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SDGs trade-offs associated with voluntary sustainability standards: A case study from the coffee sector in Costa Rica

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Abstract

The transition toward a more sustainable agricultural production has become an essential step in achieving the sustainable development goals (SDGs), launched by the United Nations in 2015. Voluntary sustainability standards (VSS) have been proposed as a useful governance tool for guiding this transition. Thus, this article uses a case study from the coffee sector in Costa Rica to assess the contribution of VSSs to the achievement of the SDGs. We rely on panel data from coffee producers captured between 2017 and 2019 to carry out this assessment. Results of the statistical analysis suggest that VSSs alone are not enough to promote a transition to a more sustainable coffee production, as trade-offs between the contributions of VSSs to the different SDGs emerge. If the VSSs are to promote sustainable practices among producers while ensuring socioeconomic benefits for producers, workers, and their families, implementation modifications are required.

KEYWORDS
certification, coffee, sustainable development goals, trade-offs, voluntary sustainability standards

1 | INTRODUCTION

The United Nations Assembly adopted the sustainable development goals (SDGs) development agenda in 2015, which consists of 17 goals and 169 associated targets. Unlike the millennium development goals (MDG), the SDGs call for a global partnership that brings "together governments, the private sector, civil society, the United Nations system, and other actors, and mobilizing all available resources" (UN General Assembly, 2015, p. 14). The success of this agenda depends on strengthening stakeholders' commitment, establishing clear milestones and targets, and a clear system of global accountability (Biermann et al., 2017). Some academics are concerned that the SDG agenda legitimizes green protectionism and distracts developing populations from their fundamental needs and priorities (Partzsch et al., 2021). Despite these criticisms, the SDGs provide a framework for addressing sustainability in the global value chain (GVC) of food. Improving the previous MDGs, the SDGs were constructed after a broad worldwide consultation. They include an integrative agenda in which all countries are invited to participate and set their aspirational objectives in collaboration with the private sector (Biermann et al., 2017; Marx & Depoorter, 2020; UN General Assembly, 2015). Furthermore, Biermann et al. (2017) emphasized that the SDGs are the most ambitious goal-oriented global initiative to date that integrates the three pillars of sustainability—economic, social, and environmental—in one comprehensive development agenda. Table 1 summarizes the 17 SDGs, with the respective number of targets, and indicators.

Given the comprehensive nature of the SDGs, interactions between their targets are an expected outcome (Pradhan et al., 2017; Scherer et al., 2018), ranging from total cancelation to total indivisibility (Nilsson et al., 2016). On this scale, the relationship between different SDGs can be synergistic when progress on one goal also improves the progress on other SDGs (Pradhan et al., 2017; Renaud

TABLE 1 SDG, targets, and indicators.

SDG			
	Goal 1. End poverty in all its forms everywhere Targets: 7 Indicators 13		Goal 9. Build resilient infrastructure, promote inclusive and sustainable industrialization and foster innovation Targets: 8 Indicators: 12
	Goal 2. End hunger, achieve food security and improved nutrition and promote sustainable agriculture Targets: 8 Indicators: 14		Goal 10. Reduce inequality within and among countries Targets: 10 Indicators: 13
	Goal 3. Ensure healthy lives and promote well-being for all at all ages Targets: 13 Indicators: 25		Goal 11. Make cities and human settlements inclusive, safe, resilient and sustainable Targets: 10 Indicators: 15
	Goal 4. Ensure inclusive and equitable quality education and promote lifelong learning opportunities for all Targets: 10 Indicators: 12		Goal 12. Ensure sustainable consumption and production patterns Targets: 11 Indicators: 13
	Goal 5. Achieve gender equality and empower all women and girls Targets: 9 Indicators: 13		Goal 13. Take urgent action to combat climate change and its impacts Targets: 5 Indicators: 8
	Goal 6. Ensure availability and sustainable management of water and sanitation for all Targets 8 Indicators: 11		Goal 14. Conserve and sustainably use the oceans, seas and marine resources for sustainable development Targets: 10 Indicators: 10
	Goal 7. Ensure access to affordable, reliable, sustainable and modern energy for all Targets 5 Indicators 6		Goal 15. Protect, restore and promote sustainable use of terrestrial ecosystems, sustainably manage forests, combat desertification, and halt and reverse land degradation and halt biodiversity loss Targets: 12 Indicators: 14
	Goal 8. Promote sustained, inclusive and sustainable economic growth, full and productive employment and decent work for all Targets: 12 Indicators: 16		Goal 16. Promote peaceful and inclusive societies for sustainable development, provide access to justice for all and build effective, accountable and inclusive institutions at all levels Targets: 12 Indicators: 17
			Goal 17. Strengthen the means of implementation and revitalize the Global Partnership for Sustainable Development Targets: 19 Indicators: 24

Abbreviation: SDG, sustainable development goal.

et al., 2022). Individual SDGs may also be in conflict with one another, such that achieving one goal impedes the achievement of others (i.e., trade-offs between SDGs; Pradhan et al., 2017; Renaud et al., 2022). Recently, the topic of synergies and trade-offs between SDGs has been extensively studied in the development field (De Neve & Sachs, 2020; Nilsson et al., 2016; Renaud et al., 2022; Zhao et al., 2021). These studies predominantly adopt a global or national perspective; local, empirical case studies on the value chain and agri-food systems are scarce (Mohd Hanafiah et al., 2022; Wei et al., 2022).

Amid this increasing interest in the SDGs and sustainability, traditional agricultural production systems, such as coffee production, are being challenged. Sustainability scholars relate agricultural production to land, water, and ecosystems degradation, biodiversity loss, and climate change (Adegbeye et al., 2020; El Bilali & Allahyari, 2018). Furthermore, from the socio-economic point of view, current agricultural production systems continue to keep a portion of the population in poverty while pushing the planetary boundaries to their limits (El Bilali et al., 2019).

Acknowledging these threats is a call for transformation in the agricultural sector, not only at the producer level but also along the entire supply chain (Vermunt et al., 2020). Furthermore, a rapidly growing body of literature suggests that transitioning toward more sustainable agricultural systems that can meet the current needs of agri-food production, without compromising the economic, social, and environmental foundations, is possible (DeLonge et al., 2016; El Bilali et al., 2019). This new system should consider objectives beyond economic performance and productivity, including environmental protection, social welfare, and food and nutrition security (Gaitán-Cremaschi et al., 2020). Based on this call for transformation, this article explores how VSSs' governance tools are contributing to achieving the broad sustainability targets embodied in the SDG agenda.

The UN General Assembly (2015) in the 2030 development agenda—where the SDGs are embedded—recognizes that capacity building will be required to achieve these goals. At the same time, they stress their will to work with existing platforms and processes to avoid duplication of efforts. Here, governance tools, such as VSSs can play a relevant role in pushing forward toward the achievement of these goals. On the understanding that VSSs are already well-established global tools to promote sustainability in a wide range of industries, and that they have already in place numerous capacity-building mechanisms to promote compliance among certified units.

The United Nations Forum on Sustainability Standards (UNFSS) defines VSSs as "standards specifying requirements that producers, traders, manufacturers, retailers or service providers may be asked to meet, relating to a wide range of sustainability metrics, including respect for basic human rights, worker health and safety, environmental impacts, community relations, land-use planning and others" (UNFSS, 2013, p. 4). Reinecke et al. (2012) highlighted various reasons for the emergence and proliferation of VSSs; among them are the liberalization of the market and the dissolution of the International Coffee Agreement (ICA), the shift on power toward big corporations, and the increase in relevance of food safety and traceability. VSSs emerged also from market demand, to help final consumers consume more ethically (Tayleur et al., 2018). To achieve this, VSSs provide positive incentives, such as premiums, higher prices, training or access to markets, to promote changes in agricultural practices, fulfillment of human rights (i.e., minimum wage, no child labor, no forced labor, and practices to protect the health of the workers), and achieve a sustainable production. To obtain these benefits, producers must be audited periodically to ensure compliance (DeFries et al., 2017; Ibanez & Blackman, 2016; Traldi, 2021).

Schleifer et al. (2022) have conducted a document analysis to understand the extent to which VSSs have incorporated the SDGs in developing their standard catalogs. Nonetheless, there is a dearth of empirical impact studies evaluating how successful VSSs can contribute to the implementation of the SDG agenda as a whole. Recent meta-studies and systematic reviews offer reliable summaries of these studies (Dietz et al., 2022; Meemken, 2020; Oya et al., 2018). However, the majority of studies on VSSs' impacts focus on a limited number of outcome variables within a single issue area of sustainable development (environmental, economic, or social sustainability), failing to provide a comprehensive picture of the sustainability impacts of VSSs on certified production sites in the context of the broad SDG agenda. Moreover, most existing impact literature largely does not connect their analysis to the SDG targets. Therefore, the extent to which current VSSs systems promote the SDG agenda is a largely open question.

In light of this research gap, we explicitly employ a SDG lens to analyze the impact of VSSs. Specifically, we present a quasi-experimental study based on empirical evidence from a panel data set of coffee producers in Costa Rica, captured between 2017 and 2019, to assess the contribution of four VSSs in the coffee industry (i.e., Fairtrade, Rainforest Alliance, Nespresso AAA, and Starbucks C.A.F.E. Practices) to the achievement of the SDGs at the producer level.

For this purpose, our guiding research question is *How are VSSs contributing to the achievement of the SDGs in the coffee sector of Costa Rica*? Based on some VSSs' studies suggesting a trade-off between environmental and socioeconomic outcomes (Vanderhaegen et al., 2018) and some SDG studies highlighting existing trade-offs between SDGs (De Neve & Sachs, 2020; Pradhan et al., 2017; Scherer et al., 2018) we worked also two secondary research questions: *Q1: Are VSSs contributions to SDGs heterogeneous among the three pillars of sustainability? Q2: Are VSSs' contributions to SDGs heterogeneous among the different certifications/verifications?*

The results show that although VSSs can improve—at least a small number of—individual sustainability outcomes, as envisioned by the SDGs, they clearly fail to successfully implement an integrated development agenda across the three pillars of economic, social, and environmental sustainability. Overall, these results indicate trade-offs between the various sustainability pillars and, consequently, between the different SDGs. According to our case study, the ability of VSSs to overcome these trade-offs in the implementation of the SDGs seems to be limited.

The remainder of the article is structured as follows: Section 2 discusses the importance of VSSs as governance tools for sustainability, followed by an analysis of the relationship between SDGs as a global framework for sustainable development and VSS. Section 3 presents the coffee sector in Costa Rica globally. After these theoretical sections, Section 4 introduces the methods to carry out the statistical analysis. Section 5 presents the results. Section 6 discusses our findings. Finally, Section 7 concludes the paper.

2 | VOLUNTARY SUSTAINABILITY STANDARDS AS A GOVERNANCE TOOL FOR SUSTAINABILITY

Manning and Reinecke (2016) argued that some degree of governance is required to guide transitions toward more sustainable agricultural production systems. They explored the role of VSSs as governance tools for directing these transitions in the coffee sector. Moreover, they found that standard-setters develop governance modules through local niche experimentation, during which they negotiate and legitimize their content before reintegrating them into an emerging

architecture. As a result of this modular design, sustainability goals are translated into standards through "… an evolving set of manageable, adaptable, governance modules" (Manning & Reinecke, 2016, p. 619) that address the three pillars of sustainability (economic, social, and environmental).

In principle, participation in the VSSs is voluntary and is generally driven by market incentives. Nevertheless, VSSs can adopt a quasi-legal character, becoming a mandatory requirement for accessing international markets (Dietz et al., 2018; Glasbergen, 2018). This is one of the most controversial aspects of the VSSs, as various authors have argued that certification programs run the risk of leaving behind poorer farmers (DeFries et al., 2017; Meybeck et al., 2014; Tayleur et al., 2017; UNFSS, 2016).

In the last decade, without any new emerging intergovernmental regulation, VSSs from independent third parties, such as non-government organizations or corporations, emerged to promote sustainable agriculture, including social equity, ecological sustainability, and economic growth (Manning et al., 2012). Reinecke et al. (2012) summarized the characteristics of the major VSSs in the coffee sector: Fairtrade focuses mainly on social justice and minimum price, and less on quality. Rainforest Alliance (now merged with UTZ) was created in 1987 (1995 for coffee) and strongly focuses on environmental conservation. In recent years, it has increased their social and economic requirements. The Rainforest Alliance has a flexible, non-mandatory certification premium. These two VSSs are third-party programs, meaning they are independent and unrelated to corporate certifications. The following three larger corporate programs exist. First, Nespresso AAA was introduced in 2003 and significantly emphasized coffee quality. Second, Starbucks C.A.F.E. Practices began in 2004 and focuses on environmental and social practices, but not as stringent as third-party certifications. Additionally, they have an optional premium. Third, Common Code for the Coffee Community (4C) was established in 2006 as a joint corporate response to third-party sustainability standards. Likewise, this has no mandatory premium. This study examines nearly all of the mentioned VSSs except for 4C, which is not present in Costa Rica.

This proliferation of standards is associated with two main adverse outcomes: First, it can cause overlapping of conflicting standards that could create confusion and additional costs to producers, thus reducing the effectiveness of these standards. Second, this proliferation might lead to a race-to-the-bottom scheme, this means the reduction of the stringency of their criteria in order to capture more market (Partzsch et al., 2021; Schleifer et al., 2022). In the middle of this growing proliferation, VSSs are contested on their contribution to the 2030 SDG agenda (Partzsch et al., 2021).

Over the years, a growing body of empirical literature has been developed that attempts to measure the impact of VSSs on sustainability in producing countries. This literature is summarized in some of the most relevant meta-studies and systematic reviews published in the last years (DeFries et al., 2017; Dietz et al., 2022; Meemken, 2020; Oya et al., 2018). However, none of these studies have addressed how VSSs contribute to achieving the SDG agenda from an empirical point of view.

Few studies have collected empirical data to measure the contribution of the VSSs toward the achievement of the SDG agenda (Fleming et al., 2017; Partzsch et al., 2021; Shamsuzzaman & Islam, 2018; Yue et al., 2020). For instance, Fleming et al. (2017) addressed the topic through a case study in a salmon aquaculture company in Australia and focused on understanding the company's perception regarding the SDGs. Partzsch et al. (2021), the only one of these studies focusing on coffee, explored whether a "race-to-the-bottom" trend presents the codes for Bird Friendly, EU Organic, Fairtrade International, 4C, and Rainforest Alliance for SDG 6 (Clean Water and Sanitation). Meanwhile, Shamsuzzaman and Islam (2018) focused on the fishery sector to study the effects of non-compliance on achieving SDG 14 (Life Below Water). Finally, Yue et al. (2020) looked for evidence of a "race-to-the-bottom" at a global level when studying the relationship between the production of sustainable food, biodiversity, and mineral price.

As observed by Tayleur et al. (2017) and Vanderhaegen et al. (2018), results are still inconclusive. Furthermore, most of the reviewed articles focus only on one or two of the three pillars of sustainability, making it difficult to identify trade-offs between them and consequently between SDGs (Traldi, 2021). This article also addresses this deficiency by comparing variables related to the three pillars of sustainability and addressing a variety of SDGs simultaneously.

3 | THE COFFEE SECTOR IN COSTA RICA

According to a survey conducted by the International Coffee Organization (ICO, 2019b), the proportion of coffee farmers living below the standard poverty line (1.90 USD/day) has increased by between 7% and 50% over the 2 years previous the survey. For Costa Rica specifically, the increase was approximately 25%, which puts the coffee sector's contribution to achieving various SDGs at risk.

The COVID-19 pandemic has also affected the coffee sector. In 2020, the ICO conducted another survey in 16 coffee-producing countries to determine the impact of the novel coronavirus on the sector. Seventy-five percent of the respondents reported potential negative effects on employment, 63% on revenues, 50% on exports, and 31% on production (ICO, 2020). In addition, 63% of respondents anticipated adverse effects on farmers' incomes within the next 6 months. Approximately one-third of participants also reported potential problems with logistics, harvesting, and cultivation. Thus, Guido et al. (2020) argued that the COVID-19 pandemic could increase the vulnerability of smallholders, as production costs may increase further, prices may become more volatile, and migrant laborers may, among other constraints, have difficulties mobilizing between countries. Amidst these evolving circumstances, a number of private actors, such as certification and verification bodies and coffee roasters, are becoming increasingly interested in developing evidence-based assessments of their impact on sustainability (UNFSS, 2016) and their contribution to achieving the SDGs.

Costa Rica, one of the first countries to implement a series of National Appropriate Mitigation Actions (NAMA) for the coffee

sector, also has a long history of sustainability. Currently, 22% of Costa Rican coffee is produced sustainably, by the country's standards (NAMACAFE, 2019). However, on a less positive note, Anselmi and Vignola (2022) highlight the strong dependence of Costa Rican farms on chemical pesticides. Their study matches our results, as in our sample more than 90% of interviewed producers reported using chemical pesticides in the previous year.

Costa Rica also has strong institutions that regulate the coffee sector, institutional records are easily available, and coffee-growing areas are relatively safe to visit for data collection compared with other regions of Central America. Furthermore, as this article aims to empirically analyze the contribution of VSSs toward the achievement of the SDGs at the local level, having at least a moderate level of economic and political stability present is important to increase the probability of VSSs being implemented adequately at the producer level. Considering all these points, Costa Rica is an ideal territory for this study.

Among the 17 SDGs, Sachs et al. (2019) identified 14 that are particularly relevant to the coffee sector: No Poverty (SDG 1), Zero Hunger and Sustainable Agricultural Production (SDG 2), Good Health and Well-Being (SDG 3), Quality Education (SDG 4), Gender Equality (SDG 5), Clean Water and Sanitation (SDG 6), Affordable and Clean Energy (SDG 7), Decent Work and Economic Growth (SDG 8), Industry, Innovation, and Infrastructure (SDG 9), Responsible Consumption and Production (SDG 12), Climate Action (SDG 13), Life on Land (SDG 15), Peace, Justice, and Strong Institutions (SDG 16), and Partnerships for the Goals (SDG 17).

However, it is important to clarify that not all of these SDGs relate directly to on-the-ground production or can be measured at the producer level, such as SDG 16 or SDG 17. Based on this, this article focuses on seven of these goals, specifically SDG 1, SDG 2, SDG 3, SDG 6, SDG 8, SDG 13, and SDG 15. As Costa Rican coffee producers sell their coffee in cherry form for it to be processed by cooperatives or by private mills, SDG 7 was also not measured at the producer level. Regarding SDG 4, in our sample, most of the children of school age were enrolled in school, so it was impossible to measure VSSs' effect on this indicator.

4 | METHODS

Randomized controlled trials (RCT) are the gold standard for impact evaluation. In the context of the VSSs, implementing a RCTs is generally difficult, as most of the time, producers or cooperatives have been previously certified, making ex ante randomization impossible (Becchetti et al., 2015). Therefore, researchers often rely on quasi-experimental designs, combined with statistical and econometric tools to ensure that results are as unbiased as possible and reflect the true effect more closely.

One of the greatest challenges researchers face when evaluating the impact of VSSs is selection bias, which can lead to systematic differences between control and intervention groups at the baseline as producers voluntarily decide whether to become certified and which cooperative they will join (i.e., the existence of a potential self-selection bias of producers joining specific cooperatives and certifications). We rely on inverse probability weighting (IPW), as suggested by Wooldridge (2007) to address the non-random sampling problem. The idea is to estimate the propensity of a farmer to become certified and then use this propensity score as a weight in the subsequent analysis. The weights adjust for differences between the certified and non-certified groups, making them more comparable. Furthermore, to control for differences at the beginning of the study, we performed analysis of covariance (ANCOVA) regressions (McKenzie, 2012). This makes use of the panel data by controlling for confounders and the outcome variable at the baseline (2016), whereas the target variable is included at the end of the line (2018).

A good model for measuring the impact of VSSs using panel data would have been a difference-in-differences model coupled with a propensity score technique to account for the underlying selection bias. However, during the study period, cooperatives in our sample did not change their certification, making it impossible to implement this method. We chose IPW based on the propensity score instead of matching for two reasons. First, IPW permits the retention of more observations (Allan et al., 2020; Guo et al., 2020). Second, King and Nielsen (2019) highlighted the risks of increased imbalance when using matching.

Simple steps are required to implement IPW: (1) Develop a model to estimate the probability of being assigned to the treatment group based on known observable characteristics (Rosenbaum & Rubin, 1983). (2) The probabilities from this step are used as weights in the following regression model to estimate the effect of the intervention (Freedman & Berk, 2008). As mentioned earlier, compared with matching, IPW retains more observations in the analysis, thereby increasing the precision of estimating treatment effects (Desai & Franklin, 2019). Propensity scores for the control group were calculated separately for each certification group (Table A1).

For the first stage, based on Rosenbaum and Rubin (1983), the general formula for calculating the propensity score, that is, the probability of certification conditional on observable confounding variables, can be represented as follows: $P(X) = P(D_i = 1|X_i)$, where X is a vector of the control variables. For the second stage, the inverse weight of the propensity scores $P(X_i)$ is used in an ordinary least squares (OLS) model, $1/p$ for the certified group and $1/(1-p)$ for the comparison group. The average treatment effect using the IPW formula proposed by Abadie and Cattaneo (2018) can be expressed as follows:

$$\text{CATE} = 1/n_c \sum_{i=1}^{n} \left(\frac{C_i Y_i}{p(X_i)} \right) - 1/n_n \sum_{i=1}^{n} \left(\frac{(1-C_i)Y_i}{1-p(X_i)} \right)$$

where CATE is the certification average treatment effect, n_c is the number of certified producers, and n_n is the number of comparison producers. $p(X_i)$ is the calculated propensity score, C is the certification variable that takes the value of one for certified and zero for non-certified, Y_i is the outcome variable, and X_i are the covariates for the individual i.

Figures A1–A4 show the propensity score distributions and the common support between the treatment and control groups. Producers certified with multiple certifications showed a more balanced distribution than both Fairtrade-only certified producers and the control group (Figures A2 and A3, respectively). The group of producers certified with Rainforest Alliance or Nespresso AAA is the most imbalanced group (Figure A4).

4.1 | Data

This study is based on a panel sample of Costa Rican coffee farmers collected between 2016 and 2019. The first data set was collected between 2016 and 2017 (for the crop year 2015/2016), and the second set was collected between 2019 and 2020 (for the crop year 2018/2019). The primary method of data collection was a producer-level survey. To analyze the impact of the certifications, we divided the producers into four groups: non-certified (control group), Fairtrade-only certified, Fairtrade multiple certifications (either Starbucks C.A.F.E. Practices or Rainforest Alliance and Nespresso AAA), and other single certifications (Rainforest Alliance or Nespresso AAA). Due to the relatively small sample size for Rainforest Alliance and Nespresso and the fact that Nespresso AAA adheres to Rainforest Alliance guidelines, we evaluated these two VSSs jointly. We believe these group compositions provide the optimal balance between comparing different VSSs and having sufficient group sizes. Adding and comparing VSSs more precisely would have been desirable, but would have necessitated a significantly larger sample size, which was not feasible for this study.

The data for this study build upon the work of Grabs (2020) and use the Costa Rican subsample to build the panel. Grabs (2020) relied on cross-sectional data, which has its temporal limitations to impact measurement, as treatment and the outcome are measured at the same time (Di Girolamo & Mans, 2019). Therefore, to increase the robustness of the results, this study relies on panel data and propensity score balancing techniques. In 2019, 434 of the initial sample size of 503 producers were re-interviewed. Figure 1 summarizes the final sample size by cooperative and certification. The final sample included 408 producers, 87 Fairtrade certified, 190 Fairtrade multiple certifications, 41 Rainforest Alliance or Nespresso AAA certified, and 90 non-certified respondents.

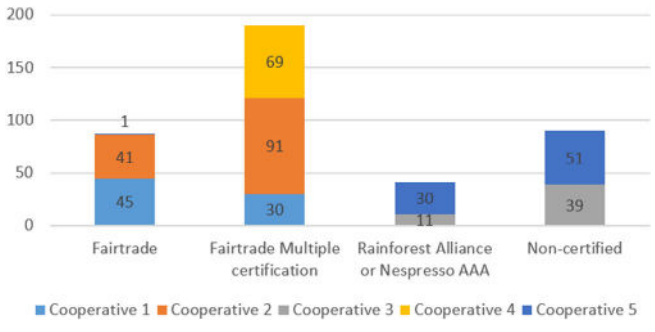

FIGURE 1 Sample size by certification group and cooperative.

The primary causes for attrition between the samples were as follows: the producer left the cooperative and refused to be contacted, the producer ceased producing coffee (sold or rented out the coffee farm), the producer passed away, or the producer or another qualified informant from the farm could be reached during the data collection period. Additionally, some observations were eliminated due to incomplete responses, extreme values, or producers outside the common support zone. Producers not surveyed in the second round of data collection were of the rest of the sample in age, being 52 years for dropout producers versus 56 years for interviewed producers. In addition, women were less likely to participate in the second round (Table A2). No differences in outcome variables were determined between the two groups.

4.1.1 | Outcome variables

The selected outcome variables include a range of SDGs the VSSs covers, which can be measured with the available data. Table 2 describes the outcome variables and the SDGs to which they are related. This connection is based on the work of Rubio-Jovel (2022). Eleven of the 12 variables selected were constructed following the guidelines of the Global Coffee Data Standard Documentation (Meems, 2019), a multi-stakeholder initiative led by the Global Coffee Platform, and aimed at developing a series of common variables for farm-level coffee sustainability. Only the variable for SDG 3 (Good Health) was specifically created based on available data to address an SDG relevant to sustainable agriculture. Due to the multidimensionality and interdisciplinarity of the SDGs and sustainable development, a single indicator may correspond to more than one SDGs. To facilitate the analysis, each indicator has been associated to single SDGs. For instance, SDG 1 focuses on eradicating poverty, whereas SDG 2 focuses on achieving sustainable agriculture. Based on their specific emphasis, the selected indicators for SDG 1 focus on increased income, whereas the selected indicators for SDG 2 concentrate on production efficiency and sustainability.

5 | RESULTS

5.1 | DESCRIPTIVES

Table 3 summarizes the descriptive statistics of the outcome variables for the different groups at the baseline and end line. Prices remained relatively stable throughout the survey period, and Fairtrade producers showed slightly lower prices than the other groups. The average daily income per adult in 2018 was between 10 and 17 times higher than the poverty line drawn by the World Bank (WB); only 5% of the producers lived below the poverty line. This indicates that most of the coffee producers in our sample are not poor. Regarding the producers' profit from coffee, those with multiple certifications had a higher income for the 2018/2019 harvest year, and Fairtrade producers had the lowest income for both years. The production costs in 2018 fluctuated between 0.37

TABLE 2 Definition of outcome variables.

SDG goal	Outcome variable	Definition
Goal 1. End poverty in all its forms everywhere	(a) Average price (USD/kg)	The average price received by the producer per kilogram of cherry coffee sold (USD)
	(b) Poverty	The daily income per adult divided by the WB poverty line in USD (1.90 USD/day per adult)
Goal 2. End hunger, achieve food security and improved nutrition, and promote sustainable agriculture	(c) Coffee profit (USD/per hectare)	Total income from coffee minus total variable costs in USD per hectare
	(d) Cost of production (USD/kg)	Total variable production costs in USD per kilogram of cherry coffee produced
	(e) Yields (kg/ha)	Total quantity of cherry coffee produced in kg/ha
	(f) Sustainable pest control practices (percentage)	Percentage of sustainable pest control practices carried out by the producer (Four practices: use natural controls for plagues, use traps to control plagues, use organic control for plagues, and keep records of their chemical applications)
Goal 3. Ensure healthy lives and promote well-being for all at all ages	(g) Practices to protect the health	The number of practices carried out by producers to protect the health of workers and the population in general from pesticides (Seven practices: use protective equipment, wash the equipment in a proper place, has a first-aid kit, wash empty bottles properly, dispose empty bottles properly, has a proper place to store chemical products, dispose of the water residues properly)
Goal 6. Ensure the availability and sustainable management of water and sanitation for all	(h) Water conservation practices (as a percentage of selected practices)	Percentage of water conservation practices carried out by the producer (Four practices: does practices to protect the water source, maintain the recommended distance between the crop and the water source, wash the equipment in the proper place, dispose of the water residues properly)
Goal 8: Promote sustained, inclusive and sustainable economic growth, full and productive employment, and decent work for all	(i) Daily wage (% of national minimum wage)	Daily wage paid by the producer as a percentage of the national minimum wage for agricultural workers
	(j) Child labor (yes/no)	Does the producer hire children under 15 years of age for agricultural work?
Goal 13: Improve education, awareness-raising, and human and institutional capacity for climate change mitigation, adaptation, impact reduction, and early warning	(k) Soil conservation practices (as a percentage of selected practices)	Percentage of practices producers implement to protect the soil (Eight practices: use crops to prevent erosion, use natural cover to protect the soil, has death barriers, has live barriers, has terraces, follow contour lines for planting, use the coffee pulp to prepare fertilizer, and distribute the pulp on the field)
Goal 15: Protect, restore and promote sustainable use of terrestrial ecosystems, sustainably manage forests, combat desertification, and halt and reverse land degradation and halt biodiversity loss.	(l) No use of prohibited pesticides (yes/no)	Prohibited chemical pesticides defined by the WHO. To create this variable, we asked producers what agrochemical they applied the previous year, and based on their answer, we identified the active ingredients, and their prohibition status

Abbreviation: SDG, sustainable development goal.

and 0.49 USD cents per kilogram across all groups. All groups' yields decreased between 2016 and 2018. As expected, we found no significant wage differences between groups, as wages in Costa Rica are tightly regulated. The average daily wage for all certifications remained below the legal minimum wage. When asked about this issue, producers responded that it is primarily because they do not hire temporary workers for the full day, but only for a portion of the day. Furthermore, the Fairtrade-only certified group had the lowest reported rates of child labor; by 2018; the non-certified group had the highest rate (17%). Among the certification groups, the Fairtrade-only group had the highest percentage of producers who did not use prohibited pesticides in either year, and those with multiple certifications had the lowest.

5.1.1 | Control variables

Table 4 summarizes the control variables at the baseline. Producers certified by Rainforest Alliance or Nespresso AAA own approximately three times more land than other producers and have a larger coffee area. Meanwhile, Fairtrade-only certified producers have, on average, nearly 2 years less education than non-certified producers and nearly 3.5 years less education than the Rainforest Alliance or Nespresso AAA group. In addition, Fairtrade-only producers have a greater percentage of farmers who cultivate crops other than coffee (85%), presenting a more diversified production. They were also less likely to have received a loan in the previous year.

TABLE 3 Descriptive statistics, outcome variables.

Variable	Fairtrade-only	Fairtrade multiple certifications	Rainforest Alliance or Nespresso AAA	Non-certified
Average price (USD/kg) 2018	0.52* (0.03)	0.56*[a] (0.06)	0.58 (0.05)	0.58 (0.07)
Average price (USD/kg) 2016	0.46* (0.09)	0.55*[a] (0.05)	0.61* (0.05)	0.59 (0.05)
Poverty (daily income per adult/WB poverty line in USD) 2018	10.47 (13.28)	16.48*[a] (19.79)	17.29 (12.4)	11.7 (16.56)
Poverty (daily income per adult/WB poverty line in USD) 2016	5.14* (7.14)	8.18[a] (8.41)	13.89* (11.10)	8.43 (10.32)
Daily income per adult (USD) 2018	19.89 (25.23)	31.31*[b] (37.59)	32.86 (23.55)	22.24 (31.46)
Daily income per adult (USD) 2016	9.76* (13.56)	15.53[a] (15.97)	26.40* (21.09)	16.01 (19.6)
Coffee profit (USD/per hectare) 2018	915.86 (1531.77)	1908.98*[a] (2,175.09)	1769.55 (2501.15)	1142.21 (2002.38)
Coffee profit (USD/per hectare) 2016	824.8* (2235.5)	2091.12[b] (1940.08)	3187.8 (3133.95)	2412.61 (2711.98)
Cost of production (USD/kg) 2018	0.43 (0.38)	0.38* (0.22)	0.37* (0.16)	0.49 (0.37)
Cost of production (USD/kg) 2016	0.42 (0.34)	0.35[a] (0.19)	0.34 (0.20)	0.46 (0.79)
Yields (kg/ha) 2018 (× 1000)	5.29 (3.61)	6.91*[a] (3.99)	8.43* (3.87)	5.48 (4.02)
Yields (kg/ha) 2016 (× 1000)	6.59* (4.72)	8.58[a] (3.89)	10.11* 5.28	8.05 4.15
Sustainable pest control practices (percentage) 2018	0.07* (0.12)	0.24*[a] (0.20)	0.35 (0.22)	0.33 (0.25)
Sustainable pest control practices (percentage) 2016	0.27* (0.18)	0.43[a] (0.25)	0.42 (0.20)	0.45 (0.25)
Practices to protect the health 2018	3.28* (1.51)	4.19[a] (1.39)	5.93* (1.31)	4.11 (1.24)
Practices to protect the health 2016	3.61* (1.67)	4.61[a] (1.31)	5.61* (1.26)	4.4 (1.24)
Water conservation practices (percentage) 2018	0.36* (0.31)	0.43* (0.31)	0.84* (0.22)	0.55 (0.27)
Water conservation practices (percentage) 2016	0.41* (0.31)	0.52*[a] (0.35)	0.77 (0.23)	0.70 (0.30)
Daily wage (% of national minimum wage) 2018	0.87 (0.11)	0.87 (0.15)	0.87 (0.08)	0.86 (0.14)
Daily wage (% of national minimum wage) 2016	0.84 (0.15)	0.87 (0.19)	0.85 (0.08)	0.86 (0.06)
Daily wage (USD) 2018	15.29 (1.89)	15.27 (2.56)	15.27 (1.39)	15.06 (2.52)
Daily wage (USD) 2016	15.07 (2.76)	15.74 (3.36)	15.37 (1.42)	15.45 (1.17)
Child labor (yes/no) 2018	0.01* (0.11)	0.08*[a] (0.27)	0.15 (0.36)	0.17 (0.38)
Child labor (yes/no) 2016	0.00* (0.00)	0.04*[a] (0.20)	0.24 (0.43)	0.28 (0.45)
Soil conservation practices (percentage) 2018	0.39* (0.18)	0.41* (0.19)	0.57* (0.17)	0.48 (0.18)
Soil conservation practices (percentage) 2016	0.35* (0.15)	0.35* (0.17)	0.45* (0.19)	0.45 (0.16)
No use of prohibited pesticides (yes/no) 2018	0.83* (0.38)	0.45*[a] (0.50)	0.76* (0.43)	1.00 (0.00)
No use of prohibited pesticides (yes/no) 2016	0.86* (0.35)	0.64*[a] (0.48)	0.71* (0.46)	1.00 (0.00)

Note: Sample sizes: Fairtrade-only = 87; Fairtrade multiple certification = 190; Rainforest Alliance or Nespresso AAA = 41, Non-certified = 90.
[a]Significant difference from Fairtrade group at 0.05, *SD* in parentheses.
*Significant difference from the control group at 0.05.

5.2 | Statistical analysis

Two regression models were run for each of the outcome variables. The first was an OLS ANCOVA model for reference (columns 1 and 3 in Tables A3 and A4), and the second was the bias-corrected ANCOVA model using IPW (columns 2 and 4 in Tables A3 and A4[1]). *p*-Values were adjusted for the multiple hypothesis test (MHT) using the Simes method (Simes, 1986). This section addresses only the results from the second model. Figures 2–5 (Jann, 2022) describe the effect of the different certification groups compared with the control group and for the specific case of the group Fairtrade multiple certification, and the results are compared against Fairtrade-only certified producers. The results are grouped by the SDG and the three pillars of sustainability. Figure 2 presents the two variables related to SDG 1 (No Poverty), which are also associated with the economic pillar. Figure 3 depicts the results for the three variables associated with SDG 2 (Zero Hunger), which are also included in the economic pillar. Figure 4 presents the variables associated with the social pillar's SDG 3 (Good Health) and SDG 8 (Decent Work). Lastly, Figure 5 presents the variables associated to SDG 2 (Zero Hunger), SDG 13 (Climate Action), and SDG 15 (Life on

[1]Table A3 summarizes the results for the groups with a single certification, Fairtrade (columns 1 and 2) and Rainforest Alliance, or Nespresso AAA (columns 3 and 4). Table A4 compares the results of the Fairtrade-multiple certifications group with those of the control group (columns 1 and 2) and the Fairtrade-only certified producers (columns 3 and 4). In both tables (Tables A3 and A4), the outcome variables are grouped according to their corresponding SDG.

TABLE 4 Descriptive statistics, control variables.

Variable	Fairtrade-only	Fairtrade multiple certifications	Rainforest Alliance or Nespresso AAA	Non-certified
Total area owned by the producer (Ha)	5.41 (6.39)	5.97 (6.37)	14.67* (22.05)	5.63 (7.48)
Total coffee area (Ha)	3.92 (4.49)	4.81 (4.37)	6.93* (4.07)	4.67 (5.53)
Distance in minutes to the closest health center	10.08 (6.78)	9.56 (5.86)	6.29 (3.61)	9.54 (12.5)
Distance in minutes to the coffee plot	11.66* (8.12)	12.56 (9.15)	15.83 (13.37)	14.77 (11.88)
Distance in minutes to the commercialization point	13.75* (6.79)	14.28* (7.37)	21.12 (12.63)	18.41 (10.82)
Age in years	58.82 (12.99)	55.81 (11.81)	55.1 (15.76)	56.8 (14.78)
Household size	5.38 (1.59)	5.43 (1.66)	5.63 (1.70)	5.14 (2.04)
Sex (1 = Woman, 0 = Man)	0.15* (0.36)	0.08* (0.28)	0.29 (0.46)	0.28 (0.45)
Average altitude of the coffee farm	1053.86 (148.89)	1001.57 (549.83)	874.26 (702.63)	1010.17 (656.72)
Years of education completed	6.93* (3.61)	8.41[a] (4.19)	10.32 (4.71)	8.81 (4.90)
Producer legally owns the coffee land (1 = Yes, 0 = No)	0.92 (0.27)	0.98[a] (0.14)	1.00 (0.00)	0.94 (0.23)
Producer grows crops other than coffee (1 = Yes, 0 = No)	0.85* (0.36)	0.61*[a] (0.49)	0.68* (0.47)	0.47 (0.50)
Producer received a loan in the previous year (1 = Yes, 0 = No)	0.07* (0.25)	0.47*[a] (0.50)	0.44* (0.50)	0.21 (0.41)
Producer received training in the previous year (1 = Yes, 0 = No)	0.84 (0.37)	0.68*[a] (0.47)	0.98* (0.16)	0.81 (0.39)
Member of UPA (Small Producers Union)	0.07* (0.25)	0.22[a] (0.42)	0.37 (0.49)	0.32 (0.47)

Note: Sample sizes: Fairtrade-only = 87; Fairtrade multiple certification = 190; Rainforest Alliance or Nespresso AAA = 41, Non-certified = 90.
[a]Significant difference from Fairtrade group at 0.05, *SD* in parentheses.
*Significant difference from the control group at 0.05.

Land), corresponding to the environmental pillar. The results section presents the statistical analysis's findings. In the discussion and conclusions sections, trade-off analyses, possible interpretations of the results, and comparisons of the findings with existing literature are conducted.

5.2.1 | Economic pillar, SDG 1 (No Poverty) and SDG 2 (Zero Hunger)

For SDG 1, both measured indicators fall into this pillar. For SDG 2, three indicators (coffee profit, production cost, and yields) are analyzed under the economic pillar.

Considering SDG 1, only prices had statistically significant results (see Figure 2). Holding a Fairtrade-only certification was associated with a 0.04 USD/kg price reduction ($p < .05$). Before adjusting for MHT, we also determined a positive significant effect for the group of Fairtrade multiple certifications. Multiple certifications were associated with a daily household income per adult 4.81 times greater than the WB poverty line (USD 1.70). These two indicators contribute to achieving SDG target 1.2, which is related to reduced poverty levels.

Regarding SDG 2, significant results were found after MHT adjustments only for the group holding multiple certifications (Figure 3). Compared with the control group, producers with multiple certifications had increased coffee profit by 841 USD/ha and increased yields by 1898 kg/ha. Before MHT, this group also had lower production costs of 0.07 kg/USD. Furthermore, before MHT, the Fairtrade-only certified group showed increased yields by 1543 kg/ha. These results contribute to achieving target 2.3, related to increasing small-scale producers' income and productivity.

5.2.2 | Social pillar, SDG 3 (Good Health), SDG 8 (Decent Work)

Figure 4 summarizes the results of the variables related to the social pillar, which correspond to SDG 3 and SDG 8. SDG 8 includes targets related to decent work and decent wages (target 8.5), and no child labor (target 8.7), in addition to focusing on economic growth. For this reason, it has been classified under the social pillar of sustainability.

Significant results for SDG 3 were found for all intervention groups, although the direction of the effect varies. The results show that being certified with Fairtrade was associated with using 0.9 ($p < .1$) fewer practices to protect the health, whereas being certified with Rainforest Alliance or Nespresso AAA was associated with the implementation of 1.15 ($p < .01$) more practices to protect the health. Similarly, holding multiple certifications was associated with an increase of 0.96 ($p < .01$) more practices to protect the health, compared with the Fairtrade-only certified group. This

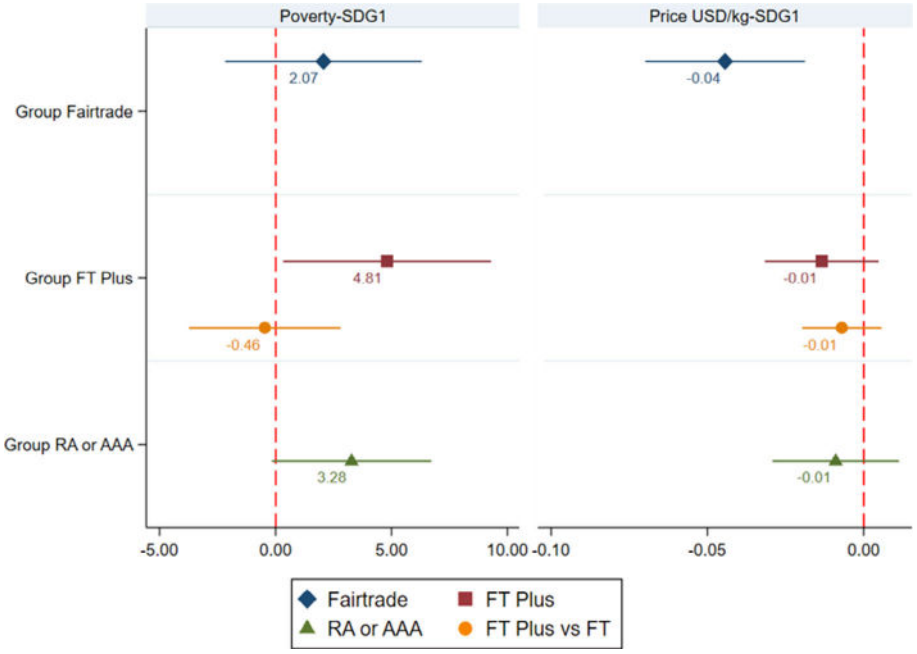

FIGURE 2 Effects of the certifications on the economic pillar, SDG 1.

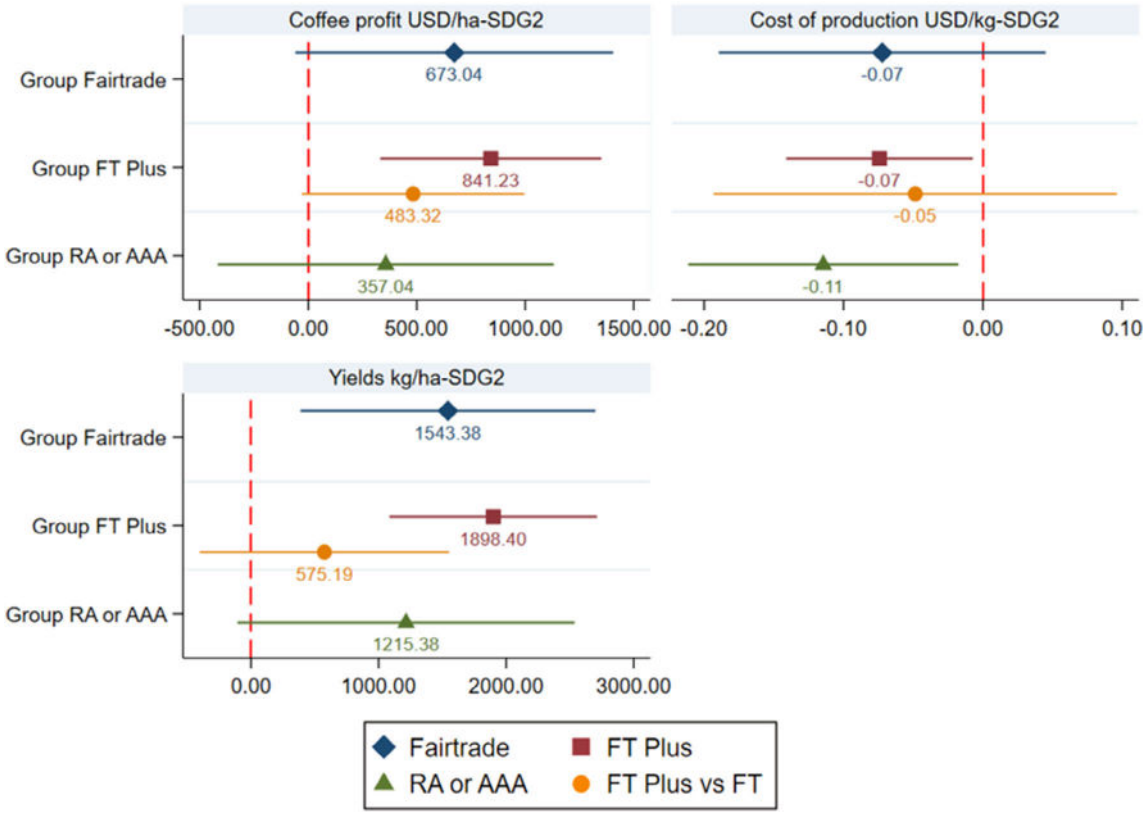

FIGURE 3 Effects of the certifications on the economic pillar, SDG 2.

specific set of practices is related to the SDG target 3.9, and the indicator 3.9.3 is related to the mortality rate attributed to unintentional poisoning.

For SDG 8, results were found for Fairtrade-only-certified producers. Holding this certification was associated with six percentage points (pp) less daily wage for workers. Furthermore, before MHT, holding multiple certifications was associated with 5 pp higher daily wage for workers compared to the Fairtrade-only certified group. This specific indicator contributes to the achievement of the SDG 8.5 target, which is related to decent work and wages for all.

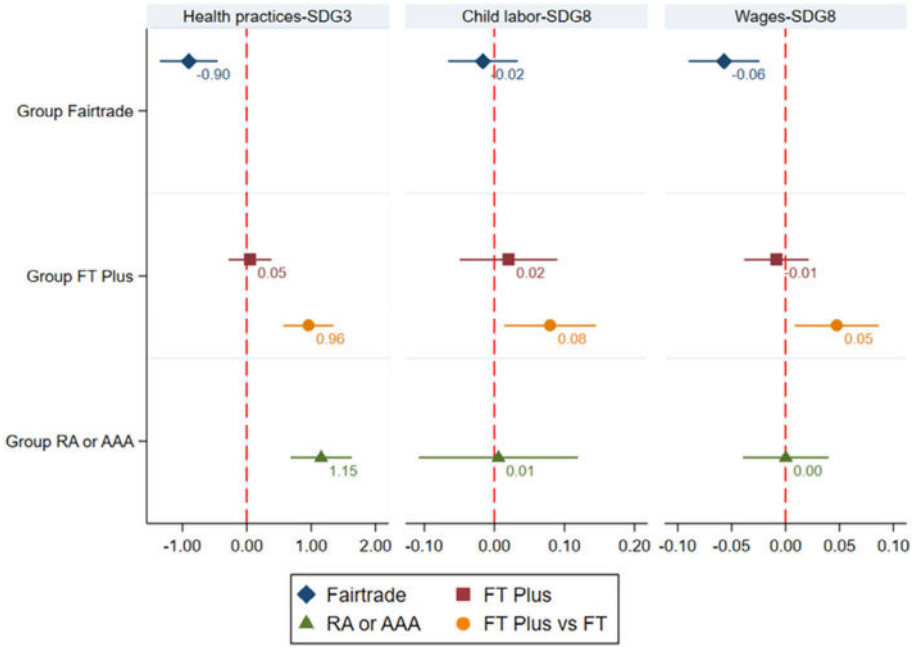

FIGURE 4 Effects of the certifications on the social pillar, by SDG.

5.2.3 | Environmental pillar, SDG 2 (Zero Hunger), SDG 6 (Clean Water and Sanitation), SDG 13 (Climate Action), SDG 15 (Life on Land)

This pillar includes four indicators, one for each SDG included in this pillar. Regarding SDG 2, being Fairtrade-only-certified reduced the implementation of sustainable pest control practices by 42 pp. In contrast to this result, compared with the Fairtrade-only-certified producers, having multiple certifications was associated with an increase of 8 pp ($p < .05$) in the implementation of sustainable pest control practices (Figure 5). This indicator contributes to target 2.4, related to land in sustainable agriculture.

For SDG 6, positive results were only found for Rainforest Alliance or Nespresso AAA, and holding either of these certifications was associated with a 26 pp increase in the number of water protection practices implemented compared with the non-certified group. Before MHT, holding multiple certifications was also associated with 14 pp more water protection practices than the Fairtrade-only certification group. The included practices to calculate this variable contribute to SDG target 6.3, that is, improving water quality by reducing pollution.

For SDG 15, compared with the control group, the group that had multiple certifications was 43% less likely ($p < .01$) to have avoided the use of prohibited pesticides in the previous year, and before MHT, they were 16% less likely than Fairtrade-only certified producers to have avoided the use of prohibited pesticides. This indicator contributes indirectly to SDG target 15.5 (i.e., reduce degradation of natural habitats).

After MHT, no significant effects were found for SDG 13. However, before MHT, being Fairtrade-only certified was associated with 11 pp less soil conservation practices, but holding multiple certifications was associated with a 6 pp increase in the number of soil conservation practices, compared with Fairtrade-only producers (Figure 5). The included conservation practices indirectly contribute to target 13.1 (i.e., strengthen resilience and adaptive capacity to climate-related hazards).

As the number of women in the sample was already small, we estimated heterogeneous treatment effects using a general certified category to examine VSSs' contribution to gender equality. We utilized the same outcome variables as in the past. For these models, we found no significant results in the interaction term (certification X gender), indicating no evidence of certification's heterogeneous effects on women (Table A5).

6 | DISCUSSION

The discussion section is structured into two parts. The first part summarizes the different trade-offs that have emerged between the VSSs outcomes and their contributions to achieving the SDGs (Table 5). Based on our findings and the existing literature, the second part focuses on whether VSSs are effective governance tools to guide transitions to more sustainable coffee production, contributing significantly to the SDGs' achievement.

The findings of our research support the idea that VSSs must overcome trade-offs between the results they promote related to the different SDGs. The results for Fairtrade-only certified producers (Table 5), column (1) reflect a negative association for average price (SDG 1, No Poverty), sustainable pest control practices (SDG 2, Zero Hunger), health protection practices (SDG 3, Good Health), and daily wages (SDG 8, Decent Work). Information from ICO (2021) shows historical data on producer prices. In 2017 (the most recent year for which data are available), Costa Rica ranked among the top five countries with the best prices, suggesting that the Fairtrade price premium

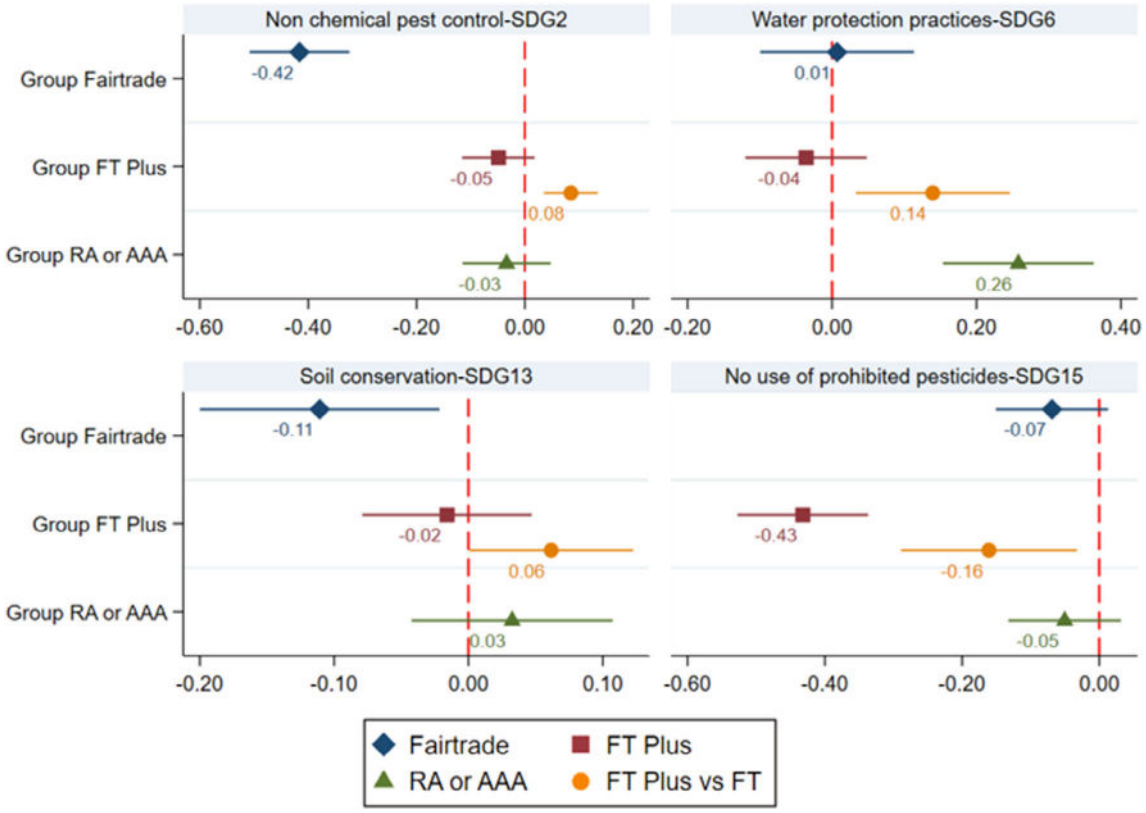

FIGURE 5 Effects of the certifications on the environmental pillar, by SDG.

TABLE 5 Summary of findings and trade-off analysis.

			Fairtrade (1)	Rainforest Alliance or Nespresso AAA (2)	Group Fairtrade plus (3)	Group Fairtrade plus vs. Fairtrade (4)
		Sustainability pillar	IPW (T_1)	IPW (T_1)	IPW (T_1)	IPW (T_1)
SDG 1	(a) Average price (USD/kg)	Economic	↓	○	○	○
	(b) Poverty (Daily income per adult/ WB poverty line in USD)	Economic	○	○	○	○
SDG 2	(c) Coffee profit (USD/per hectare)	Economic	○	○	↑	○
	(d) Cost of production (USD/kg)	Economic	○	○	○	○
	(e) Yields (kg/ha) (ln)	Economic	○	○	↑	○
	(f) Sustainable pest control practices (percentage)	Environmental	↓	○	○	↑
SDG 3	(g) Practices to protect the health	Social	↓	↑	○	↑
SDG 6	(h) Water conservation practices (percentage)	Environmental	○	↑	○	○
SDG 8	(i) Daily wage (% of national minimum wage)	Social	↓	○	○	○
	(j) Child labor (yes–no)	Social	○	○	○	○
SDG 13	(k) Soil conservation practices (percentage)	Environmental	○	○	○	○
SDG 15	(l) No use of prohibited pesticides (yes–no)	Environmental	○	○	↓	○

Note: Green arrows denote positive results, red arrows represent negative results, and gray circles are insignificant results.

may not be all that relevant in this context. Furthermore, as stated by Ruben and Hoebink (2015), the focus of Fairtrade is not on quality; therefore, in this case, the Fairtrade premium does not compensate for the difference in quality or other price-determining factors between the coffee from Fairtrade-only certified producers and the rest of the sample. Concerning the negative effects on the other variables, to remain profitable, Fairtrade producers can reduce their investments in good practices related to pest control (SDG 2) and health protection (SDG 3). Further research is required to clarify this point. In addition, they may need to pay their employees less to compensate for the lower prices, as shown in Table 2. Fairtrade-only producers also come from households with a lower per/adult income.

In contrast to our results, Knößlsdorfer et al. (2021) found positive results of Fairtrade on household expenditures in Côte d'Ivoire, indicating a positive effect of Fairtrade on living standards. This is consistent with the findings of Canwat (2023), who found a positive effect of Fairtrade on the social component in East African countries with weaker institutions. As reported by producers during the surveys, wages below the national legal wage are not common in Costa Rica. However, as labor is expensive in the country, producers sometimes pay more to retain their labor and prevent regular turnover. In addition, Costa Rica's Human Development Index (HDI) is also among the very high group, and the country has been a member of the Organization for Economic Co-operation and Development (OECD; Human Development Report 2021/2022, 2022) since 2021. This places Costa Rica among countries with robust institutions. According to Oya et al. (2018), VSSs may lose their effectiveness in countries with strong national institutions and enforcement, such as Costa Rica.

Turning to the second group of certified producers (Table 5, column 2), a positive relationship is found between those certified with Rainforest Alliance or Nespresso AAA and the variables related to SDG 3 and SDG 6. Considering the analysis of synergies and trade-offs, we can observe that for this group, the implementation of conservation practices does not translate to higher prices or income (SDG 1). Meanwhile, it is also positive to notice that the results did not show that higher costs and reduction in productivity or income accompanied the implementation of these practices. Nevertheless, it could be helpful to promote economic or technical incentives for producers to keep up with implementing these conservation practices.

Comparing the group with Fairtrade multiple certifications with the non-certified group (Table 5, column 3), we obtained the results revealing positive effects for yields (kg/ha) and coffee profit (USD/ha), which are both related to SDG 2. On the contrary, we also find a higher use of prohibited pesticides, related to SDG 15. This shows a trade-off between SDG 2 in the economic pillar and SDGs related to the environmental pillar, represented in this case by SDG 15.

Comparing the multiple certifications group to Fairtrade-only certified producers (Table 5, column 4), we obtain again positive results for the percentage of sustainable pest control practices (SDG 2) and practices to protect health (SDG 3). These results show the complex dynamics producers face, as more good agricultural practices do not always translate into direct economic benefits for the producers, and it may be difficult to sustain them over time.

As demonstrated in the results section, there is no conclusive evidence that higher yields result in higher profits (SDG 2) or a decrease in poverty levels (SDG 1). In general, these findings are similar to those of Dietz et al. (2020), who discovered that low additional economic gains from holding another industry lead certification besides being Fairtrade certified. In Ethiopia, Woubie et al. (2015) found positive effects of multiple certifications on prices, yields, and revenues, but not on other livelihood variables, such as savings or credit. Furthermore, Knößlsdorfer et al. (2021) determined that multiple certifications on top of Fairtrade had no aggregate effect on household consumption. Only Akoyi and Maertens (2018) found positive results of holding the multiple certifications of UTZ-RA-4C on poverty reduction, income, and labor and land productivity.

Various authors (Brandi, 2021; Hidalgo et al., 2023; Woubie et al., 2015) agree on the fact that overlapping VSSs' requirements and multiple certifications leads to inefficiencies in the system, as each standard requires unique instruments to measure compliance. They concur that standardization is necessary for producers and producer organizations to reduce transaction costs.

In general, our results are similar to those of Vanderhaegen et al. (2018), who studied the economic and environmental impacts of Fairtrade-Organic and the multiple certifications of UTZ-Rainforest Alliance-4C. They determined that, compared with the control group, either group of certifications could simultaneously improve economic and environmental indicators. Similarly, as shown in Table 5, in our study no group of certifications delivered positive outcomes in more than one pillar, and trade-offs between the pillars and the SDGs emerge in the multiple certified group.

In conclusion, and returning to the research questions, our results confirm that the effects of VSSs are heterogeneous across the three pillars of sustainability and vary among the three studied groups (Table 5). We find no strong contradictions between the effects of VSSs on the different SDGs, but rather we find that the studied VSSs cannot simultaneously improve two or more pillars of sustainability. Furthermore, holding multiple certifications shows trade-offs between economic outcomes (SDG 2) and environmental outcomes (SDG 15).

The existing literature analyses the impact of VSSs with a greater emphasis on one of the three pillars of sustainability—typically not together (Traldi, 2021)—and without linking them to SDGs. However, trade-offs between the three pillars still emerge in the literature. For example, Vanderhaegen et al. (2018) found trade-offs between increased use of agrochemicals and higher yields (SDG 2), labor productivity (SDG 2 or SDG 8), income (SDG 1), and reduced abundance and diversity of invertebrates (SDG 15) (trade-off between the economic and the environmental pillar). In addition, Akoyi et al. (2020) found a negative effect of UTZ-RA-4C certification on girls secondary schooling efficiency. In a separate study conducted in the same region, Akoyi et al. (2020) found positive effects on prices and income, indicating a possible trade-off between SDG 4 and SDG 1. VSSs can also have different effects depending on the stakeholder group. For example, in Cote d'Ivoire, Sellare (2022) found positive effects of Fairtrade premium on education expenditures (SDG 4) only for producers associated with Fairtrade, but not for their workers, as they typically

reside in different communities from those where the premium is focalized. In another study conducted in the same country, Sellare et al. (2020) discovered an increase in the use of highly toxic agrochemicals in the Fairtrade certified group (SDG 15), but a decrease in pesticide-related health symptoms (SDG 3), demonstrating that VSSs can contribute to one SDG, in this case SDG 3, but hinder the achievement of another (SDG 15).

Concerning SDG 5 (Gender Equality), if future researchers are interested in measuring the impact of certifications on this SDG, this must be considered at the outset of the research to develop a representative sample of women producers and address their specific needs more effectively.

The remainder of this section focuses on whether the VSSs are effective governance tools to guide transitions to more sustainable coffee production. As Grabs and Ponte (2019) have previously noted, roasters in industrialized countries are the dominant members of the GVC and maintain strong bargaining power at all levels. Meanwhile, a significant proportion of the millions of coffee-producing smallholders operate below the breakeven point (ICO, 2019a). Under these conditions, it is difficult to conceive how innovations at the producer level could facilitate a transition to a more sustainable production model. Moreover, Nelson et al. (2018) emphasized the need for complementary programs due to the limited effectiveness of VSSs alone, a claim supported by the evidence presented in this article.

Upscaling these transformations could also require generating strategies that can reach the producers for whom adopting sustainable practices might seem costly (Nelson et al., 2018). As discussed previously, approximately 5% of the producers interviewed in our sample live below the poverty line, and almost 20% of the producers in the sample were operating at a loss in 2018. Furthermore, this proportion is even higher in other countries studied by the ICO (2019a). This will continue to restrict producers' ability to engage in transformative practices. In this regard, the VSSs, in collaboration with other relevant stakeholders, should develop strategies targeting these less privileged producers.

The primary limitation of this study is that it relies on a sample of producers who were certified prior to the data collection, combined with a lack of accurate data regarding the time of certification from either the cooperatives or the producers. Related to this limitation, Blackman and Rivera (2011) highlighted the risk that already compliant producers might have higher incentives to join certifications, and our study cannot discard this risk. Moreover, the IPW accounts for observable characteristics (Table A1), but we cannot discard the existence of omitted variable bias of intrinsic producer characteristics excluded from the model, such as aversion to risk or social capital. Furthermore, producers in Costa Rica may belong to multiple cooperatives, thus introducing unmeasured confounding variables. According to the findings of Minten et al. (2018) and Sellare et al. (2020), cooperative effects may play an important role. Further research could address these caveats by selecting a larger sample, including a higher number of certifications and cooperatives, or through a multi-country study. These studies should aim at collecting data on indicators and SDGs missing in this study, as this would also provide evidence on the contribution of VSSs to SDGs along the coffee value chain and the wider spectrum of SDGs.

7 | CONCLUSIONS

The limited number of significant results found in this study support previous findings, in which certification did not show an effect on more than half of the variables studied (Akoyi et al., 2020; Bose et al., 2016; Chiputwa et al., 2015; Dietz et al., 2020; Mitiku et al., 2017; Rubio-Jovel, 2022; Takahashi & Todo, 2017).

Looking at the magnitude and direction of the coefficients, beyond statistical significance, Fairtrade-only certification had predominantly positive effects on the economic pillar, except for price, but mostly negative results in the environmental pillar. Again, this indicates trade-offs between SDGs and the three pillars of sustainability. In the economic pillar, the group with multiple certifications exhibited mostly positive results compared with the control group, but ambiguous results compared with Fairtrade-only producers, casting doubt on the economic advantage obtained by multiple-certified producers. Lastly, holding either the Rainforest Alliance or the Nespresso AAA certification showed mostly positive results for the economic pillar, except for price, but ambiguous or negligible results for the other two pillars, indicating trade-offs between the three development pillars and the different SDGs.

VSSs are sold as governance tools to promote sustainability in regions with weak national governance, but evidence of their impact is scattered and inconsistent. National policy, in which the government is a key stakeholder, may promote greater compliance among producers. For example, we found little evidence of child labor on the farms or producers not paying their workers the minimum daily wage. The strict stance of Costa Rican law on these two points seems to favor higher producer compliance. In contrast, this research did not find evidence that VSSs contributed to reducing the use of prohibited pesticides, which could reflect the government's low capacity or will to enforce these bans.

VSSs will continue to be important governance instruments for leading transition processes. Therefore, collaborative approaches and empirically systematic and independent evaluations, such as the one presented in this article, are necessary to ensure the ongoing improvement in VSSs' effectiveness.

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CONFLICT OF INTEREST STATEMENT

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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APPENDIX A

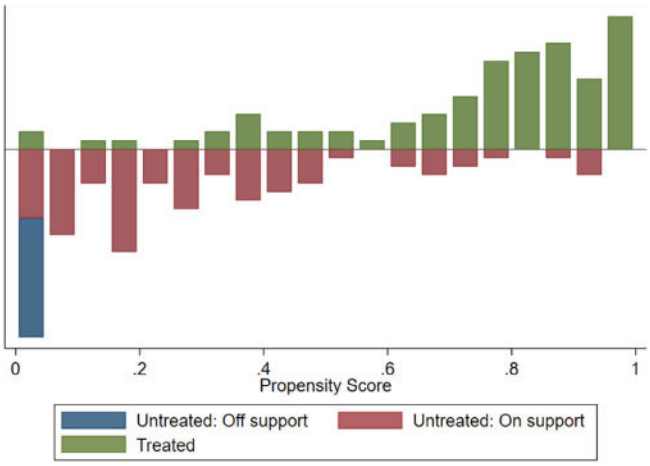

FIGURE A1 Fairtrade only certification—non-certified propensity scores distribution.

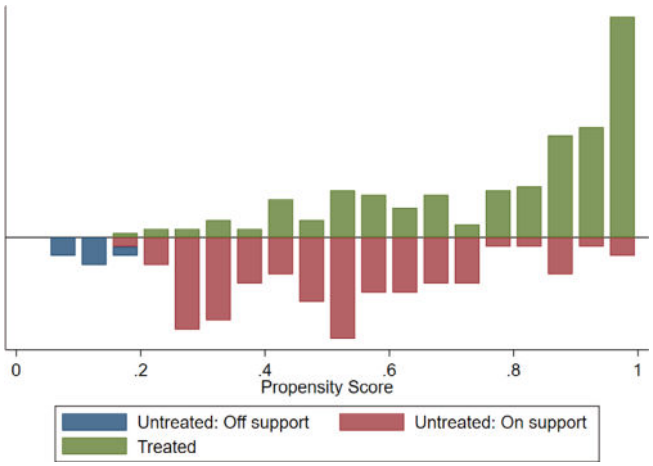

FIGURE A3 Fairtrade-multiple certifications—fairtrade only certification propensity scores distribution.

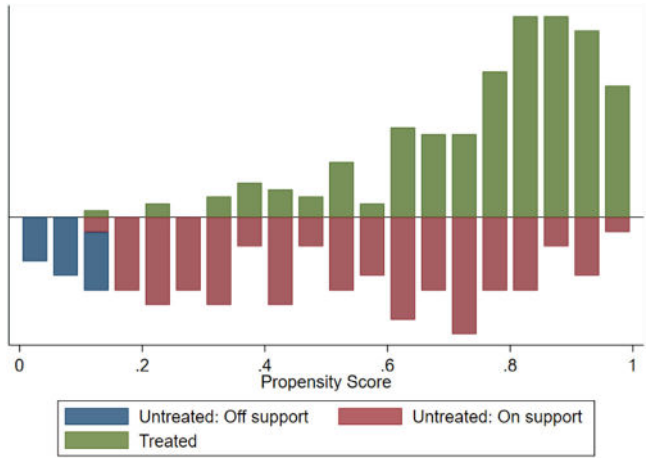

FIGURE A2 Fairtrade-multiple certifications—non-certified propensity scores distribution.

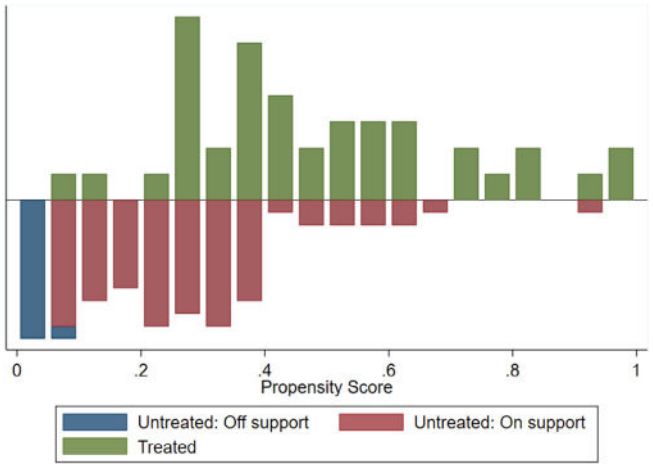

FIGURE A4 Rainforest Alliance or Nespresso AAA—non-certified propensity scores distribution.

TABLE A1 Results from propensity score calculation.

Variables	(1) Fairtrade-only	(2) Fairtrade multiple certification	(3) Rainforest Alliance or Nespresso AAA	(4) Fairtrade multiple certification vs. Fairtrade-only	(5) Group certification generic
Age in years	0.09* (0.053)	0.08* (0.042)	−0.07 (0.051)	0.04 (0.047)	0.04 (0.032)
Age squared	−0.00* (0.000)	−0.00** (0.000)	0.00 (0.000)	−0.00 (0.000)	−0.00 (0.000)
Household size	0.00 (0.074)	0.04 (0.053)	0.12 (0.080)	0.01 (0.062)	0.03 (0.046)
Sex (1 = Woman, 0 = Man)	−0.17 (0.330)	−1.03*** (0.269)	−0.04 (0.317)	−0.73** (0.311)	−0.49** (0.196)
Producer legally owns the coffee land (1 = Yes, 0 = No)	0.19 (0.505)	1.08** (0.448)		0.51 (0.455)	0.54 (0.348)
Producer grows crops other than coffee (1 = Yes, 0 = No)	1.26*** (0.269)	0.37** (0.184)	0.26 (0.297)	−0.40* (0.227)	0.52*** (0.157)
Total area owned by the producer (Ha)	−0.00 (0.021)	0.00 (0.015)	0.02 (0.017)	0.01 (0.016)	0.01 (0.011)
Percentage of total producer's land used for coffee	−2.23*** (0.652)	−0.35 (0.528)	−0.09 (0.755)	1.54*** (0.495)	−0.62 (0.434)
Producer received a loan in the previous year (1 = Yes, 0 = No)	−0.70** (0.350)	0.74*** (0.191)	0.64** (0.315)	1.31*** (0.254)	0.47*** (0.170)
Producer received training in the previous year (1 = Yes, 0 = No)	0.17 (0.353)	−0.83*** (0.232)	1.29** (0.552)	−0.63** (0.263)	−0.34* (0.194)
Member of UPA (Small Producers Union)	−1.85*** (0.379)	−0.58*** (0.205)	0.34 (0.304)	0.40 (0.306)	−0.54*** (0.173)
Distance in minutes to the closest health center	0.01 (0.013)	−0.00 (0.011)	−0.05* (0.028)	−0.01 (0.016)	−0.00 (0.009)
Distance in minutes to the coffee plot	−0.02 (0.013)	0.00 (0.009)	−0.01 (0.016)	0.00 (0.012)	−0.00 (0.008)
Distance in minutes to the commercialization point	−0.05*** (0.016)	−0.04*** (0.011)	0.00 (0.014)	0.01 (0.015)	−0.03*** (0.009)
Average altitude of the coffee farm	0.00* (0.000)	−0.00 (0.000)	−0.00 (0.000)	0.00 (0.000)	−0.00 (0.000)
Years of education completed	−0.07* (0.037)	−0.04* (0.023)	0.02 (0.034)	0.06** (0.028)	−0.04** (0.019)
Constant	−0.36 (1.742)	−0.83 (1.318)	−0.88 (1.737)	−2.41 (1.585)	0.64 (1.022)
Observations	177	280	126	277	408

Note: Standard errors in parentheses.
*p < .1; **p < .05; ***p < .01.

TABLE A2 Descriptive statistics and means differences for the attrition group.

Variable	Attrition group (59)	Panel sample (434)	*p*-Value
Total area owned by the producer (Ha)	11.20	6.98	0.0694
	14.89	0.54	
Total coffee area (Ha)	6.72	4.93	0.0300
	10.32	5.08	
Distance in minutes to the closest health center	9.93	9.30	0.5678
	8.34	7.85	
Distance in minutes to the coffee plot	12.34	13.14	0.5674
	8.44	10.25	
Distance in minutes to the commercialization point	15.66	16.03	0.7759
	9.49	9.41	
Age in years	52.71	56.48	0.0399
	12.26	13.29	
Household size	5.61	5.37	0.3198
	1.67	1.74	
Sex (1 = Woman, 0 = Man)	0.31	0.17	0.0171
	0.06	0.38	
Average altitude of the coffee farm	658.89	984.51	0.0001
	654.63	550.41	
Years of education completed	9.18	8.43	0.2141
	4.18	4.37	
Producer legally owns the coffee land (1 = Yes, 0 = No)	0.96	0.96	0.8439
	0.18	0.19	
Producer grows crops other than coffee (1 = Yes, 0 = No)	0.67	0.62	0.4649
	0.47	0.48	
Producer received a loan in the previous year (1 = Yes, 0 = No)	0.47	0.32	0.0260
	0.50	0.47	
Producer received training in the previous year (1 = Yes, 0 = No)	0.63	0.77	0.0173
	0.49	0.42	
Member of UPA (Small Producers Union)	0.25	0.22	0.5695
	0.44	0.41	

TABLE A3 OLS and propensity score weighting results for Fairtrade, and Rainforest Alliance or Nespresso certification groups.

		Fairtrade		Rainforest Alliance or Nespresso AAA	
		(1) OLS (T_1)	(2) IPW (T_1)	(3) OLS (T_1)	(4) IPW (T_1)
SDG 1	(a) Average price (USD/kg)	−0.06***	−0.04**	−0.01	−0.01
	SE	(0.014)	(0.013)	(0.013)	(0.010)
	R-squared	0.420	0.491	0.219	0.261
	(b) Poverty (Daily income per adult/WB poverty line in USD)	1.92	2.07	2.94	3.28
	SE	(2.951)	(2.143)	(2.001)	(1.732)
	R-squared	0.368	0.465	0.446	0.548
SDG 2	(c) Coffee profit (USD/per hectare)	665.16	673.04	299.26	357.04
	SE	(432.148)	(370.365)	(433.144)	(389.680)
	R-squared	0.215	0.231	0.398	0.411
	(d) Cost of production (USD/kg)	−0.10	−0.07	−0.08	−0.11[a]
	SE	(0.077)	(0.059)	(0.053)	(0.049)
	R-squared	0.199	0.211	0.249	0.251
	(e) Yields (kg/ha) (ln)	1751.26[a]	1543.38[a]	1101.66	1215.38
	SE	(753.539)	(584.648)	(718.564)	(665.314)
	R-squared	0.249	0.355	0.452	0.404
	(f) Sustainable pest control practices (percentage)	−0.41***	−0.42***	0.01	−0.03
	SE	(0.049)	(0.047)	(0.047)	(0.041)
	R-squared	0.586	0.713	0.353	0.358
SDG 3	(g) Practices to protect the health	−0.69[a]	−0.90***	1.36***	1.15***
	SE	(0.279)	(0.227)	(0.276)	(0.239)
	R-squared	0.282	0.530	0.545	0.611
SDG 6	(h) Water conservation practices (percentage)	0.03	0.01	0.27***	0.26***
	SE	(0.065)	(0.054)	(0.058)	(0.053)
	R-squared	0.286	0.499	0.373	0.460
SDG 8	(i) Daily wage (% of national minimum wage)	−0.07[a]	−0.06**	−0.00	0.00
	SE	(0.024)	(0.017)	(0.023)	(0.020)
	R-squared	0.300	0.597	0.424	0.446
	(j) Child labor (yes–no)	−0.03	−0.02	0.01	0.01
	SE	(0.037)	(0.025)	(0.068)	(0.057)
	R-squared	0.537	0.536	0.596	0.675
SDG 13	(k) Soil conservation practices (percentage)	−0.12[a]	−0.11[a]	0.06	0.03
	SE	(0.047)	(0.045)	(0.043)	(0.038)
	R-squared	0.190	0.539	0.249	0.281
SDG 15	(l) No use of prohibited pesticides (yes–no)	−0.09	−0.07	−0.04	−0.05
	SE	(0.052)	(0.041)	(0.043)	(0.041)
	R-squared	0.224	0.274	0.541	0.733
	Observations	163	163	114	114

Note: Robust standard errors in parentheses. All regressions include Province-level control variables. Observations for (i) Fairtrade: 109. Rainforest Alliance or Nespresso AAA: 83. Observations for (j) Fairtrade: 161. Rainforest Alliance or Nespresso AAA: 113.

[a]Significant at 95% confidence level before MHT adjustment.

*$p < .1$; **$p < .05$; ***$p < .01$.

TABLE A4 OLS and propensity score weighting results for the Fairtrade multiple certifications group.

		Group Fairtrade plus		Group Fairtrade plus vs. Fairtrade	
		(1) OLS (T_1)	(2) IPW (T_1)	(1) OLS (T_1)	(2) IPW (T_1)
SDG 1	(a) Average price (USD/kg)	−0.01	−0.01	−0.01	−0.01
	SE	(0.011)	(0.009)	(0.007)	(0.006)
	R-squared	0.397	0.298	0.699	0.667
	(b) Poverty (Daily income per adult)	3.65	4.81[a]	−0.42	−0.46
	SE	(2.581)	(2.276)	(1.896)	(1.659)
	R-squared	0.431	0.433	0.484	0.500
SDG 2	(c) Coffee profit (USD/ha)	794.04*	841.23**	273.77	483.32
	SE	(264.549)	(258.518)	(253.650)	(260.512)
	R-squared	0.241	0.273	0.255	0.316
	(d) Cost of production (USD/kg)	−0.06	−0.07[a]	0.01	−0.05
	SE	(0.039)	(0.034)	(0.046)	(0.073)
	R-squared	0.151	0.170	0.209	0.265
	(e) Yields (kg/ha)	1931.95***	1898.40***	513.40	575.19
	SE	(471.201)	(413.268)	(537.589)	(496.067)
	R-squared	0.296	0.352	0.289	0.344
	(f) Sustainable pest control practices (percentage)	−0.10*	−0.05	0.11***	0.08**
	SE	(0.034)	(0.034)	(0.026)	(0.025)
	R-squared	0.202	0.295	0.317	0.315
SDG 3	(g) Practices to protect the health	−0.07	0.05	0.86***	0.96***
	SE	(0.190)	(0.169)	(0.232)	(0.198)
	R-squared	0.238	0.327	0.275	0.340
SDG 6	(h) Water conservation practices (percentage)	−0.06	−0.04	0.08	0.14[a]
	SE	(0.047)	(0.043)	(0.054)	(0.054)
	R-squared	0.192	0.181	0.194	0.259
SDG 8	(i) Daily wage (% of national minimum wage)	0.01	−0.01	0.02	0.05[a]
	SE	(0.018)	(0.015)	(0.023)	(0.020)
	R-squared	0.508	0.442	0.411	0.361
	(j) Child labor (yes–no)	−0.00	0.02	0.07[a]	0.08[a]
	SE	(0.043)	(0.035)	(0.033)	(0.033)
	R-squared	0.223	0.251	0.092	0.128
SDG 13	(k) Soil conservation practices (percentage)	−0.06[a]	−0.02	0.06	0.06[a]
	SE	(0.030)	(0.032)	(0.030)	(0.031)
	R-squared	0.153	0.182	0.080	0.214
SDG 15	(l) No use of prohibited pesticides (yes–no)	−0.46***	−0.43***	−0.15[a]	−0.16[a]
	SE	(0.056)	(0.048)	(0.069)	(0.065)
	R-squared	0.450	0.550	0.314	0.407
	Observations	269	269	271	271

Note: Robust standard errors in parentheses. All regressions include Province-level control variables. Observations for (i) Fairtrade Plus: 140. Fairtrade Plus versus Fairtrade: 143. Observations for (j) Fairtrade Plus: 263. Fairtrade Plus versus Fairtrade: 265.

[a]Significant at 95% confidence level before MHT adjustment.

*$p < .1$; **$p < .05$; ***$p < .01$.

TABLE A5 Regressions results of heterogeneous effect of certification by gender.

		Certified producers interacted with gender (woman = 1 man = 0)	
		(1)	(2)
SDG	Variable	OLS (T_1)	PSW (T_1)
SDG 1	(a) Average price (USD/kg)	0.01	−0.02
	SE	(0.021)	(0.029)
	R-squared	0.479	0.597
	(b) Poverty (Daily income per adult)	0.36	−12.23
	SE	(6.152)	(10.753)
	R-squared	0.384	0.495
SDG 2	(c) Coffee profit (USD/per hectare)	1191.95	1462.81
	SE	(700.546)	(892.370)
	R-squared	0.307	0.421
	(d) Cost of production (USD/kg)	0.01	0.02
	SE	(0.114)	(0.096)
	R-squared	0.150	0.296
	(e) Yields (kg/ha)	0.20	0.25
	SE	(0.255)	(0.270)
	R-squared	0.294	0.440
	(f) Sustainable pest control practices (percentage)	0.02	−0.12
	SE	(0.062)	(0.104)
	R-squared	0.352	0.369
SDG 3	(g) Practices to protect the health	0.53	−0.19
	SE	(0.451)	(0.740)
	R-squared	0.305	0.506
SDG 6	(h) Water conservation practices (percentage)	0.11	0.07
	SE	(0.098)	(0.172)
	R-squared	0.272	0.433
SDG 8	(i) Daily wage (% of national minimum wage)	0.02	0.02
	SE	(0.036)	(0.048)
	R-squared	0.387	0.431
	(j) Child labor (yes–no)	−0.03	−0.10
	SE	(0.095)	(0.097)
	R-squared	0.278	0.189
SDG 13	(k) Soil conservation practices (percentage)	0.01	−0.13
	SE	(0.053)	(0.094)
	R-squared	0.189	0.210
SDG 15	(l) No use of prohibited pesticides (yes–no)	0.01	−0.02
	SE	(0.096)	(0.153)
	R-squared	0.397	0.466
	Observations	402	402

Note: Robust standard errors in parentheses. All regressions include Province-level control variables. Observations for (7): 238. Observations for (11) Fairtrade Plus: 395. All results are insignificant at 90% confidence level.