The Impact of Organic Equivalency Agreements on U.S. and Canadian Trade of Organic Agri-Food Products

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Abstract

Organic Equivalency Agreements (OEAs) are designed and increasingly used to facilitate the recognition and trade of organic agriculture and food products between trading partners. To date, more than twenty-four OEAs are currently in effect. This study explores the effectiveness of these novel policy instruments by offering a detailed examination of the impact of Organic Equivalency Agreements (OEAs) signed by the United States and Canada on their organic agri-food trade. The empirical analysis is implemented through a theory-consistent structural gravity model that uses highly disaggregated trade data over the period 2007-2019. We find positive and significant trade-facilitating effects of OEAs on the value of U.S. and Canadian organic agri-food product trade. Employing Poisson Pseudo-Maximum Likelihood (PPML) estimation we find that, on average, U.S. and Canadian OEAs foster an increase of 23% in trade of considered agri-food products in the first year after OEAs were in effect. OEAs signed by Canada are found to particularly facilitate the trade of organic vegetables, fruits, oil seeds, and sugar. Canada's OEA with Japan and the U.S. were found to be successful in facilitating Canadian organic imports. U.S. OEAs with Canada, the EU, and South Korea were particularly effective in facilitating organic agri-food trade. These findings offer novel and important insights into current trade patterns of organic agri-food products between the U.S. and Canada, and opportunities for the potential development of additional OEAs.

Keywords: international trade, organic policy, equivalency agreements, trade agreements, gravity model

JEL Codes: F13, Q17, Q18

Introduction

The international trade of organic agri-food products has been burgeoning in recent decades. The total value of organic trade topped 15.8 billion USD in 2019, with 3.1 million organic producers and 181 countries and regions involved in organic activities (Willer et al., 2021). As of 2020, nearly 15% of global retail sales on organic agri-food products is attributed to consumption of imported organic food (Willer et al., 2022). A growing literature has examined the impacts of agri-food standards on trade. While some studies have found that standards facilitate trade of specific agri-food products using non-linear econometric methods (Shingal et al., 2021; Traoré and Tamini, 2022), another strand of literature find that agri-food standards might impede trade through increasing production- and conformity-related costs (Tran et al., 2012; Fiankor et al., 2021). Relatively little, however, is known about the trade effects of organic agri-food standards. Organic production standards generally preclude the use of synthetic fertilizers, sewage sludge, chemical pesticides, or genetically modified organisms (GMOs), and, as such, have higher production costs. While most country's organic standards now incorporate a basic set of organic principles in their regulations, they still differ in the specific substances allowed or prohibited in organic farming, as well as labeling, testing, auditing, and inspection of organic food products.[1] Satisfying the certification requirements for multiple markets requires duplicated costs for each market and product; this, in turn, reduces farm profitability and complicates organic producers' access to international markets.

Efforts by the International Federation of Organic Agriculture Movements (IFOAM)[2] and the

[1] As one example, the antibiotics tetracycline and streptomycin are used to control fire blight in fruits such as apples and pears. Use of these antibiotics permitted by U.S. organic standards but are banned in those of the EU.
[2] IFOAM was founded in 1972 and has been promoting harmonization and equivalence in organic agriculture since 2002, in partnership with the UN Food and Agricultural Organization (FAO) and UN Conference on Trade and Development (UNCTAD). IFOAM first published the IFOAM Basic Standards (IBS) in 1980.

Codex Alimentarius Commission (Codex)[3] to harmonize organic standards have been unsuccessful. This is due, at least in part, to differences in culture and technical development codified in organic regulations (Bowen and Hoffman, 2015). By way of example, the Indian organic regulation emphasizes biodiversity, the Australian legislation focuses on water issues, and Mexican regulations include strict crop rotation requirements (Seufert et al., 2017).

Organic Equivalency Agreements (henceforth, OEAs) are an important form of Organic Trade Agreements which allow agri-food products produced and certified according to one country's organic standard to be labeled and sold as organic in another country. Unlike harmonization which aims to establish identical standards and conformity assessments across countries, OEAs allow for differences in production requirements while acknowledging organic production and certifying systems as equal in the effectiveness of environmental and health protection (Vogl et al., 2005; Pekdemir, 2018). These agreements alleviate the need for duplicating testing and certification (reducing costs), enable organic food manufacturers to source organic ingredients more easily, and allow firms to access and compete in signatory markets. As of 2021, twenty-four OEAs have been signed, in thirteen of which the United States or Canada is one of the signatories.

To date, the impacts of OEAs on the international trade of agri-food products have received scant research attention. Due to data limitations and the challenges of differentiating between organic and non-organic products in international trade data, and as these separate records of traded organic products have only begun being tracked relatively recently,[4] most of the few studies that have examined this issue have been either descriptive or case studies of particular agreements.

[3] The Codex Alimentarius Commission is an intergovernmental body established by the Food and Agriculture Organization of the United Nations (FAO) and the World Health Organization (WHO) in 1961. The Codex developed and approved the Guidelines for the Production, Processing, Labeling and Marketing of Organically Produced Foods (Codex Guidelines) in 1999.

[4] The U.S. started tracking the trade of organic products in 2011; Canada began reporting organic imports in 2007 and collecting organic exports in 2017.

Most relevant to the current study, Jaenicke and Demko (2015) first apply a gravity model to examine U.S. organic trade flows from 2011-2014. Their OLS estimation finds that U.S. exports of tracked organic products to OEA signatories are 138% more than those shipped to OEA non-signatories, while no significantly higher import values have been found between the U.S. and OEA signatories. Demko and Jaenicke (2018) use a synthetic control method to better capture the trade effects of U.S.-EU OEA and find that a 9.1% quarterly increase in U.S. exports of 23 tracked organic products shipped to the EU was generated through the U.S.-EU OEA. Using an expanded set of products, Boys et al. (2022) examined the trade impacts of U.S. OEAs. This analysis finds that the U.S.-Switzerland OEA is associated with an average 687.7% increase in the U.S. exports of organic agri-food to Switzerland, while no significant impacts on the trade of tracked products were found from the U.S.-EU OEA, U.S.-Japan OEA, and U.S.-South Korea OEA.

This study extends previous literature to offer a wholistic assessment of the value of this policy tool. We employ a theory-consistent gravity model to estimate the impacts of OEAs on agri-food imports and exports of the U.S. and Canada using highly disaggregated trade flow data during the period 2007-2019. Specifically, in this analysis we examine: (1) whether OEAs signed by the U.S. and Canada affect the trade of agri-food products and, if so, (2) how they affect the magnitude and nature of these trade flow impacts. Potential heterogeneity in the impact of OEAs on organic and non-organic agri-food trade by agreement, product categories, and direction of trade flow is also explored.

The focus on organic trade and OEAs for which either Canada or the U.S. is a signatory is due to their dominant position as sources of supply and demand in global markets of organic products. In 2020, organic retail sales in the U.S. and Canada amounted to 61.4 billion USD, accounting for 44.3% of the global organic food market (Willer et al., 2022). As of 2020, 2.3 million hectares of agricultural land (including in-conversion areas)[5] were certified for use in organic production in the United States, ranking it 8th among all countries. Canada has 1.4 million hectares of certified organic agricultural land (global rank 11th).[6]

To address the literature gap in the organic trade field and overcome the data limitations faced by previous studies, this analysis makes use of a unique dataset and innovations in methods. First, we introduce a new data set of U.S. and Canadian imports and exports between 2007 and 2019. This dataset is compiled using national trade statistics and includes the highly disaggregated product flows[7] needed to discern organic from conventionally grown or produced ("non-organic") agri-food products. Second, we include trade flows of both organic and non-organic agri-food products for selected HS-6 product categories.[8] The construction of a reference group contributes to identifying the trade impacts of OEAs from unobservable time-varying product heterogeneity between country pairs that are common to both organic and non-organic products of the same category (e.g., beef trade vulnerable to foot and mouth disease outbreaks). Third, this analysis is the first to consider the global impacts of OEAs and includes consideration of the 184 partner countries that traded with the U.S. or Canada from 2007 to 2019.

The findings of this analysis offer novel and important contributions to our understanding of the trade pattern of organic products, the effectiveness of OEAs as a trade facilitation tool, and opportunities for the potential development of additional OEAs. Briefly, our results show that OEAs generate a positive and significant effect on the international trade of U.S. and Canadian

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[5] Organic requirements for many countries require a multi-year process to transition land used for conventional production to organic. Both Canada and the U.S. require that land be managed according to organic standards a minimum of 36 months prior to the harvest of crops which can be certified as organic or used as organic pastureland.
[6] Top ten countries ranked by their area of organic agricultural land area (measured in million ha) are: Australia (35.7), Argentina (4.5), Uruguay (2.7), India (2.7), France (2.5), Spain (2.4), China (2.4), United States (2.3), Italy (2.1), Germany (1.7).
[7] U.S. imports, U.S. exports, and Canadian imports are evaluated at the HS-10 level, and Canadian exports at the HS-8 level (the most disaggregated level available from the Canadian government).
[8] We include HS-6 product categories in which at least 15% of the HS 10-digit line for organic products was found.

organic agri-food products. Using the preferred specification and estimation approach (PPML), we find that on average U.S. and Canadian OEAs foster an increase of 23% in trade of the considered agri-food products. The benefits of these agreements though vary significantly across trading partners and product categories. OEAs signed by Canada are found to particularly facilitate the trade of organic vegetables, fruits, oil seeds, and sugar; U.S. OEAs were found to notably increase the trade of edible preparations which include fortified juices, baking and cooking ingredients (e.g. yeast, sauces). There was also heterogeneity in the overall trade facilitated by each agreement. For the U.S., its OEA with Canada, the EU, and South Korea were particularly effective in facilitating trade of tracked organic products. Canada's agreements with Switzerland, Costa Rica, and Japan were found to increase trade of non-organic agri-food products, but not that of tracked organic products; these results suggest that the traded but not tracked organic products may most benefit from these agreements.

The remainder of this paper is organized as follows. Section 2 outlines the background of organic standards and OEAs. The theory-consistent gravity specifications, data sources, and zero-flow treatment used in this analysis is presented in Section 3. Section 4 reports the empirical results and summarizes the results of robustness checks, and Section 5 concludes.

2. Background

In the United States, the National Organic Program which was established under the Organic Foods Production Act (OFPA)[9] establishes regulations and guidance for certification, production, and labeling of organic products. As of 2002, farm operations with gross agricultural income from organic sales of more than $5,000 USD were required to comply with the U.S. national organic standard and become certified by an accredited certification agent (Sawyer et al., 2008). Canada's national organic standard was implemented in 1999 (Sawyer et al., 2008),[10] and codified through Canada's Organic Product Regulations (OPR) in 2009 (COTA, 2017).

While there are many similarities, today, U.S and Canadian organic standards are not identical. Most importantly there are some differences in the specific synthetic substances allowed for use, and non-synthetic substances prohibited for use in organic production.[11] In the absence of a harmonized organic standard, some countries are now using alternative policy instruments to reduce the barriers to trading and marketing organic products. Among these, equivalency agreements hold the most promise and, as such, are the focus of this study. Table 1 summaries U.S. and Canadian organic equivalency agreements.

Table 1: U.S. and Canadian Organic Equivalency Agreements

Agreement	**Description**	**U.S. Agreements (Year Entered-Ended)**	**Canadian Agreements (Year Entered-Ended)**
Organic Equivalency Agreement (OEA)	Allows products produced and certified according to one country's organic	Canada (2009-) European Union (2012-) Japan (2014-)	United States (2009-) European Union (2011-) Switzerland (2012-) Costa Rica (2013-)

[9] Enacted under the 1993 Farm Bill.
[10] Canada's national organic standard (CAN/CGSB-32.310-2015) , *Organic production systems: general principles and management standards*, is available here: http://publications.gc.ca/collections/collection_2018/ongc-cgsb/P29-32-310-2018-eng.pdf
[11] For instance, for U.S. organic firms to sell products as organic in Canada, they must be produced without sodium nitrate or hydroponic/aeroponic methods.

	standard to be sold and represented as organic in the other country.	South Korea (2014-) Switzerland (2015-) Taiwan (2020-) United Kingdom (2021-) India (2022-)	Japan (2015-) Taiwan (2020-) United Kingdom (2021-) Mexico (2023-)

Notes:

1. Reference includes IFOAM-Organic Equivalency Tracker and Boys and Hooker (2015).
2. Taiwan transitioned from a unilateral OEA to a bilateral OEA in May 2020 with the U.S. and Canada.
3. Other OEAs include agreements between Australia-New Zealand (entered into force in 1992), EU-Switzerland (1997), EU-Japan (2010), Japan-Switzerland (2013), EU-South Korea (2015), China-New Zealand (2016), EU-Chile (2018), Taiwan-Australia (2020), Taiwan-Japan (2020), Taiwan-New Zealand (2020), and EU-United Kingdom (2021).

3. Methodology and data

3.1. Empirical specification

The theoretical model is based on the structural gravity equation presented in Anderson and van Wincoop (2003) and Anderson and Yotov (2016). The world economy consists of *N* countries indexed by $j \in N$, and goods are differentiated by place of origin. Maximizing the consumer's CES utility function conditional on a budget constraint and imposing the market clearing condition, the well-known theoretical model is obtained (see Anderson and Yotov, 2016 for more details). The theory-consistent gravity model that examines the impacts of OEAs on the U.S. and Canadian imports and exports in the agri-food product sector (HS chapters 02-24) is described by:

$$X_{ijt}^{k} = \exp\left[\beta_0 + \beta_1 OEA_{ij,t-1} + \beta_2 Organic^{k} + \beta_3 OEA_{ij,t-1} * Organic^{k} + \delta_{it}^{k} + \gamma_{jt}^{k} + \eta_{ij}^{k}\right] \times \varepsilon_{ijt}^{k} \quad (1)$$

where X_{ijt}^{k} denotes the U.S. and Canadian annual exports and imports with trading partners of product k at the most disaggregated level at time t.[12] The index i represents exporting country, index j reflects importing country, and index k is the product. The time t indicates the year a given trade flow took place.

The variable $OEA_{ij,t-1}$ is a binary variable equal to one if countries i and j have an OEA in force at time $t-1$. Countries may opt to enter an OEA due to relatively high trade of organic products in previous years. To reduce concern of endogeneity, we follow Baier et al. (2014) and Fontagné et al. (2022), by using a one-year lag of the OEA variable. $Organic^k$ is a dummy variable indicating if product k is an organic product. The interaction term, $OEA_{ij,t-1} * Organic_k$ indicates the trade-facilitating effects of one-year lagged OEAs on organic agri-food products relative to non-organic (including organic but not tracked) products.

Unobservable outward and inward multilateral resistance is denoted by time-varying exporter-product (δ_{it}^k) and importer-product $\left(\gamma_{jt}^k\right)$ fixed effect terms. Country-pair-product fixed effect (η_{ij}^k) is used to account for product-varying bilateral trade costs. This gravity framework is vulnerable to the endogeneity problems due to the potential omission of unobserved confounding factors correlated with lagged OEAs and bilateral trade flows.[13] Therefore, the inclusion of the country-pair-product fixed effect helps address the endogeneity of one-year lagged OEAs by controlling for any unobserved confounding country-pair-product factors in trade regressions (Anderson and Yotov, 2020; Kox and Rojas-Romagosa, 2020). Following Shepherd and Wilson (2013), product fixed effects are defined for each six-digit product category of k to avoid multicollinearity. ε_{ijt}^k is an error term.

[12] The dependent variable is trade flows at the most disaggregated product level available, i.e., HS-10 level for U.S. exports, imports, and Canadian imports, and HS-8 level for Canadian exports.
[13] For example, the European Union excludes apples and pears cultivated with antibiotics tetracycline and streptomycin from EU-U.S. OEA, which might impede bilateral trade and can not be quantified.

As standard model specifications only allow the average effect of trade agreements to be estimated, previous works of literature have examined the heterogeneity in trade agreements across country pairs, sectors, and direction of trade flows (Grant and Boys, 2012; Baier et al., 2019; Borchert et al., 2022). First, we explore whether the impact of OEAs on trade varies across product sectors. To do so, using Eq. 2, regressions are separately run for each HS-2 sector:

$$X_{ijt}^{ks} = \exp\left[\beta_0^s + \beta_1^s OEA_{ij,t-1} + \beta_2^s Organic^k + \beta_3^s OEA_{ij,t-1} * Organic^k + \gamma_{jt} + \eta_{ij}\right] \times \varepsilon_{ijt}^{ks} \qquad (2)$$

where X_{ijt}^{ks} denotes the U.S. or Canadian annual exports and imports with trading partners of product k in sector s at time t.

Second, due to their differing scope and variation in the products produced and consumed by signatories, it is likely that OEAs may differ in their effect on organic product trade. Potential heterogeneity across OEAs is examined using:

$$X_{ijt}^{ak} = \exp\left[\beta_0^a + \beta_1^a OEA_{ij,t-1} + \beta_2^a Organic^k + \beta_3^a OEA_{ij,t-1} * Organic^k + \theta^{ak}\right] \times \varepsilon_{ijt}^{ak} \qquad (3)$$

where X_{ijt}^{ak} is the annual bilateral trade flows between member countries of OEA *a,* where *a* includes each OEA in which Canada or the U.S. are one of signatories. This analysis is separately estimated for each agreement *a*. Given this, Eq. 3 removes all importer and exporter fixed-effect terms, and adds a control for product k for each agreement a.

Third, potential asymmetries in the impacts of OEAs by the direction of trade are explored. To do so, the imports and exports of each country in an OEA are separately considered using:

$$IM(EX)_{ijt}^{ak} = \exp\left[\beta_0^a + \beta_1^a OEA_{ij,t-1} + \beta_2^a Organic^k + \beta_3^a OEA_{ij,t-1} * Organic^k + \theta^{ak}\right] \times \varepsilon_{ijt}^{ak} \qquad (4)$$

where $IM(EX)_{ijt}^{ak}$ represents the U.S. or Canadian imports (or exports) of product k at time t between member countries of OEA a. The previously described limited availability organic trade data shapes this analysis. First, tracking of Canadian organic exports began in 2017, which is after Canada established its last OEA within the time period covered by this analysis. For this reason, the impact of Canada's OEAs on Canadian exports can not be assessed. Secondly, while the U.S.-Canada OEA was signed in 2009, U.S. import and export data were not separately tracked until 2011. To evaluate this OEA on U.S. exports to Canada then, we mirror Canadian trade data in which Canadian imports from U.S. are assumed to be equal to U.S. exports shipped to Canada.

3.2. Data and estimation approach

The U.S. annual import and export data over 2011-2019 is obtained at the HS-10 level from the U.S. International Trade Commission (USITC). We obtained annual import data of Canada's agri-food products at HS 10-digit during the period 2007-2019 from Statistics Canada. It is noticeable that Canada started tracking organic exports in 2017, and Canadian exports at HS 8-digit from 2017-2019 is available from Statistics Canada. The data in this study covers HS chapters 02-24 which encompass all fresh and processed agri-food products and beverage sectors.

Information on the Organic Equivalency Agreements (OEA) was obtained from the IFOAM Organic Equivalency Tracker.[14] Data concerning gross domestic product of exporter and importer (GDP_{it}, GDP_{jt}) are denoted in U.S. dollars and are obtained from the World Bank Development Indicators.[15] Measures of distance ($Dist_{ij}$), common border ($Border_{ij}$), common language

[14] IFOAM-Organic Equivalency Tracker tracks equivalence agreements information between government trade partners; available at: https://www.ifoam.bio/our-work/how/regulation-policy/organic-equivalence.
[15] World Bank Development Indicators DataBank can be accessed at: https://data.worldbank.org/indicator/NY.GDP.MKTP.KD&country=#

($Lang_{ij}$), colony link ($Colony_{ij}$), currency union membership (CU_{ijt}), and World Trade Organization membership ($WTOBothIn_{ijt}$) are obtained from the CEPII dataset.[16] Information regarding the arable agricultural land area at the country level is obtained from FAOSTAT.[17] Regional Trade Agreements (RTA_{ijt}) are obtained from the WTO-RTA Database.[18] County level income, which is used in robustness checks, is obtained from the World Bank.[19]

As the prevalence of zeros rises with disaggregation, how to deal with the zero trade flows is a major concern in agricultural trade literature (Anderson, 2011).[20] Silva and Tenreyro (2006) point out that applying OLS to a log-linearization of the gravity equation leads to inconsistent estimates in the presence of heteroskedasticity. They suggest using the PPML method in which the disturbance term is generated from a Poisson distribution. However, the PPML estimation is vulnerable to the problem of over-dispersion in the dependent variable. The over-dispersion issue arises when the conditional variance is larger than the conditional mean of the dependent variable (i.e., large trade values occurred at relatively high frequencies). In case of over-dispersion, a negative binomial approach is recommended.

It is worth noting that both PPML and negative binomial methods are sensitive to cases when zeros are excessive (Burger et al., 2009).[21] In our analysis, we carefully deal with zero observations by excluding "false" zero trade values. The false zero trade values are instances where pairs of countries have no probability of trading due to either political actions or a lack of biological resources; or no potential to trade in view of the low frequency of trading (Baldwin and Di Nino,

[16] CEPII gravity data is available at: http://www.cepii.fr/CEPII/en/bdd_modele/bdd_modele_item.asp?id=8
[17] FAOSTAT land area data comes from the Land Use chapter: http://www.fao.org/faostat/en/#data/RL
[18] WTO-RTA Database is available at: https://rtais.wto.org/UI/PublicMaintainRTAHome.aspx
[19] The World Bank's classification of country groups by income can be accessed at the website: https://datacatalogfiles.worldbank.org/ddh-published/0037712/DR0090755/CLASS.xlsx
[20] Following the common practice used in the gravity model, we first fill in zeros where trade is missing for country pairs at the most disaggregated level for each sample year (see Bacchetta et al., 2012 for details).
[21] Silva and Tenreyro (2011) demonstrate that the PPML method applies well to trade data dominated by zero values.

2006; Hejazi et al., 2022).[22] We trim the data by dropping zeros in pair-product-year observations if a country-pair did not trade more than 5,000 USD of a product at least twice during the sample period.[23] The true zeros provide information on the trade pattern by indicating the probability of engaging in bilateral trade and the likelihood of creating new bilateral trade relations, we keep true zero trade values to avoid sample selection bias as well as loss of information (Xiong and Beghin, 2012). Multiple thresholds of identifying true zero trade values have been examined in robustness checks.

To identify the trade impacts of OEAs from unobservable time-varying product heterogeneity between country pairs that are common to both organic and non-organic products of the same category, we include a non-organic reference group.[24] We included the HS-6 product categories in which at least 15% of HS-10 product lines under the HS-6 heading are organic products, and the remaining HS-6 product categories are dropped. Applying this "rule of thumb," the share of organic agri-food products in the total agri-food products increases from 1.4% to 38.2%, thereby enhancing the comparability of organic and non-organic trade flows under the establishment of OEAs.

Table 2 presents the summary statistics. The dataset contains 57,417 observations, of which 20% of observations are between country pairs who are party to an OEA with Canada or the United States. Zero values solely occupy 21.6% of the total observations.

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[22] Baldwin and Di Nino (2006) dropped product-pair combinations if one of the country pairs never traded that product line with any of its partners in any of the years. Hejazi et al. (2022) assumed that a country has no potential to export a given product if that country did not export a given product at least 3 times over a period of 10 years (2004-2014).
[23] We dropped zero observations if a country-pair did not trade more than 5,000 USD of a product at least twice over a period of 9 years (2011-2019) for the U.S.; three times over a period of 13 years (2007-2019) for Canada imports; once over a period of 3 years (2017-2019) for Canada exports.
[24] For instance, Webb et al. (2018) find that disease outbreaks such as foot and mouth disease (FMD) outbreak encourage exporting countries to trade beef with lower-value markets not recognized as FMD-free during and after the outbreak.

Table 2: Summary statistics of variables included in the analysis of the U.S. and Canada OEAs on Agri-food trade, 2007-2019

Variable	Mean	Standard deviation	Min	Max
Y_{ijt}^{k} (million USD)	4.13	34.92	0	2331.66
$Y_{ijt}^{Organic}$(million USD)	1.21	5.94	0	131.40
$Y_{ijt}^{Non-Organic}$(million USD)	5.24	40.83	0	2331.66
$OEA_{ij,t-1}$	0.20	0.40	0	1
$Organic^{k}$	0.27	0.44	0	1
GDP_{it}(million USD)	7,109,303	8,232,262	194.65	2.14e+07
GDP_{jt}(million USD)	5,093,877	7,295,183	178.33	2.14e+07
$Dist_{ij}$(kilometers)	8,103	3,891	1,486	16,466
$Border_{ij}$	0.06	0.24	0	1
$Lang_{ij}$	0.34	0.47	0	1
$Colony_{ij}$	0.01	0.09	0	1
$AgArea_{it}$(1000 ha)	69,211	72,454	0.15	161,780
$AgArea_{jt}$(1000 ha)	54,943	59,349	0.15	161,780
RTA_{ijt}	0.31	0.46	0	1
CU_{ijt}	0.03	0.18	0	1
$WTOBothin_{ijt}$	0.97	0.16	0	1

Notes: The index *i*(*j*) denotes the exporting (importing) country, and *t* the year the trade occurred. Product k is defined at the most highly disaggregated level (i.e., HS-10 for the U.S. exports, imports, and Canadian imports; HS-8 for Canadian exports). Analysis considers agri-food trade (HS 02-24); n= 57,417.

4. Results

4.1. Impact of OEAs on the trade of agri-food products – Baseline Analysis

Baseline estimations are presented in Table 3. In column (1), we follow De Frahan and Vancauteren (2006), adding one to all trade flows before taking logarithms for the OLS estimation. The OLS finds that the coefficient of the variable $OEA_{ij,t-1}$ is not statistically significant, showing that the OEA status in the previous period did not significantly impact the non-organic agri-food products. The estimate of $Organic_k$ indicates that the imports and exports of tracked organic products are approximately 93% ((exp(-2.626)-1)*100) lower than the comparison group between the U.S. (Canada) and its OEA non-signatories. The estimate of the interaction term $OEA_{ij,t-1} * Organic_k$ is positive and significant, suggesting that one-year lagged OEAs facilitate organic trade by 176% more than the trade-facilitating effects of lagged OEAs on non-organic agri-food products. The coefficient of the interaction term in the PPML estimations shown in column (2) is not significant. However, the PPML estimates a statistically significant positive estimate for $OEA_{ij,t-1}$ (0.210), indicating that one-year lagged OEAs generate 23% more trade flows of non-organic agri-food products. The PPML results look discouraging but actually inspiring since the non-organic trade flows include trade values of organic but not tracked agri-food products. This suggests that these agreements either offer positive externalities to the trade of non-organic goods, or that the trade of organic but not tracked products strongly benefits from these agreements. In column (3), the results of negative binomial regression suggest that OEAs are associated with a 5% increase in trade of organic agri-food products in the first year after OEAs were in effect.[25] The likelihood ratio test shows that the dispersion parameter of the negative binomial model is significantly larger than zero, indicating that the trade data is over-dispersed and estimations using a negative binomial model are more efficient than estimations using a Poisson model (Burger et al., 2009). However, high-dimension fixed effects can not be included as covariates in the negative binomial regression. As such, the PPML estimations with high-dimension fixed effects are much more consistent with the gravity theory and therefore preferred in later estimations.

The Heckman selection model is used to further explore the impacts of lagged OEAs on the probability of organic trade between country pairs and on the trade intensity conditional on the decision to trade. For the selection equation (column 4a) the dependent variable is a dummy variable equal to one if positive trade flow is observed and zero otherwise. An indicator variable of country pairs sharing a common language is used as the exclusion variable since it is believed

[25] The impacts of one-year lagged OEAs on trade values of organic agri-food products are conditional on the sum of the coefficient of the OEA lagged indicator (-0.034) and the coefficient of the interaction term (0.082). Therefore, the 5% increase in trade of organic agri-food products resulting from lagged OEAs is computed using the formula: (exp(-0.034+0.082)-1)*100.

to affect fixed but not variable trade costs (Ferro et al., 2015; Hejazi et al., 2022). Results of the selection equation show that the probability of trading organic agri-food products increases by 15% between country pairs that entered OEAs in the previous year.[26] In the outcome equation (column 4b), the dependent variable is the value of positive trade flows between country pairs. The coefficient results of gravity covariates were of the expected sign and magnitude. Results indicate that traded values of organic agri-food products, conditional on the decision to trade, did not significantly increase relative to non-organic trade values following entry into an OEA. The increase in the trade values of organic products is mainly attributed to the extensive margin of OEAs, that is, the higher likelihood of trading organic products between OEA signatories relative to OEA non-signatories. As the coefficient of the inverse mills ratio is not significant, the PPML estimation approach is superior to the Heckman selection model in the baseline analysis since the data is not vulnerable to sample selection bias.

Table 3: Impact of U.S. and Canadian OEAs on the trade of agri-food products

Estimation Method	OLS	PPML	Negative Binomial	Heckman Selection Model[a]	
	(1)	(2)	(3)	(4a)	(4b)
				Selection Equation	Outcome Equation
$OEA_{ij,t-1}$	-0.174	0.210**	-0.034**	-0.041**	-0.652***
	(0.329)	(0.105)	(0.017)	(0.020)	(0.047)
$Organic^k$	-2.626***	-2.066***	-0.170***	-0.183***	-0.707***
	(0.090)	(0.067)	(0.009)	(0.015)	(0.055)
$OEA_{ij,t-1} * Organic^k$	1.015***	0.020	0.082***	0.181***	0.028
	(0.208)	(0.081)	(0.017)	(0.034)	(0.086)
$\ln(GDP_{it})$				-0.053***	0.477***
				(0.006)	(0.017)
$\ln(GDP_{jt})$				-0.007	0.784***
				(0.006)	(0.014)

[26] The 15% higher probability of trading organic agri-food products between OEA signatories relative to OEA non-signatories is computed using the formula: (exp(-0.041+0.181)-1)*100.

ln ($Dist_{ij}$)				-0.090***	-0.613***
				(0.016)	(0.040)
$Border_{ij}$				0.432***	2.211***
				(0.040)	(0.131)
$Lang_{ij}$				0.078***	
				(0.015)	
$Colony_{ij}$				-0.111*	0.887***
				(0.067)	(0.168)
ln ($AgArea_{it}$)				0.012**	0.077***
				(0.005)	(0.010)
ln ($AgArea_{jt}$)				-0.006	-0.278***
				(0.004)	(0.010)
RTA_{ijt}				0.076***	0.306***
				(0.016)	(0.038)
CU_{ijt}				0.031	-0.927***
				(0.039)	(0.090)
$WTOBothin_{ijt}$				0.218***	-0.193*
				(0.040)	(0.101)
Inverse Mills Ratio					-0.712
					(0.574)
Exporter-product-time F.E	Yes	Yes			
Importer-product-time F.E	Yes	Yes			
Country-pair-product F.E	Yes	Yes			
Country-pair F.E			Yes		
Product-time F.E			Yes	Yes	Yes
N	46,312	44,824	57,417	57,417	57,417
R^2	0.543	0.828	0.018		

Notes: The dependent variable in columns (1)-(3) is the U.S. and Canadian annual exports and imports with trading partners of product k at the most disaggregated level (HS-10 level for the U.S. exports and imports, and Canadian imports, and at HS-8 level for Canadian exports) at time t. Standard errors in columns (1)-(3) are in parentheses and are "three-way" clustered by the exporter, importer, and year. Standard errors in columns (4a)-(4b) are robust. Coefficient estimates for the constant and fixed effects are omitted for brevity. *, **, and *** denote $p < 0.10$, $p < 0.05$, and $p < 0.01$, respectively.

[a] The dependent variable in the selection equation is a dummy variable indicating whether positive trade flows are traded between country pairs; the dependent variable in the outcome equation is the trade value conditional on the decision of trade.

4.2 Heterogeneity in the impact of OEAs on agri-food trade by sector

Table 4 reports PPML estimates in Eq. 2 and investigates the impacts of U.S. and Canadian OEAs on sector-level trade flows. The dependent variable in Panel A (Panel B) is U.S. (Canadian) bilateral trade flows of products k at HS-10 level under HS-2 heading s at time t.[27]

This analysis yields mixed results. For some sectors, such as U.S. coffee and tea (HS 09), OEAs established in the previous year are associated with 130.5% higher value trade of non-organic (and organic but not tracked) coffee and tea than OEA non-signatories. Combine with the interaction term $(OEA_{ij,t-1} * Organic_k)$ coefficient, indicating that the organic coffee and tea traded between OEA signatories is smaller than those traded between U.S. and its OEA non-signatories. While the U.S. does (re-)export coffee after roasting and other value adding activities, these exports are dominated by conventionally rather than organically grown coffee. The estimates of $Organic^k$ are consistent with expectations, for many sectors except Cereals (HS 10), values of organic products traded are significantly lower than non-organic products between the U.S. and its OEA non-signatories. Given these hurtles, however, in instances where OEAs are found to significantly facilitate organic trade (i.e., edible preparations, HS 21; +214%) should be considered a strong signal of the value of this type of agreement.

The results presented in Panel B indicate that Canada's OEAs are more successful in facilitating the trade of organic foods. Positive and significant coefficients are found for the interaction term indicating that one-year lagged OEAs increased Canadian trade for organic vegetables (HS 07; +66%), fruits (HS 08; 36%), oilseeds (HS 12; 27-fold increase), and sugars (HS 17; two-fold increase) compared to non-organic trade flows in these sectors. By comparison, Canadian OEAs not encouraged more organic trade with OEA signatories relative to countries with which Canada does not have an OEA for dairy products (HS 04), coffee and tea (HS 09), or fats and oils (HS 15). Also, organic trade values are lower than trade values of non-organic agri-food products in all sectors between Canada and its OEA non-signatories.

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[27] To be clear, each row within each panel presents results of a separate regression.

Table 4. Sector-level gravity estimates, PPML, 2007-2019

		Panel A.			Panel B.		
		U.S.			Canada		
	HS Chapter	$OEA_{ij,t-1}$	$Organic^k$	$OEA_{ij,t-1} * Organic^k$	$OEA_{ij,t-1}$	$Organic^k$	$OEA_{ij,t-1} * Organic^k$
Dairy produce, eggs, honey	04[a]				0.132	-0.559***	-2.834***
					(1.540)	(0.096)	(0.391)
Vegetables	07	-0.104	-1.572***	-0.446**	-0.460***	-1.877***	0.509***
		(0.080)	(0.169)	(0.194)	(0.066)	(0.139)	(0.146)
Fruits	08	-0.293**	-1.761***	-0.407***	-0.095	-1.927***	0.308***
		(0.118)	(0.094)	(0.110)	(0.100)	(0.074)	(0.111)
Coffee, tea	09	0.835***	-2.143***	-0.959***	0.024	-1.276***	-1.824***
		(0.235)	(0.116)	(0.209)	(0.091)	(0.119)	(0.231)
Cereals	10	omitted	1.591**	-2.524***	omitted	-3.815***	0.627
			(0.697)	(0.703)		(0.774)	(0.786)
Oil seeds	12	1.610	0.676	-1.945***	omitted	-5.554***	3.343***
		(1.023)	(0.536)	(0.568)		(0.823)	(1.033)
Animal or vegetable fats, oils	15	-0.011	-0.429***	-0.450***	-0.556***	-0.671**	-0.690*
		(0.238)	(0.149)	(0.160)	(0.177)	(0.326)	(0.364)
Sugars, sugar confectionery	17[a]				omitted	-0.503***	1.096***
						(0.187)	(0.318)
Edible preparations	21[a]	omitted	-2.839***	1.143***			
			(0.113)	(0.154)			

Notes: The dependent variable is the bilateral trade flows of products (HS-10 products for U.S. trade and Canadian imports, HS-8 for Canadian exports) within traded HS Chapters at time t. All estimates include importer-time and country-pair fixed effects. Standard errors are in parentheses and are "three-way" clustered by the exporter, importer, and year. Coefficient estimates for the constant and fixed effects are omitted for brevity. *, **, and *** denote $p < 0.10$, $p < 0.05$, and $p < 0.01$, respectively.
[a] Due to the described approach for selecting relevant product sectors, products in HS Chapters 04 and 17 for the U.S., and Chapter 21 for Canada were excluded from this analysis.

4.3 Heterogeneity in the impact of OEAs by agreement and direction of trade flow

Table 5 presents the results of Eq. 3 which separately evaluates the trade impacts for each OEA that either the U.S. (Panel A) or Canada (Panel B) are signatories. Among these agreements, the U.S.-Canada OEA deserves special consideration. This 2009 agreement was the first OEA signed by either of these countries. This OEA is found to be associated with a 32% increase in the trade of organic agri-food products between the U.S. and Canada in the first year after OEA was in effect.[28] It is noticeable that the U.S.-Canada OEAs also facilitated trade of non-organic products by 114%. Importantly, this interpretation is generally consistent with findings from a recent survey that found that about 30% of U.S. organic agri-food businesses reported that their exports to Canada increased since the implementation of this agreement (OTA, 2019). Results indicate that the U.S.-EU and U.S.-South Korea OEA agreements are successful in facilitating trade of tracked organic products by 146% and 354%, respectively. However, organic trade seems not to benefit from the U.S.-Japan OEA and U.S.-Switzerland OEA.

Canada's OEA agreement with Switzerland in the previous year generated a 32-fold increase in the trade of non-organic agri-food products, while the organic trade values decreased by 55%. The coefficient of $Organic^k$ is 2.795, indicating that non-organic trade value occupies an average of 6% of the total agri-food trade between Canada and Switzerland before the establishment of their OEA. As such, the great increase in non-organic agri-food products might arise from the positive externalities of OEA and the trivial trade share. The one-year lagged OEA between Canada and Japan increased non-organic trade by 121%, and no significant trade-enhancing effects have been found on organic agri-food products relative to non-organic products. Costa Rica experienced a 3% increase in the trade value of non-organic agri-food products with Canada and a 40% reduction in organic trade, partly explained by the fact that merely 6% of agri-food trade between Canada and Costa Rica is organic products. We do not find a significant impact of Canada-EU OEA on trade flows of either organic or non-organic agri-food products.

[28] The 32% increase in trade of organic agri-food products resulting from lagged U.S.-Canada OEAs is computed using the formula: (exp(0.762-0.487)-1)*100.

Table 5. Estimates of country-pair specific OEA effects, PPML, 2007-2019

Panel A. U.S. with its OEA signatories

Country-pair	U.S.-Canada	U.S.-EU	U.S.-Japan	U.S.-South Korea	U.S.-Switzerland
$OEA_{ij,t-1}$	0.762***	0.320*	-0.205*	0.139***	1.207***
	(0.071)	(0.180)	(0.121)	(0.052)	(0.124)
$Organic^k$	-1.653***	-1.479***	-2.298***	-3.949***	-4.766***
	(0.280)	(0.298)	(0.471)	(0.249)	(0.877)
$OEA_{ij,t-1} * Organic^k$	-0.487**	0.581***	0.414	1.374***	-1.647***
	(0.208)	(0.178)	(0.312)	(0.411)	(0.546)
N	2,564	5,345	668	634	308
R^2	0.556	0.317	0.592	0.844	0.664

Panel B. Canada with its OEA signatories

Country-pair	Canada-U.S.[a]	Canada-EU	Canada-Japan	Canada-Costa Rica	Canada-Switzerland
$OEA_{ij,t-1}$		0.230	0.795***	0.031**	3.503***
		(0.240)	(0.224)	(0.015)	(0.277)
$Organic^k$		-1.766***	-1.741***	-2.846***	2.795***
		(0.372)	(0.129)	(0.376)	(0.280)
$OEA_{ij,t-1} * Organic^k$		0.175	-0.798	-0.541***	-4.301***
		(0.507)	(0.585)	(0.199)	(0.307)
N		4,596	347	443	229
R^2		0.408	0.875	0.799	0.805

Notes: The dependent variable in Panel A is the U.S. bilateral trade flows of agri-food products k at HS-10 level at time t, while the dependent variable in Panel B is Canadian bilateral trade flows of agri-food products k at the most disaggregated level (HS 10-digit for imports and HS 8-digit for exports) at time t. All estimates include product fixed effects at the HS-6 level, whose estimates are omitted for brevity. Standard errors are in parentheses and are clustered by product at the HS-6 level. *, **, and *** denote $p < 0.10$, $p < 0.05$, and $p < 0.01$, respectively.
[a] Canada-U.S. OEA estimates in column (1) of Panel B are the same as that in column (1) of Panel A.

Potential asymmetries in the effect of OEAs on import as compared to export flows are separately explored for U.S. (Panel A) and Canadian agreements (Panel B) in Table 6. The results in Panel A provide some evidence that one-year-lagged OEAs were highly successful in facilitating U.S. exports of tracked organic products to South Korea (+362%), and resulting in a 39% increase in the exports of organic agri-food products to Canada. Importantly, the EU and South Korea experienced a notable increase (+130%) in exports of organic relative to non-organic products one year after relevant OEAs came into force. Japan and Switzerland benefited from OEAs signed with the U.S. due to the increased exports of non-organic agri-food products to the United States.

Panel B of Table 6 reports these results for each of Canada's OEAs. We do not report Canada OEA effects on Canadian exports due to the data availability. Among these agreements, Canada's OEA with Japan was found to be particularly successful. Trade of non-organic agri-food products increased by 43% in the first year after the Canada-Japan OEA was in effect, and 194% more trade values of organic agri-food products relative to non-organic products resulted from the Canada-Japan OEA one year later. While trade of tracked organic products did not benefit from Canada's agreements with Switzerland and Costa Rica, the Canada-Costa Rica OEA, and Canada-Switzerland OEA are associated with a 3%, and 37-fold increase in Canadian imports of non-organic (and organic but not tracked) agri-food products, respectively. The effects of the Canada-EU OEA on Canadian organic imports are not significant.

Table 6. Heterogeneity in OEA effects by direction of trade flows, PPML

Panel A. U.S. with its OEA signatories

Exporter	U.S.	U.S.	EU	U.S.	Japan	U.S.	South Korea	U.S.	Switzerland
Importer	Canada	EU	U.S.	Japan	U.S.	South Korea	U.S.	Switzer-land	U.S.
Year signed	2009	2012	2012	2014	2014	2014	2014	2015	2015
$OEA_{ij,t-1}$	0.808***	-0.346**	0.422***	-0.258**	0.554***	0.137**	0.174***	-0.113	1.302***
	(0.076)	(0.159)	(0.146)	(0.126)	(0.070)	(0.056)	(0.045)	(0.124)	(0.033)
$Organic^k$	-1.631***	-1.336***	-1.720***	-2.556***	-0.801***	-4.027***	-5.751***	-0.897***	-6.198***
	(0.275)	(0.270)	(0.308)	(0.561)	(0.239)	(0.199)	(1.053)	(0.178)	(0.108)
$OEA_{ij,t-1}$	-0.481**	0.249	0.844***	0.464	-0.258	1.393***	0.835***	-1.176***	-1.991***
$* Organic^k$	(0.209)	(0.271)	(0.233)	(0.391)	(0.328)	(0.419)	(0.178)	(0.388)	(0.624)
N	2,098	2,467	2,878	515	152	457	175	196	110
R^2	0.586	0.228	0.269	0.654	0.625	0.908	0.774	0.658	0.708

Panel B. Canada with its OEA signatories

Exporter	Canada	Canada	EU	Canada	Japan	Canada	Costa Rica	Canada	Switzerland
Importer	U.S.[a]	EU[a]	Canada	Japan[a]	Canada	Costa Rica[a]	Canada	Switzer-Land[a]	Canada
Year signed	2009	2011	2011	2015	2015	2013	2013	2012	2012
$OEA_{ij,t-1}$			0.255		0.360***		0.031**		3.639***
			(0.249)		(0.079)		(0.015)		(0.276)
$Organic^k$			-1.766***		-1.789***		-2.846***		2.795***
			(0.373)		(0.102)		(0.377)		(0.280)
$OEA_{ij,t-1}$			0.159		1.079***		-0.551***		-4.328***
$* Organic^k$			(0.450)		(0.166)		(0.200)		(0.286)
N			4,104		299		425		210
R^2			0.316		0.868		0.797		0.839

Notes: The dependent variable in Panel A (Panel B) is the U.S. (Canada) exports and imports with each OEA signatory of agri-food products k at time t. All estimates include product fixed effects at the HS-6 level, whose estimates are omitted for brevity. Standard errors are in parentheses and are clustered by HS 6-digit product categories. *, **, and *** denote $p < 0.10$, $p < 0.05$, and $p < 0.01$, respectively.

[a] Effects of OEAs on Canadian exports can not be assessed as Canada's export data began being collected in 2017 which was after all Canadian OEAs were entered into force.

4.4. Robustness checks

A series of additional analyses were conducted to assess the robustness of the baseline findings. The phase-in effect of OEAs by including 1-year, 2-year, and 3-year lagged OEAs and the current status of OEAs were examined and results are shown in column (1).[29] It is shown there that OEAs do not facilitate U.S. or Canadian non-organic agri-food trade in the current period, but do generate 19% larger trade flows in the year after OEAs come into force and result in 10% larger trade flows in the third year after OEAs are in effect. In column (2), the country-pair-product fixed effects are dropped in exchange for standard covariates included in gravity models. Here OEAs are found not to be significant in facilitating overall trade, or that of tracked organic products. Potential differences in the effectiveness of OEAs by the national income of trading partners are explored in column (3) by including an interaction term between lagged OEA, organic dummy, and high-income country indicator. In this analysis, a 286% higher trade value of organic products among high-income OEA signatories is observed than organic trade values between U.S. (Canada) and their non-high-income signatories.

In columns (4)-(5), the sensitivity to the "rule of thumb" described in Section 3.2 is explored. Following Hejazi et al. (2022), we redefine the potential for trade as any positive trade value of organic agri-food products has occurred at least twice (three times; once) during the period over 2011-2019 (2007-2019; 2017-2019). The results shown in column (4) are robust to PPML estimations of baseline regression, suggesting that one-year lagged OEA induced 25% more trade value of non-organic agri-food products and not significant trade impacts of OEAs on organic

[29] It is believed that 1-year window in our analysis is sufficient for the OEA to be effective considering the long-time evaluation of each signatory's organic regulations and control systems before country pairs sign into OEAs. However, a 3-year organic conversion period is required by the U.S., Canada, and several other countries, requiring that no prohibited substances can be applied to soil for three years prior to harvest. As such, we examine the OEA phase-in effects by including as long as three years lagged OEAs.

products. In column (5), we tighten the threshold of potential for trade from 5,000 USD to 10,000 USD, leading to a smaller sample size but similar results in both signs and magnitudes. Next, we follow Boys et al. (2022) to include all the product categories in which at least one HS-10 product line under the HS-6 heading is an organic product (column 6). Not surprisingly, results show that OEAs have no significant impacts on either organic or non-organic trade values. Including product categories with a trivial share of trade values on organic products would possibly underestimate the OEA effects in real practice.

The Heckman selection model conducted in the baseline analysis is based on panel data that consists of all the organic product lines at the HS 10-digit level from 2007-2019, treating the trade value of organic products as zero if that product line did not exist in that year. However, the findings that a larger probability of trading organic products between country pairs might result from the evolution of (newly-added) HS 10-digit lines recorded for organic products rather than from the OEAs signed in the previous year. To disentangle the source of the extensive margin of OEAs from the evolution of organic product lines, we removed organic lines that did not exist in that year from the panel. Results of the Heckman selection model based on a new data set are shown in columns (7)-(8). We find that lagged OEAs significantly increase the likelihood of trading organic agri-food products by 13%, which is robust to results in Table 3. The results enhance our belief that the positive and significant increase in the probability of trading organic products is attributed to the OEA effects. Noticeably, the coefficient of the inverse mills ratio is significant, indicating that the new data is vulnerable to sample selection bias and, for this analysis, the use of the Heckman selection model is appropriate.

Table 7. Robustness checks

Estimator	PPML	PPML	PPML	PPML	PPML	PPML	Heckman Selection Model	
	OEA Phase-In	Include Gravity Variables	Country Income Groups	Relax Threshold of Trade Potential	Tighten Threshold of Trade Potential	Expand HS-6 Product Categories Considered	Selection Equation	Outcome Equation
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
OEA_{ijt}	0.013							
	(0.133)							
$OEA_{ij,t-1}$	0.173*	-0.081	0.226**	0.220**	0.215**	0.037	-0.056***	-0.686***
	(0.103)	(0.178)	(0.104)	(0.108)	(0.105)	(0.072)	(0.021)	(0.048)
$OEA_{ij,t-2}$	0.005							
	(0.102)							
$OEA_{ij,t-3}$	0.097*							
	(0.058)							
$Organic^{k}$	-1.994***	-2.065***	-2.066***	-2.062***	-2.072***	-1.943***	-0.227***	-0.850***
	(0.078)	(0.067)	(0.067)	(0.067)	(0.066)	(0.058)	(0.016)	(0.059)
$OEA_{ijt} * Organic^{k}$	-0.418							
	(0.374)							
$OEA_{ij,t-1} * Organic^{k}$	0.288	-0.014	-1.327***	-0.016	-0.005	-0.068	0.178***	0.149*
	(0.400)	(0.083)	(0.079)	(0.082)	(0.082)	(0.074)	(0.035)	(0.085)
$OEA_{ij,t-2} * Organic^{k}$	0.287							
	(0.290)							
$OEA_{ij,t-3} * Organic^{k}$	-0.180							
	(0.249)							
$\ln(GDP_{it})$		0.589***					-0.046***	0.444***
		(0.131)					(0.006)	(0.015)
$\ln(GDP_{jt})$		-4.442***					0.001	0.779***
		(0.245)					(0.006)	(0.014)
$\ln(Dist_{ij})$		1.032***					-0.100***	-0.671***
		(0.322)					(0.016)	(0.040)
$Border_{ij}$		0.937***					0.544***	2.551***
		(0.172)					(0.043)	(0.136)

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
$Lang_{ij}$		0.751^{***}					0.079^{***}	
		(0.160)					(0.015)	
$Colony_{ij}$		-0.032					-0.091	0.837^{***}
		(0.399)					(0.068)	(0.169)
ln $(AgArea_{it})$		0.361					0.014^{***}	0.083^{***}
		(0.342)					(0.005)	(0.011)
ln $(AgArea_{jt})$		27.730^{***}					-0.012^{***}	-0.286^{***}
		(2.494)					(0.004)	(0.010)
RTA_{ijt}		0.225^{***}					0.078^{***}	0.354^{***}
		(0.081)					(0.016)	(0.038)
CU_{ijt}		-0.604^{**}					0.026	-0.896^{***}
		(0.287)					(0.040)	(0.090)
$WTOBothin_{ijt}$		0.982^{**}					0.205^{***}	-0.058
		(0.398)					(0.041)	(0.099)
$OEA_{ij,t-1} * Organic^k * HI$			1.351^{***}					
			(0.063)					
Inverse Mills Ratio							1.030^{*}	
							(0.537)	
Exporter-product-time F.E	Yes	Yes	Yes	Yes	Yes	Yes		
Importer-product-time F.E	Yes	Yes	Yes	Yes	Yes	Yes		
Country-pair-product F.E	Yes		Yes	Yes	Yes	Yes		
Product-time F.E							Yes	Yes
N	33,160	44,956	44,821	50,509	42,768	83,832	56,514	56,514
R^2	0.833	0.832	0.828	0.827	0.824	0.757		

Notes: The dependent variable in columns (1)-(6) is U.S. and Canadian imports and exports of agri-food products k at the most disaggregated level (HS-10 products for U.S. trade and Canadian imports, HS-8 for Canadian exports) at time t. Column (7) and (8) shows the results of selection equation and outcome equation of the Heckman selection model. The dependent variable in the selection equation is a dummy variable indicating whether positive trade flows are traded between country pairs; the dependent variable in the outcome equation is the trade value conditional on the decision of trade. Standard errors are in parentheses and are "three-way" clustered by the exporter, importer, and year. *, **, and *** denote $p < 0.10$, $p < 0.05$, and $p < 0.01$, respectively.

5. Conclusions

Consumer demand for organic agri-food products has experienced a prolonged annual increase. According to FiBL Statistics[30], the global value of organic retail sales was $14.0 billion USD in 2000 and increased to $147.7 billion USD by 2021. This change reflects an average annual global market growth of 12.1% between 2000-2021. As of 2020, 96 countries have published national organic regulations.[31] While there are ongoing efforts by multilateral organizations to harmonize these standards, to date progress has been limited. As a result, some national governments have developed bilateral Organic Equivalency Agreements (OEAs) to reduce transaction costs such as dual certification costs and administrative barriers. For instance, the importance of OEAs are certain to become more important in the future as the European Green Deal's Farm to Fork Strategy has set targets of "at least 25% of the EU's agricultural land under organic farming and a significant increase in organic aquaculture by 2030".[32]

Using a unique and highly disaggregated international trade dataset, we find that OEAs are generally successful in facilitating U.S. and Canadian trade of organic agri-food products. The preferred PPML estimation finds that, on average, establishing an OEA in the previous year leads to a 23% increase in the trade of considered agri-food products. For Canada, these agreements were particularly beneficial for the trade of organic fruits and vegetables, oil seeds, and sugars. Canada’s OEAs with Japan, Costa Rica, and Switzerland were quite successful in facilitating the trade of non-organic (and organic but not tracked) agri-food products. In terms of trade-facilitating effects of OEAs on organic products, Canada benefited from the OEA signed with the U.S. and

[30] https://statistics.fibl.org/world/retail-sales.html
[31] Statistics reported by Willer et al. (2022) show that 76 countries have fully implemented regulations governing organic agriculture, and another 20 countries have developed organic regulations that are not yet fully implemented.
[32] https://agriculture.ec.europa.eu/farming/organic-farming/organic-action-plan_en#:~:text=Under%20the%20Green%20Deal's%20Farm,plan%20for%20the%20European%20Union

Japan in the previous year due to an increase in organic imports of 39% and 322%, respectively. For the U.S., more OEA trade-facilitating effects have been found on organic edible preparations. U.S. OEAs with Canada, the EU, and South Korea were particularly effective in facilitating the trade of tracked organic products.

5.1. Policy implications

Several considerations shape national decisions to pursue an OEA. Among these, and in addition to political dynamics, are the extent to which two countries are already trading organic products, and the relative similarity in their existing organic standards.

Given the usefulness of OEAs in facilitating agri-food trade, it would seem that they should be more extensively used. From the perspective of the U.S., due to its relative proximity and already deep trading relationship, the U.S. has had a long-standing interest in forging an OEA with Mexico (USCC, 2012). This trade relationship, however, has recently been strained. While the U.S. and Mexico did not have an equivalency agreement, until December 2021 USDA-certified products were recognized as organic in Mexico. (The U.S. did not reciprocate this recognition of Mexico's Organic Products Law (LPO).) As of January 2022, Mexico no longer recognizes the USDA standard as equivalent and now requires that imports from the U.S. be certified to the LPO (USDA-AMS).[33] Also, in 2021, the U.S. revoked its organic recognition agreement with India citing a need for greater oversight of organic products coming from India.[34] At the same time, Canada has been expanding the scope of existing OEAs and forging new agreements. Discussions are ongoing to expand the scope of the Canada-Japan agreement to include alcohol and enter a new agreement with South Korea (Willer et al., 2023). Also, and perhaps particularly interesting

[33] https://www.ams.usda.gov/services/organic-certification/international-trade-mexico

[34] In addition, in 2022, the U.S. launched an antidumping investigation which found that the Indian government subsidized Indian organic farmers (Willer et al., 2023).

considering the state of U.S.-Mexico organic trade relations, Canada has entered an OEA with Mexico as of May 2023 (Canadian Food Inspection Agency).[35]

It is worth reemphasizing that the policy role for OEAs is not limited to trade – these agreements, or lack thereof, may also encourage the development or enhancement of domestic organic policies. By way of example, the European Commission published its latest organic regulation EC2018/848 in 2018 and enforced it in 2022. The Australian Certified Organic Standards were revised in 2019 to keep pace with EU rules related to organic wine and livestock products, which were excluded from the EU-Australia OEA. Certainly, this and other forms of organic standard efforts harmonization will go far to strengthening the potential benefits of equivalency and other forms of organic trade agreements.

[35] The website of the Canadian Food Inspection Agency is available at: https://inspection.canada.ca/organic-products/equivalence-arrangements/cmoea/eng/1674764950639/1674764951343

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