An assessment of the effect of the Round Table on Responsible Soy certification on soybean exports

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Abstract

To minimize the negative effect of soybean production on the ecological system, multi-stakeholders along the global soybean supply chain collaborated to develop, implement, and verify a global certification standard — the Round Table on Responsible Soy (RTRS). While RTRS certification is almost a quasi-mandatory sustainability measure, its potential trade effects remain poorly understood. This paper assesses the effect of RTRS certification on soybean exports to OECD countries. Using a structural gravity model that exploits country variations in RTRS certified production volumes and certified land area, we show that RTRS certification reduces trade flows. To understand the mechanisms driving our findings, we conduct moderation and mediation analyses that reveal that RTRS certification reduces production volumes in certified exporting countries, leading to a drop in quantities available for trade.

Keywords: Round Table on Responsible Soy, Agricultural trade, Global supply chains, Voluntary sustainability standards, Gravity models

JEL Classification: F14, F18, F23

Introduction

There is a growing concern that global soybean production and trade patterns are destroying the environment through large-scale deforestation and grassland conversion (Sun et al., 2018; Boerema et al., 2016). Morton et al. (2006) estimate that between 2001 and 2004, the forest area converted to cropland was more than 540,000 ha in the Brazilian Amazon alone. Couple this with the fact that increases in soybean production in the Amazon frontier state of Mato Grosso was caused by cropland expansion from 2001 to 2005, while 78% of the increase was due to cropland expansion from 2006 to 2010 (Macedo et al., 2012). This extensive forest clearing and land conversion are driven in large part by increasing import demand for soybean in high-income countries.

The globalization of soybean is occurring on a large scale. This raises concerns. Increasing soybean production and trade are happening at the cost of increased forest destruction and land-use change (Schmitz et al., 2015; Macedo et al., 2012). This has led to private-sector driven initiatives, particularly the use of Voluntary Sustainability Standards (VSS) to regulate and promote sustainable production and trade patterns. For soybean, one such important VSS is the Round Table on Responsible Soy (RTRS). The RTRS is an international supply-chain certification program designed to reduce agricultural expansion in the rainforest for soybean planting and promote environmentally sustainable production practices. In response to growing public concern about forest loss, industry representatives joined non-governmental organisations, financial institutions, supermarkets, and other stakeholders in the soy supply chain to form the RTRS in 2006 in Zürich, Switzerland. It is a private-initiatives supply-chain certification scheme that enforces quasi-mandatory standards on soybean production and sourcing behaviours. Farmers seeking certification must produce soybean that is environmentally sustainable (e.g., deforestation- and land conversion-free), socially appropriate, and economically viable[1]. Farmers who comply with the certification requirements receive an "RTRS credit" for each metric ton of soybean produced. Sustainability-conscious buyers, such as supermarkets, processors, and other international dealers, then buy the RTRS credits from the certified farms at mutually agreed price-premiums.

RTRS, along with other VSS, has sparked a necessary debate over the role of supply-chain certification in governing the global agri-food trade system. VSS operates by internalizing the social, environmental, and economic costs of production into the price of a commodity. Hence, they affect sustainability (in this case preventing deforestation and land-use change) by influencing the production, sourcing, and consumption decisions of various economic actors — producers, firms, and individual consumers — by assuring them that the products

[1] https://responsiblesoy.org

they buy are produced sustainably. Whether and to what extent this is reflected in observed trade patterns is an empirical question. The existing empirical literature shows heterogeneous effects (Martens et al., 2009). One strand argues that private certification generates positive effects on agri-food trade (Ehrich and Mangelsdorf, 2018; Latouche and Chevassus-Lozza, 2015; Melo et al., 2014; Andersson, 2019). For example, GlobalGAP standards enhance import demand and increase the probability of certified producing countries accessing high-value export markets (Andersson, 2019; Fiankor et al., 2019, 2020b). Voluntary certifications also reinforce existing trade partnerships by signaling quality to importers (Herzfeld et al., 2011). Some studies remain skeptical about the potential trade effects of VSS, due to the significant increases in production and compliance costs that come with certification (Schuster and Maertens, 2015; Shepherd and Wilson, 2013). Besides, smaller producers may be disadvantaged as high compliance costs exclude them from participating in private certification schemes and the potential trade-enhancing effects associated with certification (Dolan and Humphrey, 2000; Martinez and Poole, 2004). In this paper, we contribute to this unresolved debate by offering further insights into the trade effects of VSS atthe country level.

We make two contributions to the existing literature. First, the existing literature has focused mainly on trade effects for high-value agricultural products such as fruits and vegetables (Andersson, 2019; Fiankor et al., 2020b) and processed products (Ehrich and Mangelsdorf, 2018).[2] Much less attention has been paid to how VSS affects trade in the cash crop sector.[3] This is nevertheless very important. Cash crops unlike fruits and vegetables are produced dominantly in developing countries that are mainly standard takers. As a result, it is hard to imagine a situation where certifications are being used to protect domestic producers in the high-incoming importing countries. This is not necessarily the case for certain fruits and vegetables. Cash crops are also not easily perishable and so the trade dynamics here may be different compared to fruits and vegetables. In this paper, we focus on soybean as a cash crop. Though existing works provide evidence on the impact of supply-chain certifications on soybean production (Garrett et al., 2016; Lambin et al., 2018; Carlson et al., 2018), few studies assess certification’s impact on the trade. Figure 1 shows that soybean export is consistently increasing in the major soybean producing countries in Southern America. In contrast with the growing importance in practice, whether and to what extent the voluntary certifications are affecting soybean trade has not been answered in the literature. Second, existing works on the VSS-trade effect (Fiankor et al., 2020b; Andersson, 2019; Grassnick and Brümmer, 2021;

[2] For a review of the existing literature on the trade effects of VSS, see Elamin and de Cordoba (2020). In this review, the authors only referenced nine studies that try to assess the trade effect of a VSS. This goes to further highlight the timeliness of our study and its potential policy relevance.

[3] The only study we are aware of that focuses on a cash crop, is the recent work by Grassnick and Brümmer (2021) on the trade effects of UTZ certification on cocoa exports.

Ehrich and Mangelsdorf, 2018)merely estimate the certification effect on trade without empirically analyzing the potential mechanisms driving the effect. In this regard, our paper digs deeper for patterns and isolates empirically the mechanisms driving the observed trade effect.

Our empirical analysis uses data on all producing countries as potential exporters and the group of OECD countries as the sample of importing countries. The latter is because globally the OECD is one of the most important soy importing region, and developed countries are more willing to purchase agrifood with low environmental cost. We estimate a structural gravity model that exploits the time and exporting-country specific variations in the certified soybean production volumes and land area, respectively. Our result shows that the RTRS certification has a negative and statistically significant effect on soybean trade flows. To understand the mechanism behind this result, we carry out moderation and mediation analyses. The results confirm our hypothesis that RTRS certification increases production costs for farmers, limits their production — by reducing available soybean planting areas — and hence reduces the volume of soybean available for exports. We also see that this mediation effect is more intensewithin countries with high forest land coverage.

The rest of the paper is structured as follows: Section 2 provides the detailed information on the standard and content of RTRS. This is followed by theoretical and empirical models in Section 3 and Section 4. Section 5 gives a description of the data, and section 6 presents the results and major findings. We provide concluding remarks and discuss policy implications in Section 7.

The role of RTRS

The RTRS is a supply chain certification program that promotes zero deforestation and ecological sustainability. The basic framework of RTRS originates from the Amazon Soy Moratorium, which was initiated by Greenpeace, the Brazilian Association of Vegetable Oil Industries, and the National Association of Grain Exporters. They required that their contracted soybean producers avoid deforestation in the Amazon biome from the soy supply chain. After a time-consuming process of negotiations on criteria, all the stakeholders agreed to implement RTRS certification for sustainably produced soy in Argentina, Brazil, Uruguay and India starting in 2010. A year later, the RTRS issued the first certification in the world of soy with a total trading volume of 85,000 tons. According to the agreement, the RTRS certification is designed to make soy production more compatible with environmental concerns and halt further expansion in areas converted to soybean farms. The RTRS's major interest is to set the growing soy industry on a sustainable path going forward since rapidly increasing soybean demand from the international market might result in increased forest loss. Since 2006, the impact of RTRS is continually increasing. By 2020, the RTRS had already covered 1.3 million hectares of certified soybean planting land, with 4.4 million tonnes of soybean produced on about 9,536 certified farms. In the past 15 years, the RTRS has protected 563,047 hectares of land from deforestation and has generated a globally wellrecognized standard for stakeholders along the soybean supply chain.[4] In practice, certified farmers self-declare how much RTRS soybean they produce and receive one "RTRS credit" for each metric ton produced. To confirm whether production units follow the RTRS standards, certified farms engage third-party auditors to verify their products meet the regulations of the RTRS. RTRS offers multiple supply chain models. Based on the mass-balance system, certified soybean producers directly sell their production to crushing plants. Farmers deliver volumes of RTRS-certified soy or derived products that correspond to the volumes of RTRS-certified soy. However, the crushing plants do not only purchase the certified soybean production that complies with the RTRS standards, but also from non-certified sources. Thence, soy from one or more RTRS-certified sites may be mixed with sources of non-certified soy. It is the responsibility of the crushing company to report the certain percentage of their output that is RTRS certified. There is also another possibility where the RTRS also provides segregation system to provide buyers with 100% RTRS-certified soybean. In the case of segregation, RTRS- certified soy is kept physically separate from non-RTRS-certified soy. From production, storage, transport, processing, to the end users, RTRS-certified soy is kept physically separate from non-RTRS-certified soy.

Potential trade benefits of RTRS

In this section, we discuss the potential benefits of RTRS certification for international soybean trade. Following the RTRS protocols, certified farmers can benefit from better farm management practices and also financial assistance from stakeholders integrated into the supply chain (see Figure 2). Supporting measures would enhance soybean productivity. For example, stakeholders like Bayer and Yara would provide technical assistance to farmers on how to use their products. Santander would offer discounted loans to reduce the financial burdens for farmers. Cargill would buy from the farmers and hire professional auditors to certify its crushing plant so it could see mass-balance certified soybean products (soybean oil). And Unilever commits to buying certified oil as the source for its production. Multinational companies utilize the RTRS certification to green their soybean supply chains by sourcing sustainably-grown crops. In general, it helps soybean producers increase their productivity, decrease the environmental costs, and improvethe soybean quality.

Another benefit of RTRS certification on trade is providing an efficient approach for buyers to identify the farmers producing in compliance with sustainable environmental criteria (Fiankor et al., 2020b). Right from the production stage, all steps are audited and verified for compli- ance. The RTRS certification acts as a cost-effective signaling mechanism, stating that certified soybean and byproducts are environmentally sustainable, socially fair and

[4] https://responsiblesoy.org/impacto?lang=en

economically feasible. From the perspective of transaction cost, the transparent and traceable certifying process solves the information asymmetry problem between farmers and their potential buyers (Henson and Jaffee, 2008), which might indirectly enhance market share and develop enterprise reputation. International buyers may reward sustainable production by paying price premiums for certified products. The average premium for RTRS certified soybeans is $1.5 per ton (Garrett et al., 2013)or around 0.5% of the normal soy price.[5]

[5] https://www.solidaridadnetwork.org/news/responsible-soy-10-years-on/

Trade cost implication of RTRS

High certification cost and incremental producing expense to meet RTRS requirements are major burdens for soybean exports (Figure 3). The RTRS standard for soy production is a holistic certification scheme including five principles and 106 mandatory criteria on (i) legal compliance and good business practices (ii) responsible labor conditions (iii) responsible community relations

(iv) environmental responsibility and (v) good agricultural practices. In essence, the farmer needs to work to ensure conformity with all the mandatory RTRS rules. For instance, environmental- friendly agricultural practices are implemented to minimize the use of chemical pesticides and fertilizers to curb the contamination of ground or surface water. Besides, the RTRS strictly compels certified farmers to ensure zero deforestation and zero rainforest conversion in their soy production. Farmers are only allowed to plant soybean in designated areas. The RTRS contracts geo-engineers to segregate soybean production areas into four categories. Any soybean production carried out within or near rainforest areas would fail to be certified. Therefore, complying with the RTRS principles drives up the production cost, potentially dragging down the production. This impact could be transmitted within the supply chain and eventually affects the international soybean trade.

Additionally, transaction cost is an indispensable expenditure for RTRS participants. To obtain the approval of membership applications, producers with > 10,000 ha soybean area pay more than €2,500 while all others pay €250. Soybean processing companies, trade dealers and financial institutions also have to pay membership fees (€2,500) to engage in RTRS soybean supply chain.[6] Participating members must submit a written annual progress report to the RTRS secretariat to reveal and self-monitor their soybean planting practices. (iii) Since certification systems rely on third-party auditors to inspect whether farms meet and maintain the standards, producers are responsible for paying periodic audit fees. All these requirements imply increased transaction cost for the soybean producers and processors.

A conceptual description on the trade costs and potential trade benefits of certification is presented in Figure 3.

Theoretical model

To assess the effect of certification on the bilateral soybean trade at the country-level, we follow a standard approach in the trade literature and estimate a demand-side structural gravity model. Gravity equations are one of the best-established relationships in economics.

[6] https://responsiblesoy.org/members?lang=en

They are expenditure functions that indicate how consumers allocate their spending across countries under trade cost constraints. In a world free of trade costs and homothetic consumer preferences, the natural benchmark prediction is

$$X_{ij}/E_j = \frac{Y_i}{Y} \tag{1}$$

Where X_{ij} is exports at destination prices from exporter i to importer j, E_j is expenditure in j, Y_i is production in i and Y is world income. We can easily infer trade frictions, if we impose market clearance, i.e., $\sum_i Y_i = \sum_j E_j = Y$ Multiplying both sides of equation (1) by E_j yields predicted frictionless trade:

$$X_{ij} = \frac{Y_i E_j}{Y} \tag{2}$$

If we then take the ratio of observed trade X_{ij} to predicted frictionless trade $Y_i E_j / Y$, we get the effect of trade frictions along with random influences.

For a model that until the 21st century was disconnected from economic theory, several theoretical models now yield predictions that are close to gravity. In this paper, we adopt the Armington-CES specification of Anderson and Van Wincoop (2003). Two main assumptions underlie the model. The first is the the Armington assumption that goods are differentiated by country of origin. Two goods of the same kind coming from different countries are imperfect substitutes. Thus, the reason home consumers purchase foreign goods is because they are different from the ones produced at home. Second, consumer preferences are assumed identical and homothetic across countries and captured by a constant elasticity of substitution (CES) utility function. Solving the consumer optimization problem and imposing market clearance yields the canonical Anderson and Van Wincoop (2003) demand-side gravity equation:

$$X_{ij} = \frac{Y_i E_j}{Y} \left(\frac{\tau_{ij}}{\Pi_i P_j} \right)^{1-\sigma} \tag{3}$$

The right-hand side of equation (3) is a product of two ratios. The first ratio is the predicted trade flow under free trade (equation 2). However, observed economic interactions are far from this frictionless benchmark. Thus, the second ratio captures exogenous bilateral trade costs. The trade cost term consists of three components: (i) the numerator, τ_{ij}, is the bilateral trade cost between i and j and contains our variable of interest. The denominator is made up of the structural terms (ii) P_j and (iii) Π_i which control for multilateral resistance. They measure the ease of market access for both the importer and the exporter. Controlling for P_j and Π_i is important to achieve precise estimates of our variables of interest. σ is the elasticity of substitution parameter for the generic goods class. In this paper, our interest lies in τ_{ij}. This term enables us to show empirically how RTRS modifies predicted frictionless trade. As we see from equation (3), observed bilateral trade flows are lower if trade costs τ_{ij} increase relative to

P_j and Π_i. We model τ_{ij} as the following log-linear function of observed trade frictions:

$$\tau_{ij} = D_{ij}^{\beta_1} RTRS_i^{\beta_2} \exp \sum_{n=3}^{6} \beta_n \Omega_{ij} \qquad (4)$$

where D_{ij} is the bilateral distance between i and j, and Ω_{ij} is a vector of gravity covariates including dummies for sharing a common language ($Language_{ij}$), past colonial ties ($Colony_{ij}$), sharing a common border ($Border_{ij}$), and membership of a regional trade agreement (RTA_{ij}).

Empirical model

Model specification

To be able to estimate our theoretical model, we need to incorporate the trade cost equation (4) into our reduced form structural gravity equation (3). We can then introduce the time dimension of our data set, log linearize equation (3) — which now accounts for equation (4) — and specifyour empirical estimation model as follows,

$$X_{ijt} = \exp\left[\alpha_0 + \alpha_1 \ln RTRS_{it-1} + \alpha_2 \ln Y_{it} + \alpha_3 RTA_{ijt} + \Pi_i + P_{jt} + \lambda_{ij} + \varepsilon_{ijt}\right] \qquad (5)$$

where X_{ijt} is soybean trade flows measured in US dollars from exporter i to importer j at year t. Y_{it} represents the domestic soybean production of exporting country i, and RTA_{ijt} is a dummy variable that takes the value of 1 if both countries are members of a regional trade agreement. In alternative specifications, we will replace λ_{ij} with the time invariant country-pair variables contained in Ω_{ijt} in equation (4). We note, however, that the λ_{ij} fixed effects are better measures of bilateral trade costs than the standard set of bilateral varying gravity variables (Fiankor et al., 2020a). Our variable of interest, $RTRS_{it}$, is concentrated in six countries in our dataset. We add a constant value of one to the $RTRS_{it}$ variable before taking logarithms. We will also use the inverse hyperbolic sine transformation as an alternative approach (Bellemare and Wichman, 2020). The RTRS certification is a non-discriminatory trade policy measure. Within theoretically-specified gravity models, identifying effects of such country-specific measures can be challenging as these variables will be accounted for by the country-specific fixed effects. To get around this identification problem, we allow our exporter fixed effects to be time invariant, i.e., Π_i, so as to avoid perfect collinearity with $RTRS_{it}$.[7] As a consequence we include the

[7] Heid et al. (2021) recently proposed a theoretically consistent way of getting around this perfect collinearity problem by incorporating domestic trade flows into their bilateral trade data matrices. With developing countries dominating our sample, this domestic trade data is unfortunately not available for us to exploit. We are thus unable to employ this approach.

theoretical size term from the gravity equation on the supplier side which we capture as domestic soybean production, Y_{it}. This should account for some of the exporter-specific time varying effects that our model may miss due to the exclusion of Π_{it}. P_{jt} accounts for all country and time varying effects that are specific to the importing countries. ε_{ijt} is our error component which we cluster at the country-pair level.

Identification strategy

The presence of zero-valued dependent variables would seriously bias econometric estimates of gravity models (Martin and Pham, 2020). The work of Silva and Tenreyro (2006) makes it clear that zero values in trade render the elasticities of log-linearized models estimated by OLS inconsistent. As in this paper, we focus merely on the soybean-sector trade flow, zeroes dominate our bilateral trade dataset. To deal with the zeroes while also controlling for heteroskedasticity, we use the Poisson pseudo-maximum likelihood estimator (PPML) estimator. This estimator has been widely used in the empirical agricultural trade literature (Ghazalian, 2019; Zhang et al., 2017; Fiankor et al., 2020b), and is generally well behaved, even when the proportion of zeros inthe sample is very large (Silva and Tenreyro, 2011).

Another potential challenge of identification is endogeneity due to omitted variable biases and reverse causality. To deal with this, we do two things. First, we incorporate importer- time (P_{jt}) fixed effects, exporter (Π_i) fixed effects, and country-pair fixed effects (λ_{ij}) into our estimation equations. The host of fixed effects in our estimation will control for the unobserved characteristics that are specific to the importer, exporter and trading-pair. Secondly, we use the one-year lag variable of RTRS to deal with the potential simultaneity of the standards-trade effect (Shepherd and Wilson, 2013; Fiankor et al., 2020b). The corresponding RTRS certification and trade flows in the same year might generate reverse causality bias. Using one-year lagged RTRS cancels out the amount of time between the time the certification decision is taken and when an effect is realized.

Data

This paper estimates the effects of RTRS certification on soybean trade based using a panel data of bilateral soybean trade volumes for the period from 2012 to 2019. 89 exporting countries that produce soybeans and 42 high-income OECD importing countries are included in the data series (Table 1). Among those exporters, six countries are RTRS certified. Time and country- variations of the certified areas in these six countries are presented in Figure 4. We assess the soybean trade values from CEPII's BACI database constructed based on UNComtrade data, at the four-digit level of the Harmonized System (HS) 2017 classification, i.e., HS1201 for soybean. We get the soybean production volume from the FAOSTAT database of the Food and Agricultural Organization. RTRS certified soybean production areas and volumes for each country are from the certified volumes and producers section of RTRS official website. The bilateral country-pair data of distance, colonial relationships, sharing common border and common language are from CEPII. The information related to RTAs come from Mario Larch's Regional Trade Agreements Database from Egger and Larch (2008). And forest area (% of land area) measures the forest area that are under natural or planted stands of trees, whether productive or not, and excludes tree stands in agricultural production systems and trees in urban parks and gardens. The data on forest area is extracted from Food and Agriculture Organization (FAO). A summary statistics on the variables used in the analysis are proved in Table 1.

Results

Baseline model

Table 2 reports the results of our benchmark estimations of the PPML fixed effect model. Standard errors are clustered by country-pairs. The odd and even numbered columns employ different measures of the RTRS variable: (i) the volume of certified soybean (ii) the area of certified soy- bean, respectively. To ensure our estimations are consistent with theoretical priors, we also add the standard gravity variables and report the results in Columns (3) and (4). This model specification includes bilateral distance, past colonial ties, sharing a common border, and speaking a common language as control variables. As we can see, most of the standard gravity variables are statistically significant and have the correct sign. Our preferred model specification is contained in Columns (5) and (6). Here, we introduce importer-time and exporter fixed effects to capture both market-size effects and multilateral-resistance indexes, widely used in the structural gravity model (Fally, 2015). But we also include country-pair fixed effects to account for all country-pair varying effects that are time invariant. Going forward, we discuss mainly the results in Columns (5) and (6). As expected, the production variables in all model specifications are positive and statistically significant, implying that countries with a high soybean production tend to export more to the OECD. Strikingly, regional trade agreements decrease soybean exports. While this may seem counter-intuitive, it is possible that the environmental commitments in newly negotiated deeper RTAs discourage trade in commodities with high environmental footprints unless the producing member countries adhere to agreed sustainable production practices.

Our primary interest is in the RTRS certification effect. We find that the coefficients on the RTRS variables show a negative and statistically significant effect of certification on exports in all model estimations. In Column (5) and (6), the estimated parameters are respectively −0.334

and −0.305, indicating that a 10% growth in certified soybean production area and volume would

decrease bilateral trade by about 3%. These findings confirm the standards-as-barriers strand of the literature. Producers use the RTRS certification to signal to international soybean buyers their commitments to zero deforestation, decent labor conditions, and better food safety. The certification in turn grants them access to the high-value OECD markets while, also generating a "push-out" effect for the soybean producers who are not RTRS certified, but also a reduction in absolute sales volumes for certified producers. For example, if importing firms have to spend a fixed budget on sourcing but now have to pay more for certified soy bean, their overall trade values may decrease even though they buy more certified production compared to non-certified ones. Another possibility is that the RTRS certification decreases domestic production, which naturally lowers export volumes. In the next subsection we will test and discuss in details the mechanisms that may explain our findings.

Understanding the mechanisms

Our finding that voluntary standards are trade impeding supports the theoretical and anecdotal implications of "standards-as-barriers" to international trade. However, it also deviates from the empirical findings in the literature that private standards such as GlobalGAP (Fiankor et al., 2019, 2020b), International Featured Standard (Ehrich and Mangelsdorf, 2018) and UTZ (Grassnick and Brümmer, 2021) are trade increasing. Hence, we consider it useful to verify the mechanisms, if any, that underly the observed negative relationship between trade value and RTRS. To do this, we construct a two-step mediation analysis model following Baron and Kenny (1986). First, we regress a mediator variable — in our case annual soy bean production in the exporting country, Y_{it}— on our variable of interest $RTRS_{it}$ in equation (6). If γ_{11} is statistically different from zero, then we confirm that our variable of interest is a significant predictor of the mediator variable.

$$\ln Y_{it} = \gamma_{10} + \gamma_{11} \ln RTRS_{it-1} + c' + \varepsilon_1 \tag{6}$$

Second, we regress the outcome — soybean trade flows, X_{ijt}— on the exposure (RTRS), the mediator (Y_{it}), and the covariates (equation 7). Here we employ the product method or the product-of-coefficients methods, where the direct effect is taken as γ_{21} in equation 7 and the indirect effect is taken as the product of γ_{11} and γ_{22} in equations 6 and 7 (Imai et al., 2010; MacKinnon et al., 2002).

$$X_{ijt} = \exp[\gamma_{20} + \gamma_{21} \ln RTRS_{it-1} + \gamma_{22} \ln Y_{it} + c' + \varepsilon_2] \tag{7}$$

From Table 3, we observe that the coefficient of RTRS in equation 6 (columns 1 and 6) and the coefficient of Y_{it} in equation 7 (columns 2 and 7) are both statistically significant. The results confirm the indirect effect via the mediator (Y_{it}). As indicated, RTRS certification decreases domestic soybean production, at least in the short term (columns 1 and 4 of Table 3). This negative effect of certification on production has been confirmed by several micro-level analyses. For example, Ibanez and Blackman (2016) show that in Colombia certified organic producers produce 31–36% less than uncertified producers. This certification-induced reduction in pro- duction will also reduce the available soybean production for exports. For

RTRS certification, each step of the supply chain, starting at the production level, is audited and verified at the farm level by internationally accredited certification bodies, in compliance with economic, social and environmental sustainability criteria. These requirements can be initial production burdens reducing output and potential trade volumes.

Since zero-deforestation is the top priority for RTRS certification, another possible reason for the negative trade effect we find is the redistribution of OECD soybean imports between soy producing countries located in rainforest and non-rainforest regions. Specifically, how domestic soybean production mediates the RTRS effect on trade may depend on available forest area within the country. We test this mechanism using a moderated mediation analysis (Petty et al., 1993). In this paper, we follow the methodology proposed by Muller et al. (2005) and estimatethe following series of equations:

$$X_{ijt} = \exp[\rho_{10} + \rho_{11}\ln RTRS_{it-1} + \rho_{12}Fr_{it} + \rho_{13}Fr_{it} \times \ln RTRS_{it-1} + c' + \mu_1] \quad (8)$$

$$\ln Y_{jt} = \rho_{20} + \rho_{21}\ln RTRS_{it-1} + \rho_{22}Fr_{it} + \rho_{23}Fr_{it} \times \ln RTRS_{it-1} + c' + \mu_2 \quad (9)$$

$$X_{ijt} = \exp\begin{bmatrix}\rho_{30} + \rho_{31}\ln RTRS_{it-1} + \rho_{32}Fr_{it} + \rho_{33}Fr_{it} \times \ln RTRS_{it-1} \\ +\rho_{34}\ln Y_{it} + \rho_{35}\ln Y_{it} \times Fr_{it} + c' + \mu_3\end{bmatrix} \quad (10)$$

Where Fr_{it} represents the ratio of forest in land for producing country i in year t. Columns (3) – (5) and (8) – (10) in Table 3 represent the regression models that estimate the equation 8 through 10. In column (3), the coefficient of the interaction term in equation 8 (ρ_{13}) is not statistically significant, which means the overall RTRS effect on trade flows does not depend on the moderator (Fr_{it})[8]. Next, given that no overall moderation effects exist, we find there is a significant effect of the RTRS and a significant RTRS $\times Fr_{it}$ interaction in equation 9. The latter term is indicative of moderated mediation effect, in that it means that the magnitude of the indirect effect of RTRS, via the mediator (Y_{it}), varies in magnitude as a function of Fr_{it}. To better understand the mechanism of how forest coverage affecting the mediation process, we move to equation 10. The statistically significant parameters of Y_{it} and $Y_{it} \times Fr_{it}$, together with the insignificant parameters of RTRS $\times Fr_{it}$, indicate that the effect of Y_{it} on the final outcome (X_{ijt}) is a function of the moderator (Fr_{it}). The sign, as we expect, shows that the effect of soybean production on observed trade flows is relatively weaker in countries with high forest coverage than in low coverage countries. The results as a whole confirm that certification may induce a substitution in sourcing between high and low forest areas. Buyers in high-income countries are more likely to source soybean that come with a relatively lower likelihood of deforestation.

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[8] In Muller et al. (2005), the authors require the RTRS variable should be significant to verify the overall effect. We do not think it is necessary for our regressions since the overall effect has been repeatedly proved in the above baseline model (see Tables 2 and 4).

Robustness checks

In this section, we test the robustness of our findings from the baseline model specification. To assess if there are any non-linearities in the RTRS-trade effect, we add square terms of the RTRS variables in Columns (1) and (2) of Table 4. The coefficients of the RTRS variables are still negative and statistically significant the 1% significance level, but their square terms are positive. The results reflect that the impact of RTRS still holds, but the marginal impact of the RTRS on trade would gradually decrease. The results support the idea that once an exporter achieves a high-level of domestic diffusion of certification and thus satisfies the demand from firms or retailers in the OECD countries, importers may not discriminate between RTRS and non-RTRS soybeans too much, e.g., using mass balance. From the production side, increasing RTRS production will over time generate economies of scale for certified producers. Therefore, the negative effects of standards on soybean production are felt relatively less strongly. It would moderate the shock of RTRS on the soybean trade. This also means that our average effects in the baseline model capture short run trade effects. In the long run, the certification effect may turn positive if the volume of certified production reaches a threshold.

It can be argued that transforming our variable of interest as $\log(1+RTRS_{it-1})$ is a problematic

way of processing control variables that contain zero value (see, e.g., Bellemare and Wichman, 2020). To ensure that our findings are not sensitive to the choice we make, we use the inverse hyperbolic sine transformation of RTRS and report the results in Columns (3) and (4) of Table 4. The results are negative and statistically significant as in all our other specifications, indicatingour estimates are robust and consistent.

Conclusion and policy implication

Deforestation and environmental challenges associated with soybean production motivated the introduction of the Round Table on Responsible Soy (RTRS) certification in 2006. From the point of view of the stakeholders involved in the standard-setting process, RTRS certification is a demonstration of competitiveness in the context of a global market, reputation in the agroin- dustry sector, and a synonym for sustainability. However, certification — which can be seen as a ban on cheaper technology and a stipulation of zone restriction — also increases production burdens for producers and cause trade redirection driven by the price premium of certifying soy- beans. The controversy provides room for the empirical analysis on the impact of RTRS on the soybean trade flows. Considering the demand of high-quality, eco-friendly soybean are mainly concentrated in the high-income countries, we narrow down our importer sample in the OECD countries.

Our structural gravity model estimation results confirm a general holding-up effect of RTRS certification on the soybean trade flows at the country-specific level. The finding is robust to the different certification measures and model specifications. The mediation and moderation analysis gives insight into how the RTRS affecting the trade flows. To be RTRS certified, producers pay initial setup fees, increase auditing expenditures and change the agricultural practices. These investments and adjustments increase the production costs of soybean producers. Hindering the soybean productions by RTRS would squeeze out the soybean products for trade. Meanwhile, empirical results verify the effect of RTRS on the trade flows through production is significantly affected the local forest coverage. The international buyers divert to purchase soybeans from areas with less risk of forest deforestation, intensifying the RTRS's impact on the soybean trade flows. In general, our findings are consistent with the "standard-as-barriers" strand of the standards literature. (Anders and Caswell, 2009; Shepherd and Wilson, 2013; Schuster and Maertens, 2015). However, the trade reducing effects we find do not say anything about the welfare of the certified producers. While their sales values may have reduced due to lower production volumes, they may be selling their certified production at higher prices. In terms of the policy implication, our empirical results provide us a new view to understand the volunteer private standards. Strict control at the production side would eventually generate pressures for the trade flows. Thus, private standards operators should provide more technical assistance and financial support to stabilize soybean production. On the other side, RTRS should decrease the transaction and production cost, making the RTRS soybean more attractive. It would help moderate "trade diverting effect" caused by RTRS.

Given the lack of firm-level trade data, the heterogeneity of the soybean traders within a certified country is partially sacrificed. The soybean export performance is critically determined by firm characteristics such as productivity levels, farm size, tax and regulation policy among others. Thus, firm-level data could help us understand the responses of importer firms and producers in the framework of RTRS. More specific information should be employed to extrapolate broader generalization of the results and to bring up comprehensive policy implementations. Still, the obtained results constitute a promising point of departure for future empirical research targeting the RTRS impact at the micro level.

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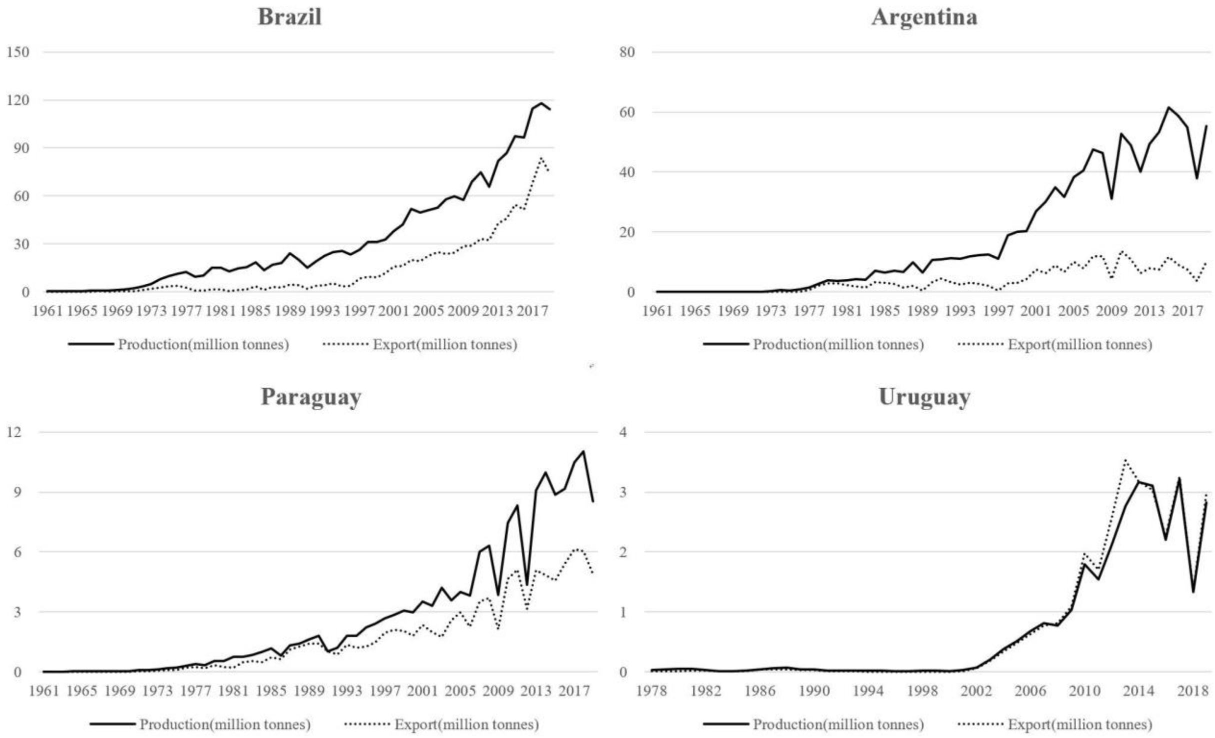
Figures and tables



Source: FAOStat data

Figure 1: Soybean production and exports in major exporting countries

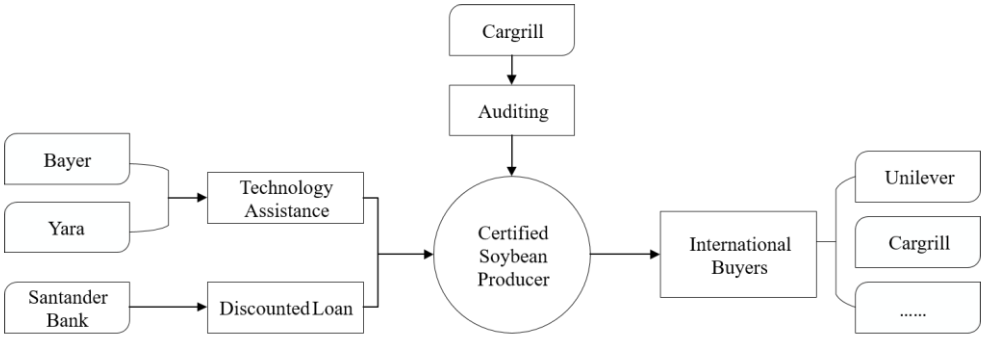


Figure 2: The RTRS in global soybean supply chain

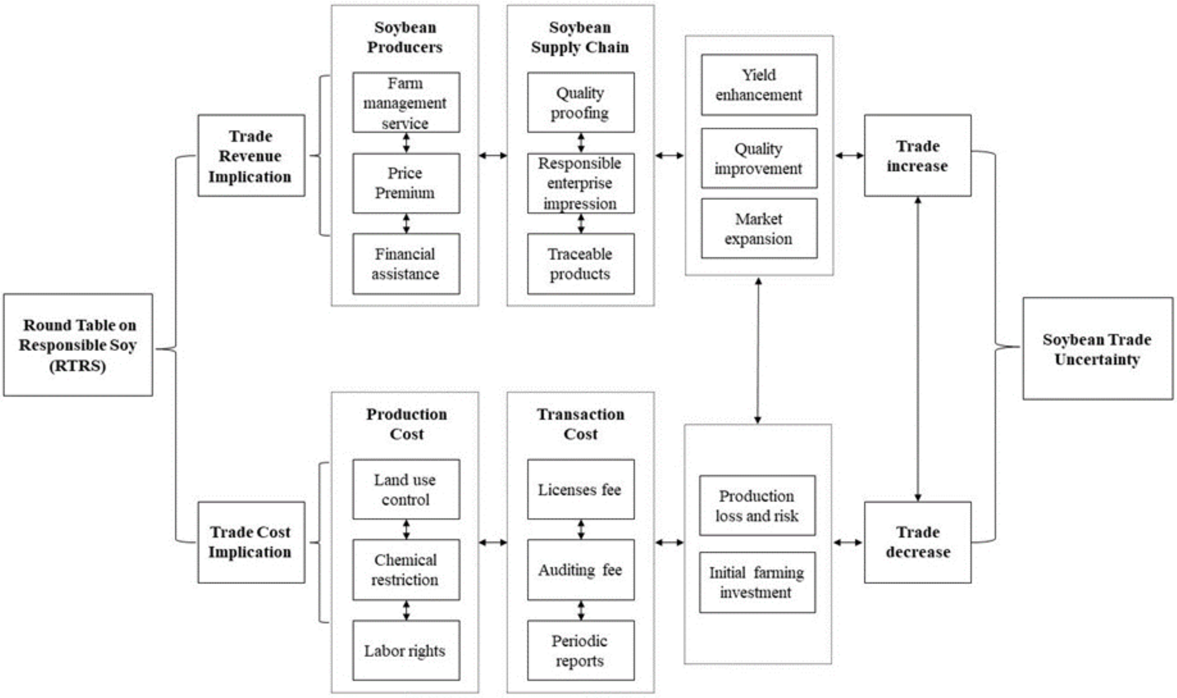


Figure 3: Cost-benefit analysis of RTRS on soybean trade

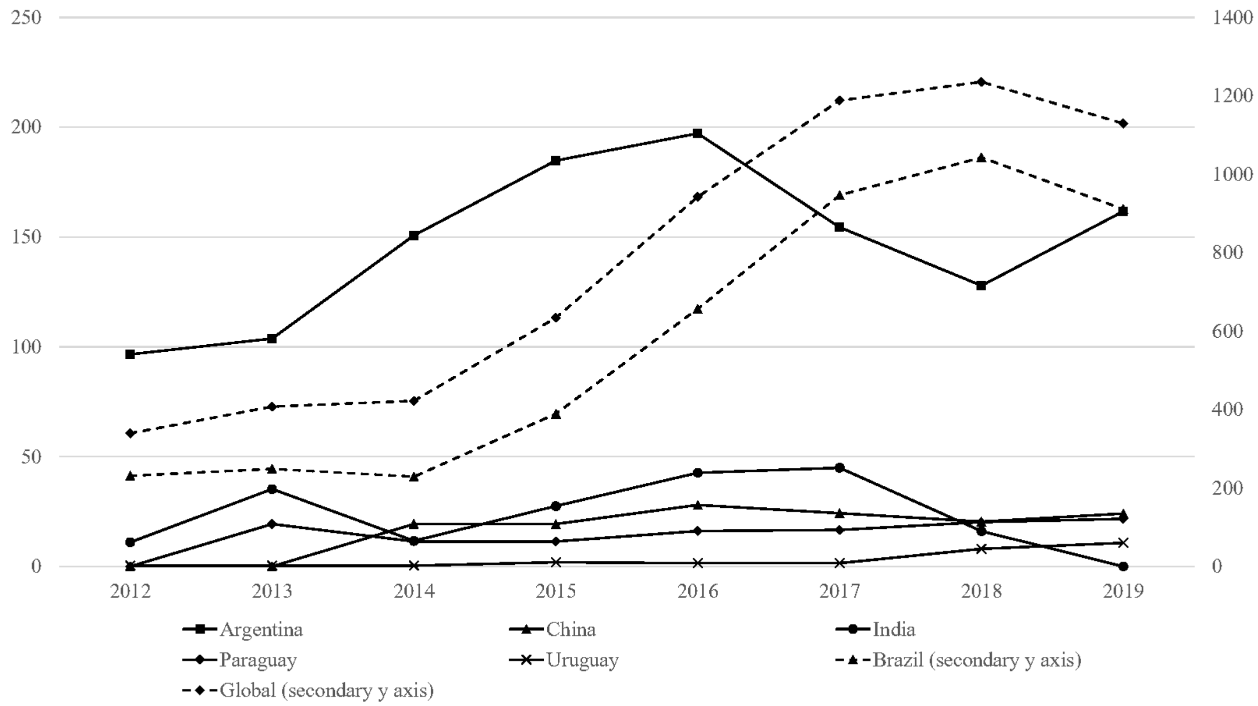


Figure 4: RTRS certified soybean production area by countries in 1000 hectares

Table 1: The effect of RTRS on global soybean trade

Variables	N	Mean	SD	Min	Max
Border	9,144	0.081	0.272		
Language	9,144	0.103	0.304		
Colony	9,144	0.053	0.223		
RTA	9,144	0.522	0.500	0	1
Distance	9,144	5,595	4,380	59.62	19,264
RTRS certified area	9,144	2.090	11.06	0	104.3
RTRS certified quantity	9,144	6.921	39.37	0	394.5
Trade value (m. USD)	9,144	11.81	92.51	0	3,829
Soybean production (m. Tons)	9,144	8.600	24.77	0	120.5
Forest area (% of land area)	9,036	32.76	16.43	0.05	97.95

Table 2: The effect of RTRS on global soybean trade

	(1)	(2)	(3)	(4)	(5)	(6)
Log RTRS Certified Quantity$_{it-1}$	-0.245***		-0.304***		-0.334***	
	(0.004)		(0.001)		(0.001)	
Log RTRS Certified Area $_{it-1}$		-0.207**		-0.281**		-0.305**
		(0.033)		(0.016)		(0.013)
Log Production$_{it}$			0.566***	0.538***	0.680***	0.648***
			(0.004)	(0.005)	(0.002)	(0.002)
Log Distance$_{ij}$			-0.521	-0.518		
			(0.123)	(0.126)		
Colony$_{ij}$			-0.594*	-0.592*		
			(0.059)	(0.060)		
Border$_{ij}$			1.112**	1.112**		
			(0.013)	(0.013)		
Language$_{ij}$			0.193	0.188		
			(0.547)	(0.557)		
RTA$_{ijt}$			-0.485	-0.477	-0.406**	-0.366**
			(0.159)	(0.167)	(0.013)	(0.027)
Importer-time FE	Yes	Yes	Yes	Yes	Yes	Yes
Exporter FE	Yes	Yes	Yes	Yes	Yes	Yes
Importer-Exporter FE	No	No	No	No	Yes	Yes
Observations	8001	8001	8001	8001	7812	7812

Notes: p values in parentheses. ***, **, * denote significance at 1%, 5% and 10% respectively. Intercepts included but not reported.

Table 3: Mechanism

Dependent variables	RTRS Certified Quantity					RTRS Certified Area				
	Mediation		Moderated Mediation			Mediation		Moderated Mediation		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
	Log Y_{it} Production$_{it}$	Log $X_{i\,jt}$ Trade$_{i\,jt}$	Log $X_{i\,jt}$ Trade$_{i\,jt}$	Log Y_{it} Production$_{it}$	Log $X_{i\,jt}$ Trade$_{i\,jt}$	Log Y_{it} Production$_{it}$	Log $X_{i\,jt}$ Trade$_{i\,jt}$	Log $X_{i\,jt}$ Trade$_{i\,jt}$	Log Y_{it} Production$_{it}$	Log $X_{i\,jt}$ Trade$_{i\,jt}$
Log RTRS Certified Quantity$_{it-1}$	-0.0219*** (0.003)	-0.334*** (0.010)	-0.310 (0.232)	-0.0306*** (0.005)	-0.376 (0.233)					
Log RTRS Certified Area$_{it-1}$						-0.034*** (0.004)	-0.305** (0.123)	-0.484 (0.339)	-0.062*** (0.008)	-0.569* (0.335)
Log Production$_{it}$		0.680*** (0.217)			1.180*** (0.349)		0.648*** (0.212)			1.189*** (0.355)
Forest ratio$_{it}$			0.251*** (0.057)	0.010*** (0.002)	0.665*** (0.133)			0.268*** (0.052)	0.011*** (0.002)	0.686*** (0.136)
Log RTRS Certified Quantity$_{it-1}$ × Forest ratio$_{it}$			0.004 (0.005)	0.0003*** (0.000)	0.006 (0.005)					
Log RTRS Certified Area$_{it-1}$ × Forest ratio$_{it}$								0.007 (0.007)	0.001*** (0.000)	0.010 (0.007)
Log Production$_{it}$ × Forest ratio$_{it}$					-0.0265*** (0.008)					-0.0269*** (0.008)
RTA$_{i\,jt}$	-0.0310*** (0.007)	-0.406** (0.164)	-0.665*** (0.240)	-0.0289*** (0.008)	-0.742*** (0.257)	-0.0317*** (0.007)	-0.366** (0.165)	-0.667*** (0.241)	-0.0301*** (0.008)	-0.742*** (0.258)
Observations	8,001	7,812	6,449	6,857	6,449	8,001	7,812	6,449	6,857	6,449

Notes: p values in parentheses. ***, **, * denote significance at 1%, 5% and 10% respectively. Intercepts included but not reported

Table 4: Robustness check

	Non-linear effect		Inverse hyperbolic sine transformation	
	(1)	(2)	(3)	(4)
Log RTRS Certified Quantity$_{it-1}$	-0.732***			
	(0.000)			
Log RTRS Certified Quantity$^2_{it-1}$	0.0539***			
	(0.002)			
Log RTRS Certified Area$_{it-1}$		-1.032***		
		(0.000)		
Log RTRS Certified Area$^2_{it-1}$		0.109***		
		(0.000)		
Log Production$_{it}$	0.382**	0.384**	0.647***	0.644***
	(0.017)	(0.019)	(0.002)	(0.003)
RTA$_{ijt}$	-0.386**	-0.366**	-0.378**	-0.414**
	(0.018)	(0.026)	(0.022)	(0.011)
arcsinh(Certified RTRS Area$_{it-1}$)			-0.314***	
			(0.005)	
arcsinh(Certified RTRS Quantity$_{it-1}$)				-0.325***
				(0.000)
Observation	7812	7812	7812	7812

Notes: p values in parentheses. ***, **, * denote significance at 1%, 5% and 10% respectively. Intercepts included but not reported

Appendix

Table A1: List of importing and exporting countries

Country groups	Members
Importers	Austria, Australia, Belgium, Bulgaria, Canada, Chile. Colombia, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Iceland, Ireland, Israel, Italy, Japan, Latvia, Lithuania, Luxembourg, Malta, Mexico, Norway, New Zealand, the Netherlands, Poland, Portugal, Republic of Korea, Romania, Slovak Republic, Slovenia, Spain, Sweden, Switzerland, United Kingdom, Turkey, USA
Exporters	Angola, Albania, Argentina, Australia, Austria, Azerbaijan, Benin, Burkina Faso, Bangladesh, Bulgaria, Bosnia, Belize, Bolivia, Brazil, Bhutan, Canada, Switzerland, China, Côte d'Ivoire, Cameroon, Colombia, Czech, Germany, Ecuador, Egypt, Spain, Ethiopia, France, Gabon, Georgia, Ghana, Greece, Guatemala, Honduras, Croatia, Hungary, Indonesia, India, Iran, Iraq, Italy, Japan, Kazakhstan, Kenya, Kyrgyzstan, Cambodia, South Korea, Lao, Sri Lanka, Lithuania, Morocco, Moldova, Madagascar, Mexico, Macedonia, Mali, Myanmar, Malawi, Nigeria, Nicaragua, Nepal, Pakistan, Panama, Peru, Philippines, Poland, North Korea, Paraguay, Romania, Russia, Rwanda, El Salvador, Suriname, Slovakia, Slovenia, Syria, Togo, Thailand, Turkey, Tanzania, Uganda, Ukraine, Uruguay, United States, Venezuela, Viet Nam, South Africa, Zambia, Zimbabwe