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Effects of Organic Equivalence Agreements on Organic Production: Evidence from the Synthetic Control Method

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The effects of organic equivalence agreements (OEA) on organic export value have been studied; however, their effect on organic production is yet to be investigated. This study examines the effect of the European Union's (EU) OEAs on the organic land share of partner exporting countries. Employing the synthetic control method, this study provides evidence that the EU's OEAs have positive effects on organic land shares of exporting countries. Additionally, the duration of the time lag following the intervention of OEAs varied across countries.

Key words: organic farming, trade, synthetic control method

1. Introduction

In the 21st century, increasing awareness of environmental protection and health has shed light on the consumption and production of organic agriculture. In 2021, the European Union (EU) has taken 37% of the global organic food and drink market in 46.7 billion euros. In the meantime, after Oceania, Europe has the second-largest expanse of organic farmland, covering a substantial 17.8 million hectares. This area accounts for approximately 23% of the world's total organic farmland (Willer *et al*., 2023). In response to the ever-growing appetite for organic products, the EU witnessed a surge in total organic product imports, escalating from 2.79 million tons in 2020 to 2.87 million tons in 2021 (European Commission, 2022).

The EU has developed several mandatory organic certifications and accreditation systems for organic products (European Commission, 1999). All organic products imported into the EU must have the appropriate electronic certificate of inspection (e-COI). Non-EU countries have the option to apply for the e-COI from relevant control bodies designated by the EU. However, various organic certification schemes in different control bodies contribute to the higher costs associated with the trade, including engaging in negotiations, and checking whether products comply with the appropriate specifications (Sawyer *et al*., 2008). Food and Agriculture Organization advises importing countries to avoid using organic certification standards as technical barriers to trade. In response to this, non-European countries have another option to apply for recognition as "equivalent countries," indicating that their national standards align with the EU's standards for organic production, processing, inspection, and certification. Organic equivalent countries can apply the e-COI from their national authorities and their products do not need a second review when entering the EU market. By 2023, the EU has established partnerships of OEAs with 14 countries for different scopes of organic products.

Past studies focused primarily on analyzing the effects of organic equivalence agreements (OEA) on the export values of organic products from trade partners. For example, the effect of the OEA on international organic trade in the United States was investigated by Demko and Jaenicke (2018). The research found that these agreements had positive effects on the flow of organic trade, although their effect was sensitive to factors such as the direction of trade flow, period, and countries involved. However, to the best of our knowledge, no study has yet investigated the effect of OEAs on the organic production of trade partners.

Among 14 the EU's trade partners, based on specific criteria, Chile, South Korea, Canada, and Australia were selected as treatment countries. These countries have reached OEAs with the EU. We applied the synthetic control method to estimate the impact of OEAs on organic land shares. Organic land share serves as a stable, direct, and clear indicator of the extent of organic production. The primary aim of this research is to provide a comprehensive and data-driven analysis of how OEAs with the EU affect organic production within these trade partner countries. We would

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like to contribute to the understanding of the dynamics between trade agreements and organic agriculture practice and potentially discuss future policy recommendations in the realm of international trade agreement and organic farming development.

The remainder of this paper is organized as follows. Section 2 elaborates on the framework of the synthetic control method and its applications. Section 3 provides detailed information on the data, including the outcome variables, predictors, and the selection of treatment countries. The results are presented in Section 4. Finally, Section 5 presents the conclusions, limitations, and future plans for this research.

2. Method

The synthetic control method was utilized to account for two key challenges: the limited small sample size of organic land share data and the substantial heterogeneity across each partner country. To tackle these issues, we constructed synthetic counterparts individually for Chile, South Korea, Australia, and Canada. These synthesized comparators were designed to replicate the performance of each country's organic land shares prior to their OEAs with the EU. For each trade partner, we employed the optimal weighted average for each donor pool to create a synthetic counterpart. The donor pool comprises non-EU countries that do not have any OEA. The application of the synthetic control method used in this study has been described in details in a series of studies by Abadie (Abadie and Gardeazabal, 2003; Abadie *et al*., 2015).

Suppose there is a sample of $J+1$ countries and only the first country is exposed to a bilateral OEA with the EU. Other J countries are called the donor group. The time periods preceding and following the year when the OEA came into effect are commonly denoted as the pre-treatment period $\boldsymbol{T_0}$ and post-treatment period $\boldsymbol{T_1}$. Since the year of issue of the OEA servers as a cutoff between $\boldsymbol{T_0}$ and $\boldsymbol{T_1}$, it can be included in either $\boldsymbol{T_0}$ or $\boldsymbol{T_1}$ and will not affect results of treatment effects. Let the outcome variable Y_{jt} be the organic land share of country j at time t of $\boldsymbol{T_0}$ or $\boldsymbol{T_1}$, which measures the ratio of the total organic land area to the total agricultural land area.

Suppose there are k predictors for each country, let $\boldsymbol{X_1}$ be a $k \times 1$ vector of predictors of the treated country and $\boldsymbol{X_0}$ be a $k \times J$ vector of the same predictors for the countries in the donor pool. The weight placed on each country in the donor pool is symbolized as w_j, and the vector of weight w_j is denoted as $\boldsymbol{W}$, a $J \times 1$ vector. Hence, the differences in the predictors between the treated trade partner and the synthetic counterparts are given by vector $\boldsymbol{X_1} - \boldsymbol{X_0 W}$. Abadie and Gardeazabal (2003) introduced $\boldsymbol{V}$ as a $k \times k$ diagonal matrix with nonnegative components to reflect the relative importance of each predictor. A calculation method for the optimized $\boldsymbol{W}^*$ is proposed as follows:

$$Minimize \sqrt{(\boldsymbol{X_1} - \boldsymbol{X_0}\mathbf{W})^{\mathrm{T}}\boldsymbol{V}(\boldsymbol{X_1} - \boldsymbol{X_0}\mathbf{W})},$$

$$subject\ to\ 0 < w_j < 1\ and\ \sum_{j=2}^{j=j+1} w_j = 1. \quad (1)$$

The choice of $\boldsymbol{V}$ can be any initial value $\boldsymbol{V_0}$ based on prior knowledge of relative importance of the predictors, and $\boldsymbol{V}$ affects the root-mean-squared prediction error (RMSPE). Intuitively, the RMSPE measures the discrepancy in fit between the outcomes of the treatment observations and their synthetic counterparts during the pre-intervention period (Abadie and Gardeazabal, 2003; Abadie *et al*., 2015). The optimal synthetic counterpart during the pre-intervention period was reproduced by identifying the optimized $\boldsymbol{W}^*$, the optimal $\boldsymbol{V}^*$ and minimizing the RMSPE with iteration. Let $\boldsymbol{Y_{1t}^N}$ be the organic land share of the synthetic counterpart. Given $w_j{}^*$ calculated from equation (1), the counterfactual $\boldsymbol{Y_{1t}^N}$ is replaced by the weighted average value of organic land shares of the donor pool. Let $\widehat{\alpha_{1t}}$ be the difference of the organic land shares between OEA trade partners and their respective synthetic counterparts. Consequently, the inferential effect of the OEA $\widehat{\alpha_{1t}}$ is calculated as

$$\widehat{\alpha_{1t}} = Y_{1t} - \sum_{j=2}^{j=j+1} w_j{}^* Y_{jt}. \quad (2)$$

Given that the data sample size in the synthetic control method is typically limited, and the number of countries in the donor pool is relatively small, it is not appropriate to rely on conventional statistical inference based on large sample theory to assess the significance of the treatment effect. Additionally, there is a potential risk that results of the synthetic control method are sensitive to the choice of the donor units (Firpo and Possebom, 2018). Therefore, we conduct placebo tests and a leave-one-out robustness to check for each treatment country.

In the placebo test, similar to the process used by Abadie in 2003 and 2015, we treated each country in the donor group as a fake treatment country individually and calculated the fake treatment effect at the same intervention time. Countries with inadequate fitness outcomes of the synthetic control method during the preintervention period were excluded. The cutoff standard of exclusion, the ratio of the fake treatment country's RMSPE to the treatment country's RMSPE, is set at two for each fake treatment country. In the leave-one-out robustness check, we deleted each country in the donor pool individually to avoid bias generated by a specific country.

3. Data

1) Treatment and Donor pool

We selected organic data of 187 countries from 2000 to 2020 collected by The Research Institute of Organic Agriculture (FiBL, 2019). Among 187 countries, 27 EU countries and their overseas islands are not objects of this research. As of June 2022, the EU has concluded bilateral OEAs for trade in organic products with 14 countries: Argentina, Australia, Canada, Chile, Costa Rica, India, Israel, Japan, Tunisia, South Korea, Switzerland, the United States, the United Kingdom, and New Zealand. These countries are regarded as the treatment group in our study.

To create an appropriate synthetic counterpart, the donor group must comprise countries without any OEA. Although this study focused on OEAs with the EU, the countries where there are OEAs with the United States, another massive market of organic agricultural products, should also be considered. By 2022, the United States has OEAs with Canada, European Union, Japan, South Korea, Switzerland, Taiwan, and the United Kingdom. Consequently, all countries and regions which have OEAs with both the EU and the United States were removed from the donor pool.

We selected different periods based on the time of OEAs . For Chile and Korea, we selected the period from 2010 to 2020, for Australia, we selected the period from 2004 to 2020, and for Canada, we selected the period from 2006 to 2020. Additionally, we need to maintain the consistency of the donor pool composition during the whole period. Therefore, we excluded countries with insufficient data of organic land shares in the respective donor pool. Finally, there are 75 (Chile/Korea), 50 (Australia), 64 (Canada) countries in the donor group for each trade partner.

2) Treatment Countries

We selected Chile, South Korea, Canada, and Australia as the treatment countries. The OEA between Chile and the EU became effective in January 2018 (European Council, 2017). The OEA between South Korea and the EU came into effect since February 2015 (South Korea Environment-Friendly Agricultural Products Certification, 2015). The OEA between Canada and the EU took effect in June 2011 (Government of Canada, 2011). Australia has agreed with the EU on the OEA since 2008 (Department of Agriculture, Fisheries, and Forestry of Australian Government, 2021).

Furthermore, the rationale for not selecting countries other than the four listed above as treatment countries is as follows: India, Switzerland, the United States, Costa Rica, and Israel do not have a cutoff year treated as the time of intervention. For example, India established the National Program on Organic Production standards in 2000, an international organic equivalent standard with the EU. However, since 1992, India has been included in the list of trade partners for the products that were certified by a voluntary accredited public control body in India, the Agricultural and Processed Food Products Export Development Authority (Archana, 2013). The intervention periods for Argentina and the United Kingdom were not sufficiently defined to apply the synthetic control method and do not have sufficient data. Additionally, Japan, Tunisia, and New Zealand exhibited poor outcome fitness during the pre-intervention period, meaning that it is not appropriate to use them to predict counterfactual results after OEAs.

3) Outcome Variable and Predictors

The outcome variable is the organic land share, specifically fully converted land. In the EU's organic control system, food producers, processors, and traders must be registered with a control agency to market their products as organic. During the conversion period, farms undergo a transition phase in which organic production methods are practiced; however, products cannot be sold as organic until the conversion is complete. The duration of the conversion period varies depending on the type of organic products being grown.

About the predictors, we selected pre-intervention organic land shares at certain intervals. We also employed the mean

Table 1. Descriptive Statistics

Variable	Treatment Group			Synthetic Control Group			Unit
	Obs.	Mean	Std. Dev.	Obs.	Mean	Std. Dev.	
Organic land share	290	2.2	3.1	1869	1.3	4.0	Percentage
Organic processors	162	918.0	856.4	1018	93.6	474.3	Legal/Natural person

value of organic processors (calculated as an average value in time-series direction for each country) as a predictor in the synthetic control method. The mean value is applied to account for the issue of data missing in some years to keep enough countries in the donor group. This choice was based on the validity of using characteristics unaffected by the intervention as predictors (Abadie and Gardeazabal, 2003). Furthermore, it is a common practice to include lagged values of the outcome as predictors in the pretreatment period, along with other covariates (Kaul *et al*., 2022). Table 1 provides a description of the predictor data for both the treatment and synthetic control groups.

4. Results

Table 2 displays the treatment effect, *p*-values calculated from the placebo test, and ranges of estimated effects calculated from the leave-one-out robustness check, in the time period after the EU's OEAs. Our study observed that overall, OEAs with the EU increased organic land shares in trade partner countries. Statistically significant positive effects were observed at the 5% level for Chile in 2020 (2 years after agreement) and Australia in 2014 (6 years), and at the 10% level for South Korea in 2019 (4 years) and Canada in 2019 (8 years).

Below, we discuss the results of the treatment effects and the evolution of the actual value of organic land shares by country. The most remarkable effect was observed in Chile, where the estimated treatment effect in 2020 was approximately 0.9%. In terms of actual value, organic land share in Chile was only 0.1% in 2017, which means that the treatment effect was nine times greater than the pre-treatment value. Similar results are observed for the other three countries. The treatment effect in South Korea in 2019 was approximately 1.0%, the fourth year after the OEA in 2015. In terms of actual value, the organic land share in South Korea increased from 1.0% in 2014 to 1.8% in 2019. In Australia case, the treatment effect took six years to become significantly positive, which has remained stable at approximately 5.3% since 2016. The organic land share of Australia increased from 2.8% in 2007 to 7.9% in 2016. Finally, regarding the results for Canada, it can be concluded that the OEA increased the organic land share of Canada by 0.6% in 2019, nearly eight years after the OEA in June 2011 (Kaul *et al*., 2022). In terms of actual value, the organic land share of Canada increased from 1.2% in 2011 to 2.3% in 2019. The expansion of organic farmland typically took place several years after agreements were established. One common reason for this delay is the organic certification requirement, which mandates that the land must be chemical-free for the previous two or three years, depending on the crops.

Table 2. Results

		Treatment Effect	*p*-value		Treatment Effect (LOO) Min	Max
Chile	**2018**	**-0.024**	**0.548**		**-0.031**	**0.006**
	2019	0.016	0.774		0.004	0.045
	2020	0.872	0.032	**	0.861	0.911
South Korea	**2015**	**0.076**	**0.297**		**0.067**	**0.137**
	2016	-0.198	0.219		-0.366	-0.189
	2017	0.141	0.328		-1.017	0.272
	2018	0.270	0.297		-0.525	0.305
	2019	0.972	0.094	*	0.700	1.041
	2020	1.563	0.063	*	1.234	1.626
Australia	**2008**	**-0.238**	**0.125**		**-0.305**	**-0.043**
	2009	-0.426	0.125		-0.553	-0.049
	2010	-0.337	0.292		-0.477	0.058
	2011	-0.516	0.167		-0.625	-0.193
	2012	-0.399	0.188		-0.469	-0.193
	2013	0.993	0.104		0.911	1.231
	2014	2.180	0.021	**	1.435	2.427
	2015	3.042	0.021	**	2.180	3.324
	2016	5.364	0.021	**	2.560	6.300
	2017	5.754	0.021	**	3.470	6.526
	2018	5.895	0.042	**	2.973	6.880
	2019	5.922	0.021	**	2.969	6.906
	2020	5.539	0.021	**	1.147	6.998
Canada	**2012**	**0.184**	**0.027**	**	**0.108**	**0.245**
	2013	0.213	0.081	*	0.146	0.275
	2014	-0.011	0.811		-0.063	0.073
	2015	0.269	0.135		0.217	0.362
	2016	0.265	0.108		0.146	0.415
	2017	0.115	0.378		-0.127	0.422
	2018	0.112	0.432		-0.156	0.320
	2019	0.601	0.054	*	0.382	0.762
	2020	0.967	0.054	*	0.504	1.164

Note: 1) Asterisks ** and * denote significant difference from zero at 5 and 10 percent level, respectively. Bar length reflects the size of treatment effects. The last two columns show the minimum and maximum treatment effects estimated by the leave-one-out (LOO) test.

In 2021, the EU imported 27, 909 tons of organic food from Chile, which was nearly equivalent to the EU's imports from Canada, totaling 30,610 tons (Willer *et al*., 2023). When we consider the total farmland in Chile, which stood at 2.5 million hectares according to FAO statistics for the year 2021, and compare it to Canada's vast expanse of 73.1 million hectares, it becomes evident that the volume of organic farming trade with the EU has a significant impact on the overall agricultural landscape in Chile.

We can take into consideration that the treatment effect, especially in Chile—a developing country—is significant in terms of fixed costs associated with quality signaling. Auriola and Schilizzi (2015) made the argument that the expense associated with quality signaling, which includes organic products, can be a substantial fixed cost that is separate from the actual cost of producing organic products. In affluent nations, there should be extensive adoption of high-quality certified products, while in less affluent countries, their utilization tends to be limited, even when the production of these products isn't overly expensive. Lowering fixed costs associated with quality signaling through the OEA could incentivize organic production in less capital-rich developing countries. However, our study, limited to Chile, didn't detect significant differences in OEA's impacts between developed and developing nations. Further research is imperative.

As a robustness check for the choice of synthetic controls, we applied the leave-one-out test (The rightmost column, Table 2). It shows that the results of synthetic control method are hardly affected by the choice of any observation in the donor group and supports the conclusion that the OEA with the EU has positive effects on organic land shares.

5. Conclusion

Generally, countries with lower levels of organic production benefit from OEAs, as they facilitate technology adoption and the management of organic information (Sapbamrer and Thammachai, 2021). From organic agriculture development perspective, past literature suggests that OEAs have several benefits, including the establishment of national organic standards, government control systems, and the provision of information about organic producers, processors, exporters, and importers at the national level (Ellis *et al*., 2006). From an economic perspective, the harmonization of certification systems in different countries has been shown to reduce certification and transaction costs and boost organic trade (Pekdemir, 2018).

In this research, we found that the EU's OEAs have a positive effect on the increase in organic land shares in exporting countries, and organic export volume to the EU can be an important factor for different time lags and treatment effects.

These findings have important policy implications for organic agriculture development. The study demonstrates the positive effects of the EU's OEAs on promoting organic production in trade partners. In the case of Chile, a developing country, the rapid promotion effect was observed with less time lag. This implies that the transaction costs associated with organic trade, like dealing with multiple authorities, diverse certification processes, negotiations, and product checks, which are supposed to be higher in developing countries, may have a notable negative influence on the adoption of organic farming. OEAs could help address these market hurdles stemming from high fixed costs, thus promoting the production of organic agricultural goods. This also suggests that promoting organic agriculture requires more than just offering technical assistance to local farmers and educating consumers within their own countries. It also necessitates engaging in diplomatic initiatives with countries that serve as international shipping destinations on a broader scale.

This study has several limitations that warrant further research. OEAs with the US can also affect the results. South Korea-US Organic Equivalency Agreement was enacted in July 2014 just before the agreement signed with the EU. Canada also has the OEA with the United States since June 2009 (Government of Canada, 2009). Previous studies have indicated a strong positive effect of the agreement between the Unites States and Canada on the US export value (Jaenicke and Demko, 2015). Therefore, the observed increase cannot be solely attributed to the EU's OEA. Future research could focus on analyzing agricultural trade flows using specific organic codes to determine the individual effects of the EU and the US OEAs. The research scope can involve both organic trade flows and organic land shares. This would provide a more comprehensive understanding of the specific effects of different OEAs on organic production.

Another limitation is the choice of predictors. Although using the value of the outcome variable in the pretreatment period as a predictor is a practical and commonly used approach, Firpo and Possebom (2018) pointed out that the results could be sensitive to choices of covariates. Because the determinants of organic land shares may vary across different counties, and data availability is limited for additional characteristics, the potential choices for predictors in this study are limited. By incorporating more information on the determinants of organic land shares, the predictors of the synthetic control method can be modified to yield more accurate results. In future studies, a broader range of predictors should be considered, including a longer period following the intervention of OEAs.

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