regress t-statistics of the estimates (δ^{NTM})[4] (i.e., $\hat{t}$) on the precision of δ^{NTM} (i.e., the inverse of the estimated standard error, $\frac{1}{\hat{\sigma}}$), on M

4 We use estimated t-statistics instead of the estimated effects of NTMs to avoid problems of heteroschedasticity (Stanley, 2001).

regressors correlated with δ^{NTM} but not with the publication selection (Φ_m), and on N regressors correlated with the publication selection but not with δ^{NTM} (Ω_n):

$$\hat{t} = \lambda_0 + \lambda_1 \frac{1}{\hat{\sigma}} + \sum_{m=1}^{M} \varphi_m \frac{\Phi_m}{\hat{\sigma}} + \sum_{n=1}^{N} \omega_n \Omega_n + u \quad (3)$$

The constant (λ_0) informs on publication bias, λ_1 measures the significance of δ^{NTM}[5], and u is an i.i.d. error term. In order to account for potential publication bias, we standardise Φ_m by the precision of δ^{NTM}.

We estimate model in equation (3) through a robust regression technique capable of mitigating potential problems related to outliers and influential data points (Belsley et al., 1980). Influential data points may be due to multiple (correlated) estimates derived by the same study.

Results and discussion

A qualitative assessment of empirical evidence

An extensive literature has investigated the trade effects of non-tariff measures (NTMs), providing contrasting evidence: few studies support the "standards as catalysts" view (e.g., de Frahan and Vancauteren 2006; Cardamone 2011), and the vast majority favours the "standards as barriers" hypothesis (e.g., Chen, Yang, and Findlay 2008; Hoekman and Nicita 2011; Peterson, et al. 2013; Dal Bianco, et al. 2016). The same is true for empirical evidence on NTMs and African trade, but the trade-impeding nature of NTMs prevails (e.g., Otsuki, J.S. Wilson, and Sewadeh 2001a, b; Anders and Caswell 2009; Drogué and De Maria 2012;

5 In line with previous studies that adopt the meta-analytical approach (e.g., Santeramo and Lamonaca, 2018), the constant term collects potential information on the publication selection that are not directly included in the model, whereas the coefficient λ_1 informs on the significance of the estimated effects of NTMs in that it refers to the inverse of the standard error associated with the estimated effects of NTMs.

F.O. Kareem, Brümmer, and Martinez-Zarzoso 2015, 2017), while few studies provide mixed evidence (J.S. Wilson and Otsuki 2004; Xiong and Beghin 2011; O.I. Kareem 2016a, b, c). As also suggested in Kee, Nicita, and Olarreaga (2009), not all NTMs are binding: on average binding NTMs are 16% for African countries.

Empirical studies are also heterogeneous in their designs and tend to be country-, product-, and NTM-specific (table 2)[6].

6 Appendix provides descriptive statistics for each of the selected papers (table A.1).

Table 2. Selected papers.

Authors	Publication		Country[b]		Product		NTM		Main effect of NTMs on trade
	Year	*Outlet*[a]	*Reporters*	*Partners*	*Commodity*	*Aggregation*	*Measure*[c]	*Types*	
Anders S., and Caswell J.A.	2009	AJAE	USA	ICs, DCs (2 ACs)	Fish	HS-2	HACCP	Mandatory	Negative
Disdier A.C., Fekadu B., Murillo C., and Wong S.A.	2008	ICTSD WP	DCs	DCs (1 AC)	Tropical	HS-6	SPS	Mandatory	Negative
Drogué S., and De Maria F.	2012	FP	ICs, DCs (1 AC)	ICs, DCs (1 AC)	Apple, pear	HS-6	MRL	Mandatory	Negative
Ferro E., Wilson J.S., and Otsuki T.	2013	WB WP	ICs, DCs	ICs, DCs	Agri-food	HS-6	MRL	Mandatory	Negative
Ferro E., Otsuki T., and Wilson J.S.	2015	FP	ICs, DCs	ICs, DCs	Agri-food	HS-6	MRL	Mandatory	Negative
Gebrehiwet Y., Ngqangweni S., and Kirsten J.F.	2007	Agrekon	EUN, USA	15 ACs	Agri-food	HS-2	MRL	Mandatory	Negative
Jongwanich J.	2009	FP	DCs	ZAF	Processed	HS-2	SPS	Mandatory	Negative
Kareem O.I.	2014a	CP	EUN	52 ACs	Fish, vegetables	HS-4	SPS	Mandatory	Mixed effects
Kareem O.I.	2014b	EUI RSCAS WP	EUN	52 ACs	Fish, vegetables, coffee, cocoa	HS-6	SPS	Mandatory	Mixed effects
Kareem O.I.	2014c	WP	EUN	52 ACs	Fish, vegetables, coffee, cocoa	HS-6	SPS	Mandatory	Mixed effects
Kareem O.I.	2016a	ITJ	EUN	52 ACs	Fish, vegetables	HS-6	SPS	Mandatory	Mixed effects
Kareem O.I.	2016b	JAD	EUN	52 ACs	Fish, coffee	HS-6	SPS	Mandatory	Mixed effects
Kareem O.I.	2016c	JCM	EUN	52 ACs	Fish	HS-6	SPS	Mandatory	Mixed effects
Kareem F.O., Brümmer B., and Martinez-Zarzoso I.	2015	Global Food WP	EUN	27 ACs	Tomato	HS-6	MRL; EP	Mandatory	Negative
Kareem F.O., Brümmer B., and Martinez-Zarzoso I.	2017	WE	EUN	27 ACs	Tomato, orange, lime, lemon	HS-6	MRL; EP	Mandatory	Negative
Otsuki T., Wilson J.S., and Sewadeh M.	2001a	ERAE	CHE, EUN	9 ACs	Groundnut	HS-6	MRL	Mandatory	Negative
Otsuki T., Wilson J.S., and Sewadeh M.	2001b	FP	EUN	9 ACs	Cereal, fruit, vegetables	HS-2	MRL	Mandatory	Negative

Scheepers S., Jooste A., and Alemu Z.G.	2007	Agrekon	EUN	ZAF	Avocado	HS-6	MRL	Mandatory	Negative
Shepherd B., and Wilson N.L.	2013	FP	EUN	DCs (1 AC)	Agri-food	HS-4	Standards	Voluntary	Mixed effects
Wilson J.S., Otsuki T., and Majumdar B.	2003	JITED	AUS, CAN, EUN, JPN NZL, USA	DCs (1 AC)	Beef	HS-6	MRL	Mandatory	Negative
Wilson J.S., and Otsuki T.	2004	FP	CAN, CHE, EUN, JPN, NZL, USA	DCs (4 ACs)	Banana	HS-6	MRL; TRQ	Mandatory	Mixed effects
Xiong B., and Beghin J.	2011	ERAE	CHE, EUN	9 ACs	Groundnut	HS-6	MRL	Mandatory	Mixed effects

[a] Acronyms are as follows: American Journal of Agricultural Economics (AJAE), International Centre for Trade and Sustainable Development (ICTSD), Working Paper (WP), Food Policy (FP), World Bank (WB), International Trade Journal (ITJ), Conference Proceeding (CP), European University Institute Robert Schuman Centre for Advanced Studies (EUI RSCAS), Journal of African Development (JAD), Journal of Commodity Markets (JCM), The World Economy (WE), European Review of Agricultural Economics (ERAE), Journal of International Trade & Economic Development (JITED).

[b] Countries implementing (reporters) and affected by (partners) NTMs are labelled according to the officially assigned ISO 3166-1 alpha-3 codes (UN Statistics Divisions 2018): Argentina (ARG), Australia (AUS), Brazil (BRA), Canada (CAN), Switzerland (CHE), Chile (CHL), China (CHN), the European Union (EUN), Japan (JPN), Republic of Korea (KOR), Mexico (MEX), New Zealand (NZL), Russian Federation (RUS), the United States (USA), South Africa (ZAF). ICs and DCs stand for developed (industrialised) countries and developing countries respectively.

[c] Acronyms are as follows: HACCP stands for Hazard Analysis and Critical Control Points, SPS stands for Sanitary and Phytosanitary Standard, MRL stands for Maximum Residue Level, EP stands for Entry Price, TRQ stands for tariff rate quota.

The vast majority of empirical literature investigates the trade effects of NTMs implemented by developed countries (European Union in particular), exception made for Drogué and De Maria (2012), Ferro, J.S. Wilson, and Otsuki (2013), and Ferro, Otsuki, and J.S. Wilson (2015) who analyse wider samples.

NTMs tend to hinder agri-food trade (e.g., Gebrehiwet, Ngqangweni, and Kirsten 2007; Ferro, J.S. Wilson, and Otsuki 2013; Ferro, Otsuki, and J.S. Wilson 2015), but differences emerge for specific commodities: trade of bananas (Wilson J.S., and Otsuki 2004) and coffee (e.g., O.I. Kareem 2016b) is favoured, whereas NTMs hinder trade of seafood products (e.g., Anders and Caswell 2009; O.I. Kareem 2016c), beef (J.S. Wilson, Otsuki, and Majumdar 2003), avocados (Scheepers, Jooste, and Alemu 2007), apples and pears (Drogué and DeMaria 2012), tomatoes, oranges, and lemons (F.O. Kareem, Brümmer, and Martinez-Zarzoso 2015, 2015). In addition, trade of groundnuts is negatively affected by beyond-the-border policies (Otsuki, J.S. Wilson, and Sewadeh 2001a), but also by domestic supply (Xiong and Beghin 2011).

As for specific types of NTMs, some studies on Maximum Residue Levels (MRLs) provide mixed evidence: Xiong and Beghin (2011) suggest that the trade potential of African groundnut exporters is more constrained by domestic capacity (e.g., farming and storage practice, other barriers before the border) rather than by limited market access due to NTMs. More frequently the literature concludes that MRLs are barrier for trade (e.g., Otsuki, J.S. Wilson, and Sewadeh 2001a, b; J.S. Wilson and Otsuki 2004; Scheepers, Jooste, and Alemu 2007).

Sanitary and Phytosanitary Standards (SPSs) may either hamper or facilitate trade: some studies support the “standards as barrier” view (Disdier, et al. 2008; Jongwanich 2009), while others provide mixed results (e.g., O.I. Kareem 2016a, b). A plausible explanation of the heterogeneity in findings for SPSs may be the effect of specific regulations: Schlueter, Wieck, and Heckelei (2009, 1489) suggest that some types of SPSs have positive impacts and others have a negative influence. The direction of the effect may also depend on product categories under investigation. Jongwanich (2009) finds that SPSs implemented by developed countries impede processed food exports from developing countries; vice-versa, O.I. Kareem (2016a, b) suggest that the impacts of SPSs on African exports are commodity-specific (at the intensive margins, SPSs are trade-enhancing for coffee, but trade-impeding for vegetables, fish, and cocoa).

Other types of NTMs may be either trade-impeding (i.e., HACCP, Entry Price) (Anders and Caswell 2009; F.O. Kareem, Brümmer, and Martinez-Zarzoso 2015) or trade-enhancing (i.e., tariff-quotas) (J.S. Wilson and Otsuki 2004). As for the impact of voluntary standards, Shepherd and N.L. Wilson (2013) find that harmonised standards are trade-promoting, while non-harmonised standards are trade-inhibiting, with great differences within specific product categories.

All in all, empirical literature suggests that MRLs and SPSs friction African agri-food trade, but marked differences exist across product categories.

Graphical and statistical analysis

Descriptive statistics (table 3) show that 56% of estimates (δ^{NTM}) (152) are negative, and the remaining 44% (119) are positive; 46% are statistically significant, of which 25% (69 out of 271) are negative and 21% (57 out of 271) are positive.

The mean and median values of (total) δ^{NTM} are, respectively, 0.533 and -0.020, with the confidence interval ranging from -3.622 to 4.687. The total variability of observations (point estimates) is marked, mainly due to higher variability of positive estimates.

Table 3. Descriptive statistics of the estimates: detail on direction of the effect and statistical significance.

Estimates	Min		Max	Mode (min; max)	Median	Mean	Std. Dev.	C.I.[a]	Obs.[b]
Total	-12.162	54.140	-12.162	-2.847; -0.020	-0.020	0.533	4.155	[-3.622; 4.687]	100%
Positive	4.000	54.140	4.000	0.050; 2.711	0.650	2.240	5.582	[-3.342; 7.822]	44%
Negative	-12.162	-0.0004	-12.162	-2.847; -0.020	-0.380	-0.804	1.555	[-2.359; 0.752]	56%
Significant	-12.162	18.105	-12.162	-0.336	-0.066	0.635	3.360	[-2.725; 3.994]	46%
Significant positive	0.267	18.105	0.267	1.107; 2.711	1.420	2.788	3.384	[-0.596; 6.171]	21%
Significant negative	-12.162	-0.015	-12.162	-0.336	-0.670	-1.144	2.055	[-3.199; 0.911]	25%
Not significant	-5.683	54.140	-5.683	-2.847; -0.020	-0.015	0.444	4.749	[-4.304; 5.193]	54%

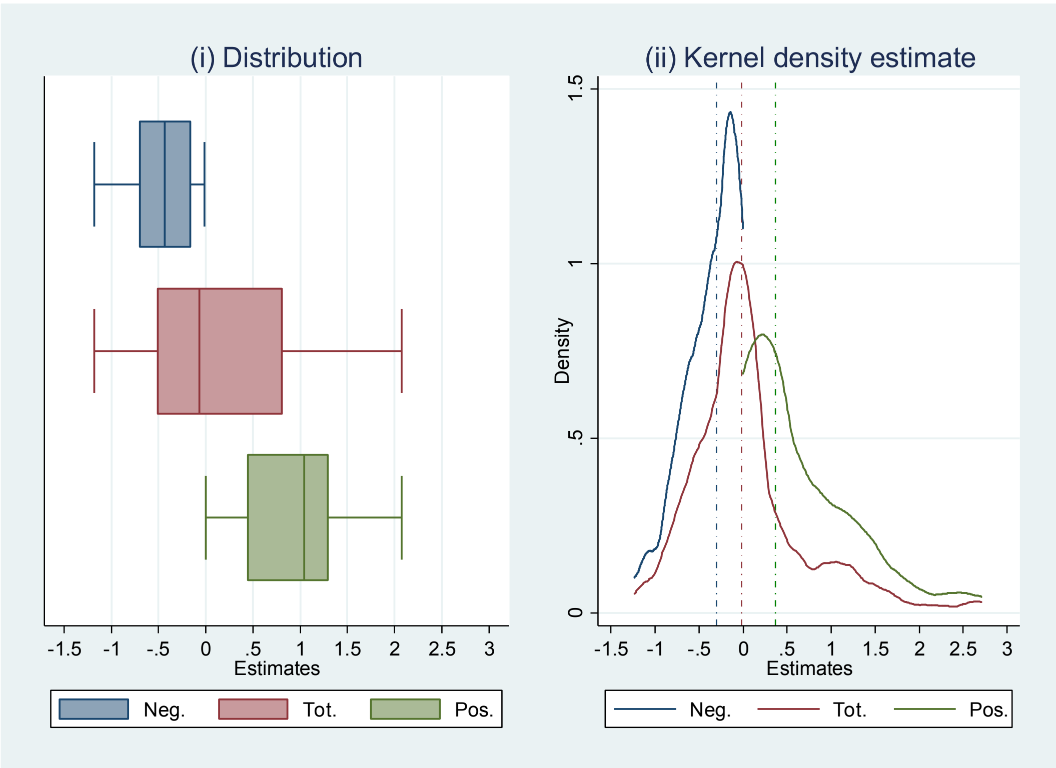
[a] Confidence interval (C.I.) ranges between mean minus standard deviation (minimum) and mean plus standard deviation (maximum).

[b] Percentages computed on the total number of observations (271).

[c] The magnitude of estimates are of the order of 10^{-15}.

Figure 4 presents the distribution (boxplots) and the kernel densities of statistically significant total, positive, and negative δ^{NTM}[7]: the first and the third quartiles (85 out of 271 point estimates) range between median values of (significant) negative ($Me_{Neg.}$ = -0.45) and of (significant) positive ($Me_{Pos.}$ = 0.92) observations (figure 4, panel (i)). The kernel densities (referred either to significant or not significant δ^{NTM}) highlight differences between distributions: negative δ^{NTM} are less dispersed than positive δ^{NTM} (in terms of standard deviations of negative, $\sigma_{Neg.}$ = 1.555, and positive δ^{NTM}, $\sigma_{Pos.}$ = 5.582) (figure 4, panel (ii)).

The global effect of NTMs does not capture the discrepancy between negative and positive estimates: negative estimates are more accurate and closer to zero, while positive estimates are more dispersed.



7 Distributions and kernel density estimates in figure 3 refer to a subsample ranging between the 5th and the 95th percentiles. Extreme outliers (12%) have been removed to make the distribution less erratic.

Figure 4. Estimates arranged by direction.

Notes: In panel (i), the distributions of estimates are on statistically significant observations within the 10th and the 90th percentiles. Horizontal lines within boxes are median values (Me) (i.e., $Me_{Neg.}$ = -0.45, $Me_{Tot.}$ = 0.13, $Me_{Pos.}$ = 0.92). In panel (ii), the estimated densities for estimates are computed removing observations which exceed 10th and 90th percentiles. Dashed lines are median values (Me) computed on total observations (i.e., $Me_{Tot.}$ = -0.02, $Me_{Pos.}$ = 0.37, $Me_{Neg.}$ = -0.30).

The mixed evidence found in literature and the high variability of estimates may be partly explained by methodological and structural differences[8]. A systematic assessment of potential sources of heterogeneity is worth.

Meta regression results

The results of the meta regression analysis[9] (table 4) show that negative estimates (δ^{NTM}) have negative publication bias (λ_0). In addition, we find that the coefficient λ_1 is statistically different from zero for negative δ^{NTM}.

Methodological and structural heterogeneity affects positive and negative estimates: negative δ^{NTM} are higher if the empirical model is in log-log form or includes fixed effects, or if a study adopts *ad valorem equivalent* (AVE) to proxy NTMs. Similarly, Li and Beghin (2012) pointed that the trade effects of NTMs are influenced by the use of multilateral trade resistance terms.

Using exports as dependent variable in gravity equations (*Y-exports*) or lower aggregation of data (*HS-4 digit*) is associated with larger estimates. The treatment of zero trade flows tends to distort the estimates: positive δ^{NTM} are higher, whereas negative δ^{NTM} are lower. In line with Li and Beghin (2012, 507) "*t-values becomes more negative by retaining zero-trade*".

8 As an example, table A.2 and figure A.1 in Appendix show descriptive statistics, and boxplots and kernel density estimates of δ^{NTM} arranged by types of NTMs.

9 Our empirical model involves several dichotomous variables: potential collinearity may arise and confound estimation results. We check the data to control for potential collinearity. We dropped the covariates with the relative higher variance inflation index (VIF): "*Inventory*", "*Log-Level form*", "*Level-Level form*", "*Y-imports*", "*Y-value*", "*Y-volume*", "*HS-6 digit*" and "*Other NTMs*". Collinearity diagnostics without the problematic covariates show no additional problems.

The type of NTMs under investigation does matter: negative δ^{NTM} are lower if studies deepen on Sanitary and Phytosanitary Standards (SPSs) or Maximum Residue Levels (MRLs). In particular, MRLs are related to larger positive δ^{NTM}. The twofold effect of MRLs may be due to the facts that "*the NTM is clearly identified rather than being some aggregate measure of heterogeneous policies*" (Li and Beghin 2012, 508).

Table 4. Results of the meta regression analysis.

Covariates	**Positive δ^{NTM}**		**Negative δ^{NTM}**	
Constant (λ_0)	-0.437		-2.858	***
	(0.758)		(0.735)	
1/σ (λ_1)	-3.570		-0.117	***
	(0.249)		(0.014)	
AVE (φ_1)	-0.004		0.054	***
	(0.013)		(0.018)	
Log-Log form (φ_2)	0.150		0.070	***
	(0.264)		(0.021)	
Y-exports (φ_3)	0.244	***	0.048	**
	(0.026)		(0.018)	
HS-2 digit (φ_4)	0.059		-0.109	
	(0.041)		(0.079)	
HS-4 digit (φ_5)	0.456	***	0.128	***
	(0.025)		(0.032)	
Fixed effects (ω_1)	-0.597		2.676	***
	(0.437)		(0.719)	
Zero trade (ω_2)	1.126	***	-0.757	**
	(0.336)		(0.370)	
MRL (ω_3)	1.952	***	-0.888	*
	(0.541)		(0.492)	
SPS (ω_4)	0.503		-0.919	*
	(0.617)		(0.510)	
N-S (ω_5)	0.696		0.027	
	(0.502)		(0.486)	
Observations	113		139	
R-squared	0.834		0.563	

Notes:

Standard errors are in parentheses.

***, **, and * indicate statistical significance at 1%, 5%, and 10%.

The magnitude of estimated coefficients and related standard errors for variables 'Publication bias' and 'Log-Log form' are of the order of 10^{-15} in models "Positive δ^{NTM}".

Acronyms are as follows: Sanitary and Phytosanitary Standard (SPS), Maximum Residue Level (MRL), North-South (N-S), *ad valorem equivalent* (AVE), Harmonised System (HS).

To sum up, positive δ^{NTM} tend to be larger in some cases (if associated with exports, disaggregated data, treatment of zeros, MRLs), but are less affected by heterogeneity across studies than negative δ^{NTM}. In fact, structural heterogeneity underestimates, whereas methodological heterogeneity (exception made for the treatment of zeros) overestimates negative δ^{NTM}.

Concluding remarks

The proliferation of non-tariff measures (NTMs) has stimulated a growing empirical literature on their effects on the agri-food trade, but the global impact of NTMs is not clear cut: the hypotheses of NTMs either as catalysts and barriers coexist.

We reviewed a set of empirical studies on the trade effects of NTMs in the African agri-food sector, through a meta-analytical approach, in order to address two main concerns: disentangle the prevailing effect in literature and identify factors affecting the heterogeneity in the estimated effects.

We found that, in literature, the trade-impeding effect of NTMs prevails: in our sample, the negative estimates are widespread and less erratic than the positive ones. The NTMs are mostly barriers for trade: the African producers tend face greater costs of compliance with NTMs and obtain lower profits than producers in the destination markets. An NTM locks out African exporters from the destination market (where the NTM is implemented), that becomes less competitive, favouring domestic producers.

Our findings also suggest that the heterogeneity in the estimated effects is partly explained by methodological and structural differences across empirical studies. In particular, we showed that positive estimates are less affected by heterogeneity, whereas negative estimates tend to be exaggerated by methodological issues and lowered by structural differences. Our results reveal that, although differences exist across commodities, Maximum Residue Levels (MRLs) and Sanitary and Phytosanitary Standards (SPSs) implemented by developed countries are likely to friction African agri-food trade. In this regard, since the 2004, the Trade Ministers of G-90, the Alliance of the African, Caribbean and Pacific Group of States, the African Union, and the Least Developed Countries, asked to the *"WTO members [to] exercise restraint in applying TBT and SPS measures to products of G-90 countries and [to] provide technical and financial assistance for compliance with SPS and TBT requirements for the export of G-90 agricultural commodities"* (Disdier et al., 2008, p. 336).

In line with previous studies (Santeramo et al. 2018), our analysis highlights that the trade effects tend to be NTM-specific: however, literature generally deepens on measures intended to protect human health (i.e., SPSs, MRLs), but neglects other measures frequently implemented against African agri-food products (i.e., export-related measures, price control measures, Technical Barriers to Trade, pre-shipment inspections). Some research areas are still unexplored: in particular, the impacts of NTMs implemented by major reporters for Africa (i.e., Indonesia, Russian Federation, Liberia, Guinea, Gambia, and Philippines) have not been yet investigated. In addition, developing countries have moved from negative to positive (and steadily growing) protection in the agri-food sector, with implications for trade not completely known (Martin 2018).

Our paper would be a toolkit for academics and policymakers to understand the prevailing effects of NTMs on African trade. In particular, policymakers aiming at introducing new NTMs should carefully take into consideration the peculiarity of the trade effects across products and types of measures.

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Appendix

Table A.1. Descriptive statistics for selected papers.

Country	ISO-3 digit	Country area	Rank
High income			
Nigeria	NGA	West Africa	1
Egypt	EGY	North Africa	2
South Africa	ZAF	Southern Africa	3
Algeria	DZA	North Africa	4
Angola	AGO	Southern Africa	5
Morocco	MAR	North Africa	6
Sudan	SDN	North Africa	7
Libya	LBY	North Africa	8
Ethiopia	ETH	East Africa	9
Kenya	KEN	East Africa	10
Ghana	GHA	West Africa	11
United Repuplic of Tanzania	TZA	East Africa	12
Medium income			
Tunisia	TUN	North Africa	13
Côte d'Ivoire	CIV	West Africa	14
Cameroon	CMR	Central Africa	15

Uganda	UGA	East Africa	16
Zambia	ZMB	Southern Africa	17
Mozambique	MOZ	Southern Africa	18
Botswana	BWA	Southern Africa	19
Zimbabwe	ZWE	Southern Africa	20
Congo	COG	Central Africa	21
Senegal	SEN	West Africa	22
Gabon	GAB	Central Africa	23
Mauritius	MUS	Southern Africa	24
Namibia	NAM	Southern Africa	25
Burkina Faso	BFA	West Africa	26
Madagascar	MDG	East Africa	27
Benin	BEN	West Africa	28
Rwanda	RWA	East Africa	29
Niger	NER	West Africa	30
Guinea	GIN	West Africa	31
Malawi	MWI	Southern Africa	32
Mali	MLI	West Africa	33
Sierra Leone	SLE	West Africa	34
Low income			

Mauritania	MRT	North Africa	35
Togo	TGO	West Africa	36
Burundi	BDI	East Africa	37
Lesotho	LSO	Southern Africa	38
Cabo Verde	CPV	West Africa	39
Central African Republic	CAF	Central Africa	40
Djibouti	DJI	East Africa	41
Gambia	GMB	West Africa	42
Eritrea	ERI	East Africa	43
Comoros	COM	East Africa	44
Guinea-Bissau	GNB	West Africa	45
Sao Tome and Principe	STP	Central Africa	46

Source: elaboration on UN (2017) and CEPII (2017).

Notes: Considering the distribution of African countries' GDPs, a country is low income if GDP is lower than the 25th percentile, medium income if GDP range between the 25th and the 75th percentile, high income if GDP is higher than the 75th percentile.

Table A.2. Descriptive statistics for selected papers.

References	Obs.	Positive obs.	Positive significant obs.	Negative obs.	Negative significant obs.	Me	μ	σ	Min	Max
Anders S., and Caswell J.A. (2009)	17	3	1	14	12	-0.42	-0.35	0.40	-0.92	0.50
Disdier A.C., Fekadu B., Murillo C., and Wong S.A. (2008)	80	22	4	58	20	-0.25	-0.14	0.91	-1.91	5.11
Drogué S., and De Maria F. (2012)	8	3	-	5	3	-0.04	-0.04	0.12	-0.23	0.12
Ferro E., Wilson J.S., and Otsuki T. (2013)	15	2	1	13	4	-0.96	-1.03	2.11	-5.68	4.46
Ferro E., Otsuki T., and Wilson J.S. (2015)	10	6	1	4	2	0.14	1.11	2.88	-0.23	9.22
Gebrehiwet Y., Ngqangweni S., and Kirsten J.F. (2007)	2	2	2	-	-	0.39	0.39	0.03	0.37	0.41
Jongwanich J. (2009)	1	1	1	-	-	0.05	0.05	-	0.05	0.05
Kareem O.I. (2014a)	2	1	1	1	1	0.81	0.81	3.55	-1.71	3.32
Kareem O.I. (2014b)	4	1	1	3	2	-1.59	-3.16	6.42	-12.16	2.71
Kareem O.I. (2014c)	4	1	1	3	2	-1.59	-3.16	6.42	-12.16	2.71
Kareem O.I. (2016a)	8	5	1	3	2	0.00	-0.42	0.99	-2.85	0.07
Kareem O.I. (2016b)	2	1	1	1	1	1.76	1.76	6.11	-2.57	6.08
Kareem O.I. (2016c)	5	4		1	-	0.00	10.27	24.55	-2.85	54.14
Kareem F.O., Brümmer B., and Martinez-Zarzoso I. (2015)	12	4	3	8	7	-0.07	3.72	6.91	-1.51	18.11
Kareem F.O., Brümmer B., and Martinez-Zarzoso I. (2017)	21	15	11	6	3	3.73	2.89	2.78	-0.09	6.89
Otsuki T., Wilson J.S., and Sewadeh M. (2001a)	25	23	3	2	1	0.88	1.25	1.38	-0.91	5.20
Otsuki T., Wilson J.S., and Sewadeh M. (2001b)	2	2	2	-	-	0.74	0.74	0.44	0.43	1.05
Scheepers S., Jooste A., and Alemu Z.G. (2007)	1	1	1	-	-	0.26	0.26	-	0.26	0.26
Shepherd B., and Wilson N.L. (2013)	25	6	4	19	16	-0.03	-0.58	0.94	-3.80	0.47
Wilson J.S., and Otsuki T. (2004)	3	3	3	-	-	1.45	1.42	0.07	1.34	1.48
Wilson J.S., Otsuki T., and Majumdar B. (2003)	2	2	2	-	-	0.59	0.59	0.01	0.58	0.59
Xiong B., and Beghin J. (2011)	24	11	3	13	5	-0.01	0.34	0.98	-0.72	3.00

Table A.3. Descriptive statistics of the estimates: detail on types of measures.

Estimates	Min	Max	Median	Mean	Std. Dev.	C.I.[a]	Obs.[b]
Maximum Residue Level (MRL)							
Total	-5.683	18.105	0.580	1.509	3.268	[-1.759; 4.778]	37%
Positive	0.008	18.105	1.139	2.630	3.381	[-0.751; 6.012]	25%
Negative	-5.683	-0.0010	-0.435	-0.800	1.129	[-1.929; 0.328]	12%
Significant	-2.980	18.105	1.107	2.080	3.675	[-1.595; 5.756]	21%

Significant positive	0.008	18.105	1.501	3.146	3.715	[-0.568; 6.861]	15%
Significant negative	-2.980	-0.181	-0.556	-0.904	0.822	[-1.726; -0.083]	6%
Not significant	-5.683	9.222	0.099	0.770	2.502	[-1.732; 3.272]	16%
Sanitary and Phytosanitary Standard (SPS)							
Total	-12.162	6.077	-0.240	-0.345	2.117	[-2.462; 1.772]	37%
Positive	4.030 [d]	6.077	0.265	0.980	1.555	[-0.575; 2.535]	12%
Negative	-12.162	-0.0100	-0.390	-0.960	2.068	[-3.028; 1.109]	25%
Significant	-12.162	6.077	-0.485	-0.536	3.908	[-4.444; 3.372]	10%
Significant positive	0.267 [d]	6.077	2.711	2.811	1.968	[0.843; 4.779]	3%
Significant negative	-12.162	-0.300	-0.750	-2.122	3.596	[-5.718; 1.475]	7%
Not significant	-2.847	1.310	-0.170	-0.272	0.691	[-0.963; 0.419]	27%
Other [c]							
Total	-3.796	54.140	-0.062	0.389	6.607	[-6.219; 6.996]	25%
Positive	4.000 [d]	54.140	0.050	2.965	12.394	[-9.429; 15.359]	7%
Negative	-3.796	-0.0004	-0.197	-0.591	0.777	[-1.368; 0.187]	18%
Significant	-3.796	0.468	-0.408	-0.576	0.783	[-1.359; 0.207]	15%
Significant positive	0.015	0.468	0.248	0.244	0.232	[0.012; 0.476]	2%
Significant negative	-3.796	-0.015	-0.604	-0.716	0.758	[-1.475; 0.042]	13%
Not significant	-2.847	54.140	-0.001	1.801	10.274	[-8.473; 12.075]	10%

[a] Confidence interval (C.I.) ranges between mean minus standard deviation (minimum) and mean plus standard deviation (maximum).

[b] Percentages computed on the total number of observations (271).

[c] ‘Other’ includes tariff rate quotas, Hazard Analysis and Critical Control Points (HACCP), voluntary standards, entry price.

[d] The magnitude of ETEMs are of the order of 10^{-15}.

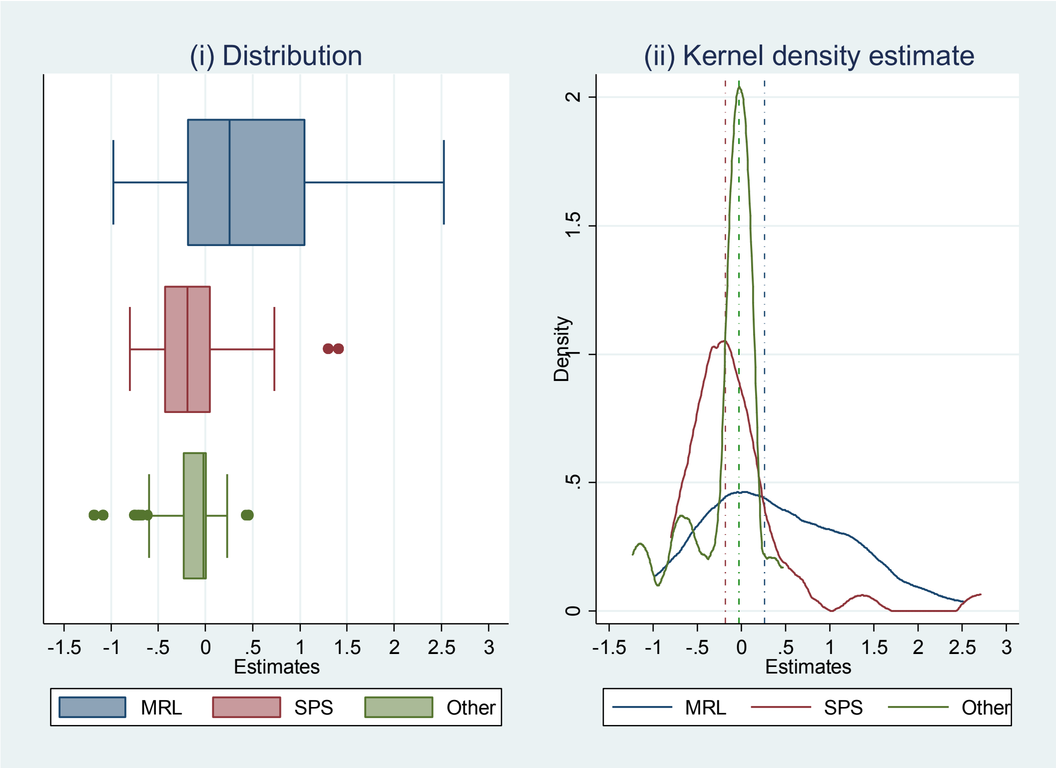

Figure A.1. Estimated trade effect of measures (ETEMs) arranged by types of measures.

Notes: Types of measure are as follows: Maximum Residue Level (MRL), Sanitary and Phytosanitary Standard (SPS), Other (includes tariff rate quotas, Hazard Analysis and Critical Control Points (HACCP), voluntary standards, entry price). In panel (i), the distributions of estimates are on observations within the 10th and the 90th percentiles. Horizontal lines within boxes are median values (Me) (i.e., Me_{MRL} = 0.26, Me_{SPS} = -0.18, Me_{Other} = -0.03). In panel (ii), the estimated densities for estimates are computed removing observations which exceed the 10th and the 90th percentiles. Dashed lines are median values (Me).