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RESEARCH ARTICLE

Can fair trade resolve the "hungry farmer paradox"?

Ninon Sirdey [1] · Sylvaine Lemeilleur [1]

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Abstract
Fair trade (FT) schemes claim to improve food security by generating economic gains for certified households. Previous research has shown that FT-certified households may benefit from higher prices and incomes. However, little attention has been paid to the implications of FT for food security. In this paper, we use qualitative data, cross-sectional household surveys conducted among coffee-growing households in Peru and matching econometric methods to investigate whether economic gains resulting from FT are enough to ensure food security for farming households. Results show that although FT increased the return from certified coffee (prices, production, yields and net return), the extent of the food insecurity facing FT participants remained unchanged. Our qualitative results suggest that farming households use the additional income they receive from FT to pay for their children's higher education as a long-term non-farm investment. This leakage effect raises the question of the effect of FT in the medium and long term from a rural development perspective.

Keywords Fair trade · Food security · Impact · Coffee · Peru

Introduction

The rapid development of voluntary sustainability standards and product labelling in international agricultural trade has been fuelled by the increasing globalisation of production, reduced state regulation and the growing consumer concern about how the goods they consume are produced and distributed. Fair trade (FT) standards and labels aim to contribute to sustainable development by offering better trading conditions and securing rights for marginalised producers, especially in developing countries. FT labels have become far more than a niche market. They are known and

✉ Ninon Sirdey
ninon.sirdey@cirad.fr

[1] CIRAD, UMR MoISA, Univ Montpellier, CIRAD, CIHEAM-IAMM, INRAE, Institut Agro, IRD, Montpellier F-34398, France

recognised by many consumers, producers and citizens. While there are no state-run FT labels anywhere in the world, there are several private labels, which have been developed and are governed by different organisations[1]

Although FT labels have different specifications, target products and rules, they are all critical of the current global trade system arguing that small producers in developing countries cannot live decently from what they earn farming. In response to market failures, FT labels are striving to establish key instruments, namely, minimum guaranteed prices, collective premium, long-term contracting, pre-financing and capacity building with technical training for more sustainable agricultural practices. These labels are part of the same paradigm: by participating in FT markets, smallholders are expected to improve their bargaining position, obtain higher prices and increase their net income thereby improving their livelihoods. Fairtrade International claimed that the minimum price has also proven to be "*an effective tool to protect producers from the volatility of global commodity markets, improving food security*" (FI 2016). Fair prices and higher incomes are assumed to automatically increase food security and reduce vulnerability for certified households. However, some research challenges this idyllic vision (Caswell et al. 2012; Bacon et al. 2014; Bacon et al. 2017). The evidence in the literature on development economics is mixed: better farming incomes are not systematically correlated with improved food security for smallholders (Anderman et al. 2014). In a randomised experiment, Banerjee and Duflo (2012) demonstrated that purchasing food is not necessarily a priority for poor households when they have a new source of income. In addition, food security depends on a variety of factors including the production of subsistence food. For instance, Pellegrini and Tasciotti (2014) found that food crop diversification was positively correlated with the dietary diversity of rural households in eight developing countries. Although the FT movement claims to contribute to achieving sustainable development goals, including food security objectives, the Fairtrade International theory of change (FI 2015) needs to be tested empirically.

In the academic literature on FT, the domain of food security remains a blind spot (Schleifer and Sun 2020). Very few studies have focussed on the impact of FT on the food security of certified farmers (Becchetti and Costantino 2008; Chiputwa and Qaim 2016; Meemken et al. 2017). Moreover, the findings of these studies differ and fail to provide conclusive evidence to support the claim that FT is an effective development instrument for promoting food security. This paper contributes to this literature by focusing on FT coffee producers in Peru. We consider to what extent FT certification, which is likely to benefit farmers in terms of higher coffee prices and net income, is sufficient to achieve food security for farming households. We test the hypothesis that, given the complexity of smallholder farming systems, the composition of their income and potential leakage effects, there is no direct link between increased income from certified crops and food security for poor, small and diversified farmers. Following Ruben and Fort (2012), we use cross-sectional data and a propensity score matching (PSM) approach to assess the impact of FT on coffee producers in Peru. This type of data does not account for unobservable factors. We relied on the recommendations made by Lampach and Morawetz (2016) to improve the credibility of PSM. This paper

[1] Fairtrade International, Fair Trade USA, Fair For life, Biopartenaire, Símbolo de Pequeños Productores, WFTO, Naturland Fair (CEF et al. 2020)

sheds light on a little explored topic in Northern Peru, where food insecurity still prevails among small farmers (MIDIS and DGSYE 2012) despite the success of FT-certified producer organisations (PO). We used both qualitative and quantitative data collected at the household level in the coffee farming communities to test our hypothesis.

The article is organised as follows: the "Tackling food insecurity with FT: review of the literature" section provides an overview of literature on FT and food security. The "Empirical study" section introduces the Peruvian study area and data and provides an outline of the preliminary descriptive statistics. The "Method and data collection" section describes the methodological approach used for the impact assessment. The "Results and discussion" section presents and discusses the results. The "Conclusion" section presents the conclusions.

Tackling food insecurity with FT: review of the literature

Combining food security and sustainable agriculture

According to the definition provided by the Food and Agriculture Organisation of the United Nations (FAO), "food security exists when all people, at all times, have physical and economic access to sufficient safe and nutritious food that meets their dietary needs and food preferences for an active and healthy life" (FAO, 1996). After decades of decline, the prevalence of undernourishment is again on the rise in South America and in most regions in Africa. Food insecurity (i.e. unreliable access to food) affects 821 million people (FAO et al. 2018). Paradoxically, the majority of people facing food insecurity are small farmers living in extreme poverty. This is the "hungry farmer paradox" (Bacon et al. 2014). Seasonal food shortage, known as "lean months", is widespread in coffee-growing communities. This is caused by insufficient reserves of food crops, high market prices for food, low incomes from coffee and job scarcity (Bacon et al. 2014; Caswell et al. 2012).

The impact of FT certification on food security

A broad and growing body of empirical literature has attempted to evaluate the impact of FT certification on farmers' socioeconomic well-being. Based on the review of 21 quasi-experimental studies, Oya et al. (2018) found that certification can improve intermediary outcomes for farming households, including prices and income from certified production. However, little attention has been paid to outcomes further along the causal chain, such as food security (Schleifer and Sun 2020). In addition, the results of the few existing studies differ and fail to discuss impact pathways, yet all suggest that food insecurity remains an issue among FT farmers (Sirdey and Lemeilleur 2019).

According to a study by Méndez et al. (2010) of 596 coffee-growing households in Guatemala, El Salvador, Nicaragua and Mexico, significantly more organic FT-certified households report difficulties than non-certified households. These authors also reported no significant difference in gross income between food secure and food insecure households. More recently, Bacon et al. (2017) found no correlation between the length of the lean period and membership of a FT-certified cooperative for

Nicaraguan coffee farmers (the analysis examined 258 FT-certified farms and 95 control farms). These studies provide valuable information on the extent of the food insecurity phenomenon among certified producers. To our knowledge, only three studies assessed the causal impact of FT certification on food insecurity. First, Becchetti and Costantino (2008) measured the impact of FT on producers' welfare in the Kenyan fruit sector (120 producers). Their study focussed on food consumption and diet quality using data on food expenditure and a food frequency questionnaire, and their results showed that FT-certified producers had better access to food in terms of quantity and quality (more dietary diversity) than non-certified producers. In addition, the longer producers had been affiliated to an FT PO, the more diverse their diet. Lastly, FT producers had more diversified farm systems than non-certified farmers. The authors suggest that crop diversification encourages a more diversified diet (Becchetti and Costantino 2008). Second, Chiputwa and Qaim (2016) assessed the impact of UTZ[2], FT and organic standards on the nutrition of coffee growers in Uganda. Using a 7-day recall method at household level, they measured caloric (quantity) and nutritive (quality) consumption in certified and non-certified households: 108 UTZ-FT, 101 UTZ-organic, 62 UTZ and 148 conventional households. They showed positive causalities between sustainable certification and both food security indicators. Using a simultaneous equation model, they suggest that the improved food security is due to the impact of positive causality of FT on farmers' income and gender equality (control over income). Third, Meemken et al. (2017) assessed the impact of organic and FT standards using a panel sample (2012–2015) of 409 coffee-growing households in Uganda (including 121 FT certified, 71 organic certified and 193 non-certified in 2015). These authors concluded that although FT certification increased incomes and total expenditures, it had no significant impact on food expenditure or household nutrition.

In this paper, we contribute to this understudied issue by investigating the impact of FT on food security in a Peruvian coffee community using different objective and subjective indicators of food access at household level.

Empirical study

The study area

Peru is particularly relevant to our research because of the critical role of FT in the coffee sector. In the mid-1990s, FT and organic labels encouraged producers to reinvest in coffee after the collapse of the International Coffee Agreement[3] in 1989, coupled with economic liberalisation. They aimed to revitalise existing cooperatives and create new ones. Peru now has the largest number of POs certified by Fairtrade International in the world (FI 2016). It is also the largest exporter of organic coffee. Double

[2] UTZ is a program and a label for sustainable farming launched in 2002. UTZ and Rainforest Alliance merged in 2018

[3] From 1962 to 1989, the International Coffee Agreement (ICA), signed by 26 producing and 13 consuming countries, regulated coffee prices by allocating export quotas per country. This agreement resulted in a rise in prices for exporting countries and kept them stable. The collapse of the ICA was followed by an immediate drop in international coffee prices, an increase in price volatility and shift in governance from public regulation by producer countries to private regulation by roasters in importing countries (Daviron and Ponte 2005)

certification is widespread: 90% of FT-certified coffee is also certified organic. Nowadays, almost all of the coffee POs in Peru which export coffee directly comply with FT and organic standards. However, not all the coffee sold is labelled. In fact, the global supply of certified Fairtrade International coffee is more than three times the actual volume of sales (Lernoud et al. 2017).

Our survey was conducted in northwestern Peru in *Cañarís* and *Salas*, two highland districts located in the Lambayeque department. These districts are located approximately 800 kilometres away from the capital of Peru, Lima. Coffee production is historically rooted in the region, where 54% of farms are geared to coffee production (INEI 2012). It is the main source of income for most producers, meaning that households are largely dependent on coffee for their livelihoods. However, coffee exports are affected by several factors: limited road access; lack of institutional support; small size of holdings (0.81 ha on average) and low yields (8.81 quintal.ha^{-1}), which are both below the national average (1.9 ha and 17.51 quintal.ha^{-1} in 2012, respectively) (INEI 2012). Low coffee production and rare job opportunities account for the high rate of poverty (more than 60%) (INEI 2012). The communities in *Cañarís* and *Salas* are located in areas that are qualified as "highly vulnerable to food insecurity" (MIDIS and DGSYE 2012)[4].

Coffee is harvested, washed and sold from May/June to September (Fig. 1). Smallholders also grow food crops for home consumption. Alternative sources of income include on-farm activities (sale of animals, fruit or alcohol made from sugar cane), off-farm activities (seasonal work on plantations in suburban areas) and non-farm activities (for example, running small retail shop in the village). The lean months typically last from January to April (Fig. 1), when food reserves (beans, peas, corn and wheat) are low and there are no prospects of a farm income before the next coffee harvest. In addition, although food is available at the local market in the lean months, high prices and insufficient supplies (rain may disrupt transport) can limit access to food.

Producer organisations and coffee farmers surveyed

The first producer group in the area was created in 1993 with the support of a local non-governmental organisation (NGO) and obtained organic certification in 1996 (Fig. 2). Later, this group merged with other POs working with the same NGO in other administrative departments in Peru to create a second-grade PO (CECANOR), which was certified FT in 2000. Since then, CECANOR has been working in partnership with the NGO to provide technical support in the area. It is also associated with an export company which provides marketing support. CECANOR includes a women's coffee programme which reserves a place for women in the governance structure and gives women a price premium of US$3/quintal of coffee. A second producer group was created in 2009 in association with the second-grade PO, NORANDINO, which has been certified organic and FT since 1997[5]. In addition to coffee, NORANDINO is

[4] This index represents the spatial distribution of people facing a food insecurity risk. It is calculated from food availability, access to food and food consumption variables at the district scale

[5] NORANDINO is certified Fairtrade International as well as Hand in Hand (since 2011) and *Símbolo de Pequeños Productores* (since 2013)

Fig. 1 Calendar of agricultural activities and seasonal food insecurity

diversifying its activities to include other products, for example, sugar cane. The third PO in the area was created in 2006 with the support of an export company, PRONATUR. It received certification for organic coffee in 2006.

The two FT POs sell a large proportion of green coffee under FT conditions (100% for CECANOR and over 75% for NORANDINO), despite the global oversupply of FT-certified coffee (Lernoud et al. 2017). Both FT POs build on long-term trading partnerships with several roasters.

The PO members are smallholders who grow coffee in multi-species plots and use wet post-harvest treatment. They sell pulped, fermented, washed and dried coffee (parchment coffee) directly to their PO. Between one and five sales take place from June to November as the harvest progresses, each year. Farmers do not store coffee from one year to the next. In each village, one farmer is responsible for transporting the parchment coffee to the POs' collection centres. The POs clean the beans (which may also require further drying) to prepare the green coffee for export. Farmers are paid a few days after each delivery. The farm gate price depends on the following parameters: the international Free-On-Board price of coffee or the minimum price FT (whichever is higher), US$ exchange rate, organic certification and the humidity rate. The price is lower if the humidity rate of the parchment coffee exceeds 12%. The second FT-certified PO makes an additional quality adjustment according to the physical yield of coffee (i.e. ratio of parchment to green coffee beans, for which 83% is the reference). Thus, there may be significant differences in prices, which reflect the quality of the coffee delivered by different members of the same PO.

Method and data collection

Sampling strategy and data collection

The sampling strategy was based on the following criteria. First, to limit the potential self-selection bias linked to PO participation, we only surveyed PO members. Second, we compared FT organic certified producers and organic certified producers. Indeed, in Peru, 90% of FT-certified coffee is also certified organic. Therefore, to grasp the impact of the FT economic instruments, we needed to consider organic certified farmers as a control group. Third, we only surveyed producers who became members of the PO after 2006 because we used pre-treatment information collected through recall questions concerning the year 2006.

In the absence of a baseline survey, the questionnaire included information about the farmers' situation in 2006 to ensure that FT and non-FT farmers' pre-treatment assets (amount of land under coffee, number of food crops and number of cows) were comparable. Indeed, FT POs often attract farmers who already have a minimum of farming assets (coffee land, livestock, etc.) (Ruben and Fort 2012; Chiputwa et al.

2015; Karki et al. 2016). The year 2006 was chosen because it was the year of the presidential elections, consequently an easy date to remember.

Based on these criteria, sampling covered 17 villages and 140 coffee farming households. The FT group comprised 75 members of the two FT and organic certified POs. Based on the lists of members provided by these POs, we surveyed all the producers in the study area who became members of the PO after 2006 and were still members at the time of the survey, who were at least 18 years old in 2006 and were present in the village at the time of the survey.

The control group included 65 farmers who belonged to the third PO, were only certified for organic production and were located in the same or neighbouring villages as the FT-certified farmers. We built on a list of members drawn up with local leaders. Like in the FT group, we surveyed organic coffee producers who became members of this PO after 2006, who were at least 18 years old in 2006 and were present in the village at the time of the survey.

In our study, there appears to be no selection bias when it comes to joining a FT scheme. Indeed, the decision to join is not individual, but collective and is made by the PO. In our case, the producers we surveyed had no influence on the PO's decision because they did not become members until after the PO had decided to join an FT scheme (Fig. 2). However, producers do choose which PO to join. Their decision depends primarily on which POs are present in their village: 22% surveyed farmers live in a village where there is only one PO; 14% surveyed farmers live in a village where there are only FT POs, while 64% of surveyed farmers live in villages where they have several options. In these cases, the decision is largely determined by the producer's social relations: participation in FT POs is significantly and strongly correlated with the total number of FT members in the village (significant at 1%).

Given our particular interest in food security, we conducted the household survey during the lean period in March/April, 2016. In addition to the recall questions, the following information was included in the questionnaire: current household

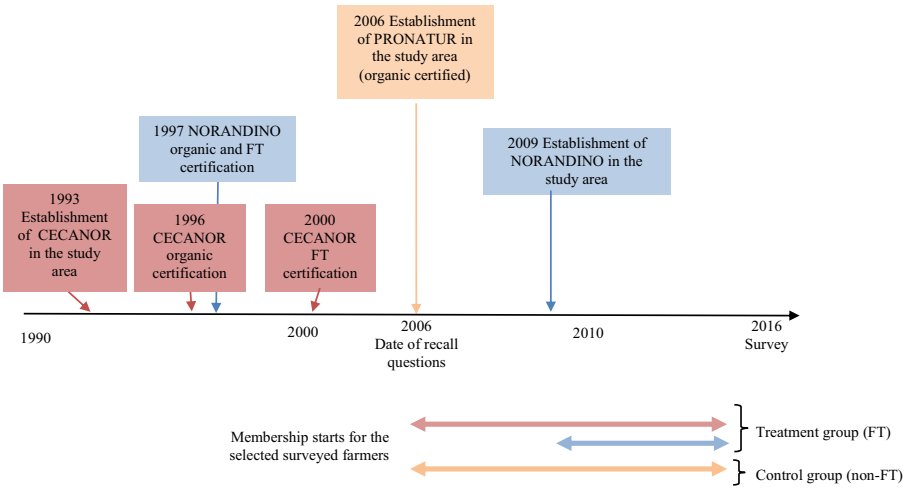

Fig. 2 Timeline of the establishment, certification and membership of POs by the farmers surveyed in the present study

characteristics and assets; coffee production and sales in the 2015 cropping season; other farming activities; sources of on-farm, off-farm and non-farm income; objective and subjective food security indicators; and leadership position in a PO. The leadership position in a PO was used as a control variable in the model to reduce the potential self-selection bias due to unobservable characteristics, such as entrepreneurship or leadership.

Outcome variables

Economic return variables

In order to measure the expected FT impact, we identified six variables of interest related to coffee production:

- Mean farm gate prices paid by POs (Peruvian Soles (PEN)/quintal)
- Coffee production in 2015, measured as the quantity of coffee harvested in quintals (1 quintal of washed coffee = 55.2 kg)
- Area under coffee in 2015, i.e. area used to grow the coffee harvested in 2015 in hectares, not including land planted with unproductive young coffee trees
- Coffee yield (quintal/hectares), calculated from total yield and area under coffee
- Coffee net return (PEN), calculated from gross coffee revenue minus purchased inputs and paid labour (Barham et al. 2011)

According to Valkila and Nygren (2010) and considering the Peruvian context at the time of the survey, we would expect FT participation to have a positive impact on the farm gate prices of certified farmers. Indeed, the international reference prices for organic coffee (*C. arabica* price from NYC, plus organic premium) were lower (around US$130–140 per quintal) than the FT minimum free on-board price for organic coffee (US$170 per quintal) (Fig. 3).

In addition, FT certification may involve changes in agricultural choices: certified farmers may increase their land under coffee, their labour requirements and use of inputs (Van Rijsbergen et al. 2016; Sirdey and Lemeilleur 2019). According to Valkila (2009), the impact of FT on coffee yields and production depends on the use of chemical inputs, fertilisers or agricultural practices prior to certification: a positive impact is usually observed when coffee farmers used no chemical inputs prior to FT certification and a negative impact is observed when farmers used chemical inputs prior to FT certification (e.g. Beuchelt and Zeller (2011)). Since in our study area, the farmers used no chemical inputs or fertilisers prior to certification, we would expect FT to have a positive effect on coffee production and yield.

According to the literature, incomes from the certified crop are likely to increase through FT certification, in particular when production and yields remain unchanged or are improved (Oya et al. 2018). Based on this literature and given the Peruvian context, we hypothesised that FT is likely to improve net returns from coffee.

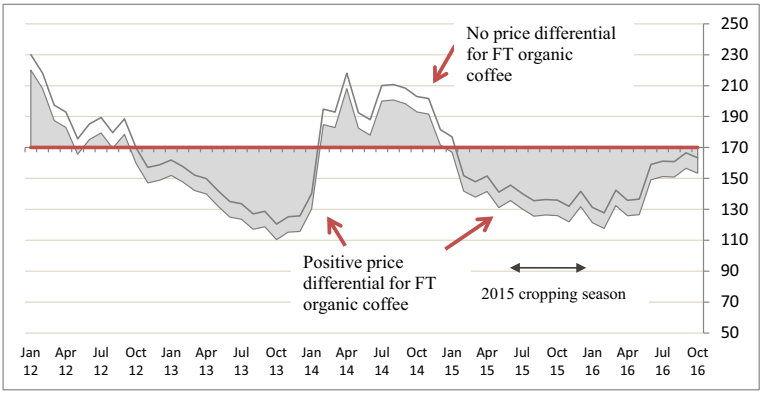

Fig. 3 Difference between Fairtrade International minimum guaranteed prices for organic coffee (Threshold of US$170 in red) and US C coffee prices for organic coffee (bandwidth of US$10) in the 2012 to 2016 period

Food security variables

To measure the impact of FT certification on food security, we identified four indicators that reflect different components of household food insecurity, as recommended by Coates (2013): intra-annual stability; food anxiety; access to sufficient food of good quality and variety in accordance with preferences; and access to nutrient-rich foods.

Respondents were asked about the stability of food provisioning throughout the year and whether they had any problems of access to food (inadequate food or lack of money to buy food) to feed all the members of the household during the year before the survey and, if so, for how long. We use the binary variable *SHORTAGE* equal to 1 if households experienced at least 1 month of inadequate food provisioning and the *Months of Inadequate Household Food Provisioning* (MIHFP) (number of months between 0 and 12) (Bilinsky and Swindale 2007).

Food access anxiety and food insecurity experienced during lean months were considered according to the standardised classification of households from the *Latin American and Caribbean Household Food Security Scale* (ELCSA). ELCSA consists of eight standardised questions designed to identify the occurrence and frequency (never, rarely, sometimes and often) of concern about food access (uncertainty) and changes in consumption practices due to lack of resources (which covers dietary coping strategies and quantitative cuts in food) (FAO 2012). We used three dummy variables: food secure households (ELCSA = 0), slightly food insecure households (ELCSA = 1 to 3) and moderately to severely food insecure households (ELCSA $\geq$ 4).

In order to determine the access to a sufficient quantity of food and the dietary diversity at household level, we generated a *Household Dietary Diversity Score* (Swindale and Bilinsky 2006). HDDS is based on the presence of 12 food groups (two caloric, three energy-rich and seven nutrient-rich groups from a 24-h dietary recall at household scale). HDDS is correlated with caloric sufficiency (Kennedy et al. 2013). In our sample, the majority of households consumed caloric food groups (staple cereals, roots and tubers) and energy-rich food groups (sweets, fats and condiments), so we used another indicator to determine the level of access to the seven nutrient-rich food groups (HDDSqual).

We were sceptical about the hypothesis that fair prices and higher incomes from cash crops automatically increase food security. We hypothesised that despite the positive impact of FT on coffee net return, food access remains a concern and households struggle to secure access to sufficient nutritious and socially accepted diets in the lean season. Indeed, several factors are likely to disrupt the impact pathway between coffee income and food security: reduced food crop production and home consumption; specialisation in coffee is detrimental to other sources of income; greater income seasonality, which means less money is spent on daily food needs; higher non-food expenditure, etc. (see Sirdey and Lemeilleur (2019) for a review of potential impact pathways). To assess the impact of FT on food crop production and home consumption, we used five variables: cereal production (maize and wheat) (total and per capita), legume production (peas and beans) (total and per capita), area used for food crops in 2015 (hectare) and percentage of food consumed that is grown on the farm[6].

Comprehensive survey and focus groups

The structured survey was an integral part of a comprehensive mixed approach designed to shed light on impacts (Nelson and Martin 2017). We collected qualitative data in three periods (July–August 2015, February–May 2016 and February 2017) to improve our understanding of the farmers' personal experience of food insecurity and of coffee farming under FT schemes.

Twenty-seven small-scale coffee farmers participating in FT were interviewed to gather information on their "livelihood trajectories". They were asked about the trends and shifts that affect their coffee-related and livelihood activities over time, as well as the factors that drive these trends and changes. Factors linked to FT PO membership (e.g. technical support, credit opportunities, collective premium) were distinguished from individual (e.g. assets) and contextual drivers (e.g. loss of soil fertility, crop diseases). In addition, we conducted semi-structured interviews with 12 key informants including PO managers, technical staff and local leaders. The interviews addressed several topics including FT schemes, the history of the POs, services and projects in the communities and coffee farmers' livelihoods. Finally, after having collected and analysed the quantitative data, we organised two focus groups, one with 15 and the other with 20 farmers in February 2017. The focus group discussions consisted of two parts. First, we created a participatory map of the perceived causes of seasonal food insecurity to discuss pathways between direct and underlying causes of food insecurity. Second, we presented the findings of our econometric analysis to the farmers and asked them to give us their opinion of—and explanations for—the results we had found. We proceeded in the same way in two semi-structured individual interviews with the staff of the FT POs. These qualitative data were used to interpret our quantitative results.

[6] Calculated from 24-h recall. We requested information on the provenance of each food to calculate the ratio of food produced on the farm to total food. Foods that cannot be produced on-farm (oil, rice, sugar, pasta, tuna) were excluded from the calculation

General descriptive statistics

Descriptive statistics revealed some slight differences between the FT group and the non-FT group at the sample level (Table 1). The villages are located at a similar altitude, which suggests they have similar climatic conditions. The differences were linked to household characteristics: the FT-certified farmers were younger and had less experience in coffee cultivation. Their households were significantly larger than non-FT households. FT participants lived significantly farther away from local cities (where basic commodities can be purchased) than non-FT participants. Asset variables from the year 2006 provided no insights into the probability that farmers would participate in the FT programme.

Descriptive statistics for outcome variables (Table 2) showed that the FT group cultivated a larger area of coffee and obtained higher yields than the control group. Although the standard deviations revealed variations in farm gate prices (depending on the period of sales and on coffee quality), FT participants were significantly more likely to be paid a better price and to obtain a higher net return from coffee. In contrast, descriptive statistics indicate that in terms of food insecurity, FT-certified farmers were in a very similar situation to the control group. Respectively, 79% and 77% of households said that they experienced a period of inadequate food provisioning that had lasted more than 2 months in the preceding year. They were worried about access to food and had to change their consumption habits because of the lack of resources during the lean months. For both groups, around two-thirds of households classified as slightly food insecure, while one-third classified as moderately or severely food insecure. Despite these indicators, the household dietary diversity was quite high (average 7.7 for HDDS). The variable HDDSqual revealed that FT and non-FT participants had access to almost three groups of nutrient-rich foods (high legume consumption and very low meat, fish and vegetable consumption).

Nonetheless, given the non-random distribution of FT certification, these simple comparisons of means are not sufficient to identify causality. In the following section, we use econometric analysis to estimate the causal impact.

Econometric approach

Covariate regression

First, we use parametric models of the treatment variable (*FT participation* is a dummy variable). We also use a range of covariates to account for heterogeneity between FT and non-FT groups. To avoid problems of endogeneity, we consider the variable assets for 2006. We use a simple regression model for the outcome variables linked to coffee production, income from coffee and HDDSqual. We use a logit model for the binary variable SHORTAGE and binary variables extracted from the ELCSA score.

Propensity score matching

Second, we use propensity score matching (PSM). PSM assumes that selection bias could be reduced by comparing a given FT participant with non-FT participants with similar observable characteristics. Unlike regression models, the additional common

support condition makes it possible to compare observations that are comparable. In addition, PSM is a non-parametric technique that avoids potential misspecification. PSM comprises two stages: the participation model and the matching method.

Participation model The first stage is to estimate a propensity score. A propensity score is the probability of participating in FT according to a set of covariates. Following the recommendations of Lampach and Morawetz 2016, we use a probit regression to model the probability that farmers would participate in FT $\Pr(FT_i = 1 \mid X_i)$, with a set of control variables X_i that influence the probability of being FT certified and may also affect income from coffee and food insecurity indicators. At the same time, covariates should not be influenced by FT.

$$\mathbf{Pr}(\boldsymbol{FT_i}=\mathbf{1} \mid \boldsymbol{X_i})=\boldsymbol{F}(\boldsymbol{X_i}) \tag{1}$$

Covariates include the number of cows owned by the household in 2006 as a lagged proxy for wealth. Indeed, a wealthier household may be more likely to join a FT PO (cows are assets commonly used as savings) (Karki et al. 2016). The amount of land used to grow coffee could influence the probability of obtaining certification (Ruben and Fort 2012; Chiputwa et al. 2015; Jena et al. 2012), as well as income from coffee and seasonal food insecurity. Land use is also likely to be affected by FT. The economic benefits of FT are granted per production unit and, therefore, may be incentive to grow more coffee (Lemeilleur and Carimentrand 2014). Hence, the amount of land used for coffee production in 2006 is an important factor to take into consideration to avoid possible reverse causality (Chiputwa et al. 2015). Lastly, the amount of land

Table 1 Descriptive statistics

	FT participants	Non-FT participants	Diff.
	n = 75	n = 65	
Variables	Mean (SD)	Mean (SD)	
Age of head of household	44.38 (10.71)	49.64 (11.45)	***
Years of experience of coffee growing	22.44 (10.23)	25.58 (11.03)	*
Number of years of education of head of household	6.23 (3.30)	6.89 (3.87)	
Worker equivalent	2.33 (1.21)	2.03 (1.14)	
Number of household members	4.61 (2.15)	3.86 (1.77)	**
Time from house to the place where basic commodities are bought (minutes)	64.11 (62.60)	35.48 (63.84)	***
Time from house to furthest plot (minutes)	48.95 (34.64)	52.91 (36.24)	
Altitude of farm house (metres)	1612.92 (253.58)	1612.77 (296.59)	
Access to non-farm income (dummy)	0.11 (0.31)	0.20 (0.40)	
Number of cows in 2006	3.45 (3.68)	2.78 (3.40)	
Land used to grow food crops in 2006 (ha)	0.96 (0.98)	0.85 (1.18)	
Land under coffee in 2006 (ha)	1.31 (1.01)	1.25 (0.80)	

*Note: Standard deviation in parentheses; significance threshold of T tests: *p < 0.1,**p < 0.05,***p < 0.01*

Table 2 Outcome variables and comparison of means between FT and non-FT participants

	FT participants	Non-FT participants	
	n = 75	*n* = 65	
Coffee-related variables	Mean (SD)	Mean (SD)	Diff.
Mean farm gate price (PEN)	386.02 (30.76)	348.98 (54.22)	***
Coffee net return (PEN)	5025.59 (4910.54)	1651.79 (1894.78)	***
Area under coffee area in 2015 (ha)	2.25 (1.38)	1.66 (0.92)	***
Coffee production in 2015 (quintal)	15.24 (12.81)	6.30 (9.98)	***
Yields in 2015 (quintal/hectares)	7.48 (5.38)	4.38 (3.74)	***
Use of compost and organic input (dummy)	0.89 (0.31)	0.75 (0.43)	**
Cost of hired labour per ha (PEN)	491.18 (433.25)	355.55 (472.73)	*
Food crop–related variables			
Cereal production (maize and/or wheat) (quintal) (total)	5.83 (5.35)	4.09 (7.96)	
Cereal production (maize and/or wheat) (quintal) (per capita)	1.56 (1.85)	1.44 (3.74)	
Legume production (beans and/or peas) (quintal) (total)	2.57 (2.17)	1.42 (2.41)	***
Legume production (beans and/or peas) (quintal) (per capita)	0.78 (0.87)	0 .35 (0.59)	***
Area used for food crops in 2015 (hectare)	0.90 (0.70)	0.58 (0.62)	***
% food consumed grown on the farm	0.68 (0.23)	0.61 (0.22)	*
Food security variables			
SHORTAGE	0.79 (0.41)	0.77 (0.42)	
MIFP	2.34 (1.39)	2.37 (1.40)	
Food secure households [a]	0.04 (0.19)	0.04 (0.21)	
Slightly food insecure households[a]	0.64 (0.48)	0.69 (0.46)	
Moderately or severely food insecure households[a]	0.32 (0.46)	0.26 (0.44)	
HDDS	7.77 (1.10)	7.69 (0.90)	
HDDSqual	2.91 (1.01)	2.78 (0.91)	

*Note: Standard deviation in parentheses. Significance threshold of T tests: *p < 0.1,**p < 0.05,***p < 0.01;*
[a] *dummy variables calculated from ELCSA*

used to grow food crops could influence access to food for home consumption. Indeed, food crop production is associated with the length of the food insecurity period (Bacon et al. 2014; Bacon et al. 2017). Thus, to determine a households' previous capacity to access home-grown food, we use the area allocated to growing food crops prior to certification.

We also added traditional variables, such as the age and education of the head of the household and household size (Saenz-segura and Zuniga-Arias 2008; Ruben and Fort 2012; Jena et al. 2012; Van Rijsbergen et al. 2016). We assumed that the larger the household, the harder it is to secure access to food. Since family labour availability is also likely to distinguish between farmers (Fischer and Qaim 2014), we used workers as a covariate (Chiputwa et al. 2015). This is the number of all household members aged between 15 and 55, as well as those aged between 55

and 65 who claimed to still be active farmers. We also included the dummy covariate access to non-farm income (Jena et al. 2012), which can be positively or negatively correlated with participation. At the farm level, the model also considers the time it takes to travel from the house to the place where basic commodities can be purchased. This factor refers to the physical accessibility of food and descriptive statistics show that it also distinguishes between FT and non-FT participants. Lastly, it is commonly argued that unobservable characteristics, such as entrepreneurship or leadership, may influence outcome variables (income from coffee and food security) and self-selection in a PO. To reduce any potential bias caused by personal characteristics, we introduced a dummy leadership variable (1 for farmers mandated to play a role in the PO and 0 for those who never had any responsibility in the PO) as covariate in the PSM model.

Matching methods The second stage is to match FT participants to non-FT participants with a similar probability to participate (the so-called neighbours). For each FT participant i and each outcome $Y_i(1)$, the matching model associates a matched outcome $\widehat{Y}_i(0)$ given by the (weighted) outcomes of its neighbours in the non-participant group. Equation 2 presents the ATT, which is the average difference between $Y_i(1)$ and $\widehat{Y}_i(0)$ for the group of matched participants. N_{mt} is the number of matched FT participants.

$$\boldsymbol{ATT}=\frac{\mathbf{1}}{\boldsymbol{N_{mt}}}\sum\left[\boldsymbol{Y_i}(\mathbf{1})-\widehat{\boldsymbol{Y}}_{\boldsymbol{i}}(\mathbf{0})\right] \tag{2}$$

The ATT is sensitive to the method used to calculate the counterfactual outcome $\widehat{Y}_i(0)$ (Caliendo and Kopeinig 2008). Therefore, we performed different matching algorithms to test the robustness of the results to the method applied: nearest neighbour matching (3NNM), radius matching (RM), kernel matching (KM) and, lastly, stratification matching (SM), as suggested by Stuart (2010) for small samples, as in our case, where the number of control observations does not exceed the number of treatment observations.

Checking covariate balance and testing robustness Observations in the two groups overlapped considerably. The region of common support was set after dropping 10 FT observations with a propensity score higher than 0.87 (the highest propensity score of non-FT observations). We carried out several tests to check whether the PSM algorithms produced a well-balanced distribution of the covariates in the two groups (Lampach and Morawetz (2016)). As shown in Table 4 in the Appendix, non-FT and FT participants had similar characteristics after matching and the balancing properties in all four models were fulfilled thus making it possible to interpret the ATT estimations: the standardised differences (% bias) were less than 10%; the absolute standardised difference (B) did not exceed 25%, as recommended by Stuart (2010); and the aggregated ratio of treated (matched) to non-treated variances (named R) was below the recommended value of 2. Kernel matching had the lowest mean (4.2) and median (4.6) biases compared to the other matching methods. To interpret our results, we examine the 95% confidence intervals and t values (Table 3) and use Kernel matching estimators to comment them.

Lastly, we use the Rosenbaum bounds test to analyse the sensitivity of the PSM estimation to hidden bias (un-confoundedness assumption), as suggested by Lampach and Morawetz (2016). The violation of the un-confoundedness assumption is measured by the log odds differential assignment due to these unobserved factors (gamma Γ). The higher the gamma value, the more robust the ATT. Gamma Γ values in Table 3 reveal that the estimated ATT are still significant when the observations do not have equal propensity scores as a result of unobserved factors (Rosenbaum 2014)[7].

Results and discussion

Impacts on outcome variables

The ninety-five percent confidence intervals and *t* values of the PSM listed in Table 3 consistently show that FT has a significant and positive impact on the net return from coffee. For example, the results of Kernel matching indicate an estimated average effect of 3494.07 PEN. In relative terms, FT participation almost triples the per capita net returns from coffee[8]. This is explained by the significant and positive impact of FT on farm gate coffee prices, the amount of land under coffee and yields. First, FT farmers received around 33.42 PEN more (US$9) per quintal for their coffee than non-FT farmers. Second, while no differences were found between FT and non-FT farmers in 2006, the kernel matching estimates found that FT farmers increased their coffee area by an average of 0.61 ha. Third, FT farmers harvested significantly more coffee per hectare (an average of 3.37 quintal/hectare more) than non-FT farmers. The impact results are significant irrespective of the parametric or matching model used (see 95% confidence intervals in Table 3).

By contrast, results indicate that FT has no significant impact on any of the food security indicators: experience of the lean months period (SHORTAGE), the qualitative dimension of food access (HDDSqual) and the perception of food rationing (moderate or severe food insecurity according to ELCSA).

[7] Gamma are only presented for ATT estimated to be significant to the extent they are (in)sensitive to hidden bias. As Gamma increases, the confidence interval becomes wider and eventually becomes uninformative (including both very large and very small *P* values). Gamma represents the point at which the interval becomes uninformative. Consequently, gamma values are not relevant for non-significant ATT because the confidence intervals are already wide and do not allow conclusions to be drawn

[8] With 1033.99 as the estimated average treatment effect for per capita net returns for control group. This important effect may raise concerns about potential contamination effects at the expense of non-FT farmers. Yet, first, the potential contamination effect of price should be positive rather than negative: when prices rise in a PO, other POs have to line up so as not to lose their producers. Second, the potential contamination effect for productivity of land acquired by FT farmers cannot be checked with our data. However, no significant differences were found between the share of FT and non-FT farmers who purchased or sold land in the 3 years preceding the survey. This indicates that no land was transferred from non-FT to FT farmers

Factors and impact pathways explaining the positive impacts on coffee-related variables

FT farmers received a higher price for their coffee than non-FT farmers. This positive price effect is probably driven by two main factors. First, in 2015, the price safety net provided by FT schemes was activated: the international prices for organic coffee were lower than the FT guaranteed minimum price for organic coffee. Second, FT schemes probably supported the two FT POs in establishing long-term partnerships with buyers and being able to sell a high proportion of coffee on the FT market. The POs' ability to sell FT coffee on FT markets means that members benefit from FT prices for their whole coffee harvest. The external validity of our findings in terms of prices may be limited, since global demand for FT-certified coffee is far below supply. Second and despite these price benefits, our results suggest that yield is the key to increasing net returns for coffee farmers, as already suggested by Barham et al. (2011) and Barham and Weber (2012) in Mexico and Peru. Increases in yield appear to be linked to changes in agricultural practices. FT participants use more compost and organic inputs (89% compared to 75%-significant 5 per cent level) and spend more on labour than non-FT participants (Table 2). While they are composed of the same number of family workers on average, FT participants spend on average 136 PEN/ha more on labour than non-FT farmers (significant differences at 10 per cent level). Information gathered in focus group discussions and on livelihood trajectories in semi-directive interviews support these results. We observed major changes in FT households' livelihood trajectories (Sirdey and Lallau 2020): they adopted new agricultural practices, such as weeding three times a year, pruning trees, renewing plots, controlling the density of trees and using fertilisers. The drivers of change reported in these interviews suggest that these changes are related to both PO incentives and FT schemes. POs provide training and are able to sell a large proportion of the coffee produced by their members under FT conditions, which motives farmers to increase coffee production as well as the size of their farm. In addition, FT guarantees minimum prices and collective premiums allocated per kilo of coffee and may consequently encourage farmers to invest more in coffee. FT standards require POs to allocate at least 25% of the collective premium to improving coffee production and/or quality. To fulfil this requirement, one PO allocated a share of the premium to an organic input bank, thereby enabling farmers to access credit to purchase organic inputs at a low interest rate. Our findings suggest that FT mechanisms provide enabling conditions for POs to support farmers improve their production practices (higher yields and more land for coffee production), while guaranteeing a minimum price.

Possible reasons for persistent food insecurity

In our sample, 78% of coffee farmers experienced inadequate food provisioning for at least 1 month during the lean season, 36% had to eat lower quality food or less variety due to lack of resources during the lean months and 30% had to reduce their total food consumption. Our findings indicate that although FT generates a higher income from coffee, it is not sufficient to improve food security. We discuss these findings in the light of the existing literature and in relation to our own qualitative and quantitative data and focus group discussions.

Table 3 Results of parametric and matching models

	Parametric models			Nearest neighbour matching (3)				Radius matching			
				3 neighbours within the calliper distance (0.03), with replacement				All non-FT participants within the calliper distance (0.03), same weight			
	ATT (SE)	95% confidence interval	t	ATT (SE)	95% confidence interval	t	Γ	ATT (SE)	95% confidence interval	t	Γ
Net return from coffee[a]	3370.19 ***(695.83)	[2006.36–4734.02]	4.84	3580.48 ***(720.47)	[2168.35–4992.60]	4.97	3.4	3589.81 ***(708.85)	[2200.46–4979.16]	5.06	3.6
Farm gate price[a]	35.85***(7.69)	[20.78–50.92]	4.66	35.52***(10.8)	[14.35–56.68]	3.29	3.5	36.94***(10.23)	[16.89–56.99]	3.61	4.0
Area under coffee[a]	0.47***(0.15)	[0.176–0.76]	3.23	0.64***(0.24)	[0.17–1.11]	2.59	1.4	0.64**(0.24)	[0.17–1.11]	2.66	1.5
Yields[a]	3.69***(0.85)	[2.02–5.36]	4.33	3.38***(0.99)	[1.44–5.32]	3.40	1.8	3.42***(0.96)	[1.65–5.18]	3.56	1.9
Coffee production[a]	8.96***(1.92)	[5.20–12.72]	4.66	9.33***(2.11)	[5.19–13.46]	4.42	2.7	9.36***(2.05)	[5.34–13.38]	4.55	2.8
SHORTAGE[b]	−0.62 (0.49)	[−1.58–0.34]	−1.25	0.03 (0.09)	[−0.15–0.21]	0.33		0.03 (0.09)	[−0.15–0.21]	0.32	
Moderately or severely food insecure households (ELCSA ≥ 4)[b]	0.07 (0.45)	[−0.81–0.952]	0.16	0.03 (0.10)	[−0.17–0.23]	0.31		0.03 (0.10)	[−0.17–0.23]	0.37	
HDDSqual[a]	0.94 (0.17)	0.61–1.27	0.54	0.27 (0.20)	[−0.12–0.66]	1.32	-	0.29 (0.20)	[−0.10–0.68]	1.46	-

	Kernel matching				Stratification		
	All non-FT participants within the default bandwidth (0.06), weight according to propensity score distance				Four blocks, weighted average of treatment effects in each block		
	ATT (SE)	95% confidence interval	t	Γ	ATT (SE)	95% confidence interval	t
Net return from coffee[a]	3494.07 *** (695.02)	[2131.83–4856.31]	5.03	3.4	3444.98 ***(733.07)	[2008.16–4881.79]	4.7
Farm gate price[a]	33.42***(9.61)	[14.58–52.25]	3.48	4.1	33.57***(7.34)	[19.18–47.96]	4.34
Area under coffee[a]	0.61**(0.23)	[0.16–1.06]	2.64	1.4	0.58***(0.23)	[0.13–1.03]	2.49
Yields[a]	3.37***(0.91)	[1.57–5.15]	3.68	1.9	3.29***(0.86)	[1.60–4.97]	3.81

Table 3 (continued)

	Kernel matching				Stratification		
	All non-FT participants within the default bandwidth (0.06), weight according to propensity score distance				Four blocks, weighted average of treatment effects in each block		
Coffee production[a]	9.13***(1.99)	[5.23–13.03]	4.59	2.6	8.74***(2.18)	[54.47–13.01]	4.01
SHORTAGE[b]	−0.03 (0.08)	[−0.19–0.13]	−0.31		−0.02 (0.08)	[−0.18–0.13]	0.04
Moderately or severely food insecure households (ELCSA ≥ 4)[b]	0.003 (0.09)	[−0.17–0.18]	0.03		0.004 (0.09)	[−0.17–0.18]	0.04
HDDSqual[a]	0.24 (0.19)	[−0.10–0.64]	1.28	-	0.20 (0.18)	[−0.15–0.55]	1.10

*[a] The parametric model used is OLS, [b] the parametric model used is the logit model; standard errors (SE) in parentheses; significance rates: ***1%, **5%, *10%, sample size = 140*

First, we could have assumed that FT mechanisms encourage farmers to overspecialise, by growing more coffee and less food for home consumption (Van Rijsbergen et al. 2016). However, our findings show that the investment in coffee was not detrimental to staple food production and food crop diversification, which may actually benefit the dietary diversity of rural households (Pellegrini and Tasciotti 2014). While we found that FT had a significant positive impact on legume production (total and per household member), we observed no significant impact on cereal production, the area of land allocated to staple food crops or the share of self-consumption (Appendix, Table 5). In practice, coffee and staple crops do not compete for land in our study area: coffee trees require irrigation, which is not available in the highland plots where staple food is grown.

Second, we observed that FT participants depend more on coffee for their living (81% report that coffee is their main source of income) than non-participants (54%), who also rely on off- and non-farm activities. This is in line with the results of a study conducted in Colombia, where the authors show that increased income from coffee as a result of FT failed to generate higher total household incomes because other sources of revenue declined at the same time (Vellema et al. 2015). Yet, diversification of livelihoods is likely to make a positive contribution to small farmers' total income. It may allow the very poor to avoid destitution and increase their total income thanks to non-farm work for the better-off (Ellis 2000).

Third, it is noteworthy that seasonal lump sum payments (which is the case for coffee incomes) are less likely to be spent on food than money from a regular income (Anderman et al. 2014).

Lastly, the difference in the net return from coffee between FT and non-FT participants may be used for other expenses (Dury and Bichard 2015; Banerjee and Duflo 2012). We could have assumed that FT does not contribute to improving the diets of FT farming households simply because local food availability is limited. However, we found no correlation between the impact of food security among FT farmers and geographic remoteness. In fact, food can be bought at the local markets, although the food available is limited in terms of quantity and diversity, with few fruits and vegetables and no fresh meat or fish. This food is also more expensive during the lean months. But even if food supply does not encourage households to improve their diet, local food availability is not a limitation. When participants in the focus groups were presented with the paradox of a significant increase in coffee net return but no significant effect on household food security, they spontaneously said that improving their diet is not a priority, but that their children's education is. They unanimously agreed that any additional net income generated by coffee tends to be used to finance their children's higher education, rather than for immediate food security needs. This claim was supported by the information gathered in the semi-directive interviews with members of NORANDINO's and CECANOR's staff when they were presented with the econometric results. The staff of both organisations spontaneously mentioned that priority is given to children's education. This explanation is also in line with the results reported by Meemken et al. (2017), who found that FT has no impact on food expenditure and nutrition, but a strong positive impact on educational expenditure. Several other studies also concluded that FT has a positive impact on primary (Arnould et al. 2009) and secondary schooling (Gitter et al. 2012). Qualitative data suggest that farmers want their children to work in a non-farm sector, which is why they invest in their children's higher education rather than spending money on immediate food security.

Conclusion

In this article, we examine the impact of fair trade (FT) certification on small producers in terms of their income from coffee and food security in a year when the minimum price was guaranteed. Using cross-sectional household data collected from 140 coffee farming households in Peru, we examine whether the FT benefits (higher prices and net return from coffee) are sufficient to guarantee food security for farming households. An integrated approach using an econometric model (propensity score matching, PSM) and qualitative analyses (based on qualitative interviews and focus groups) helped explain our main findings. The study has some limitations. The external validity is limited because the FT producer organisations (POs) we studied managed to sell a high proportion of their green coffee under FT conditions, which is rare. The internal validity is somewhat limited by the use of simple cross-sectional analysis and PSM methodology, which rely on observable factors alone. Although in our case FT participation does not appear to be closely linked with farmers' individual decisions, follow-up research using difference-in-difference would properly account for the unobserved time-invariant factors and confirm the robustness of our results. Despite these limitations, our findings confirm that FT participants received a significantly higher net return from coffee than non-FT participants. The increase is not so much driven by higher sales prices as by increased yields. This suggests that although the FT minimum price provides a safety net (in the event of a fall in international coffee prices), the changes seem to be driven by the FT project as a whole (collective premiums, agricultural training courses, long-term partnerships), as well as by the POs' ability to sell a high proportion of coffee under FT conditions.

However, these favourable conditions are not sufficient to improve food security. Even if FT participants produce more staple foods for home consumption and earn more from coffee, they still struggle to secure access to food in the lean months.

These results suggest that more caution is required regarding FT claims that fair prices and higher incomes automatically increase food security and reduce the vulnerability of certified households. Our study suggests that additional income from FT is used for long-term non-farm investments, in our case children's higher education. This leakage effect raises several questions. First, is FT pertinent as a strategy to escape poverty and improve food security in the short term? Second, given that the economic returns generated by FT are likely to be used to pay for children's higher education in non-farm sectors, what are the long-term effects of FT and what are the trajectories of "fair trade children"? Third, given that FT-certified POs and FT proponents want to keep producers in the FT system as well as in the agricultural sector, isn't that a contradiction? Following on from that question, should FT be considered as a transitional short-term development tool? Alternatively, should FT POs strive to develop opportunities for young people to help build a future in rural areas? These key issues require further study and should be included on the follow-up research agenda. Beyond the broad and still growing body of empirical literature on the impact of FT certification on economic well-being, more in-depth research is required to explore the non-economic, knock-on and long-term effects of certification.

Appendix

Table 4. Covariate balance for the different matching methods

	% bias between (matched) treatment and control groups			
	Before matching	Radius (cal 0.03)	Kernel (bandwidth 0.06)	NN(3) (cal 0.03)
		$N = 129$	$N = 129$	$N = 129$
Number of cows in 2006	17.6	−2.1	−4.1	−4.7
Area under coffee in 2006	6.7	6.7	9.7	4.3
Area under food crops in 2006	8.8	−8.5	−0.8	−6.9
Age of head of household	−50	2.9	0.1	−1.3
Number of years of education of head of household	−16.7	−4.3	−5.1	−2.3
Household size	39.0	9.7	6.3	6.0
Worker equivalent	25.5	12.0	−0.4	6.1
Access to non-farm income	−26.7	−1.9	2.1	1.4
Time from house to city where basic commodities can be bought (minutes)	44.3	−4.9	−7.0	−5.9
Leadership	4.6	0.2	6.4	7.7
Meanbias	23.7	5.3	4.2	4.7
Medbias	21.6	4.6	4.6	5.3
$p > \text{chi}^2$ (joint significant effect of covariates on adoption)	0.002	1.000	1.000	1.000
B (absolute standardised difference of the means of the propensity score in the treatment and (matched) control group)	94.6	18.6	18.9	16.3
R (ratio of treatment to (matched) control variances of the propensity score index)	1.20	1.11	0.92	0.91
Sample size = 140				

Table 5. Results of parametric and matching models (food production variables)

	Parametric models			Nearest Neighbour Matching (3)				Radius Matching			
				3 neighbours within the caliper distance (0.03), with replacement				All non-FT participants within the caliper distance (0.03), same weight			
	ATT (SE)	95% confidence interval	t	ATT (SE)	95% confidence interval	t	Γ	ATT (SE)	95% confidence interval	t	Γ
Cereal production (maize and/or wheat) (quintal) (total)	0.08 (1.11)	[−2.09–2.25]	0.08	−1.52 (1.66)	[−4.57–1.73]	−0.92		0.40 (1.40)	[−2.3–3.14]	0.29	
Cereal production (maize and/or wheat) (quintal) (per capita)	−0.08 (0.45)	[−0.96–0.80]	−0.18	−1.07 (0.76)	[−2.56–0.42]	−1.41		−0.12 (0.62)	[−0.133–1.10]	−0.20	
Legume production (beans and/or peas) (quintal) (total)	1.01** (0.46)	[0.11–1.91]	2.18	0.79 (0.50)	[−0.19–1.77]	1.58		0.78 (0.44)	[0.08–1.64]	1.76*	1.1
Legume production (beans and/or peas) (quintal) (per capita)	0.55***(0.16)	[0.23–0.86]	3.36	0.39** (0.15)	[0.096–0.68]	2.55	1.3	0.38*** (0.14)	[0.10–0.56]	2.61	1.2
Area used for food crops in 2015 (hectare)	0.08 (0.11)	[−0.13–0.29]	0.72	−0.03 (0.14)	[−0.30–0.24]	−0.23		0.02 0.12)	[−0.21–0.25]	0.14	
% food consumed grown on the farm	0.04 (0.04)	[−0.04–0.12]	1.00	0.07 (0.05)	[0.03–0.168]	1.36		0.06 (0.05)	[0.04–0.16]	1.24	

	Kernel Matching				Stratification		
	All non-FT participants within the default bandwidth (0.06), weight according to propensity score distance				Four blocks, weighted average of treatment effects in each block		
	ATT (SE)	95% confidence interval	t	Γ	ATT (SE)	95% confidence interval	t
Cereal production (maize and/or wheat) (quintal) (total)	0.18 (1.40)	[−2.56–2.92]	0.13		1.29 (0.97)	[−0.61–3.19]	1.245
Cereal production (maize and/or wheat) (quintal) (per capita)	−0.23 (0.63)	[−1.46–1.00]	−0.37		0.134 (0.138)	[−0.13–0.40]	0.35
Legume production (beans and/or peas) (quintal) (total)	0.83* (0.44)	[0.03–1.69]	1.86	1.2	0.52 (0.53)	[0.52–1.56]	0.98

Table 5. (continued)

	Kernel Matching				Stratification		
	All non-FT participants within the default bandwidth (0.06), weight according to propensity score distance				Four blocks, weighted average of treatment effects in each block		
	ATT (SE)	95% confidence interval	t	Γ	ATT (SE)	95% confidence interval	t
Legume production (beans and/or peas) (quintal) (per capita)	0.39*** (0.14)	[0.11–0.66]	2.68	1.2	0.31* (0.16)	[−004–0.62]	1.92
Area used for food crops in 2015 (hectare)	0.01 (0.12)	[−0.22–0.24]	0.13		0.05 (0.20)	[0.34–0.44]	0.25
% food consumed grown on the farm	0.06 (0.05)	[−0.04–0.16]	1.34		0.05 (0.04)	[−0.03–0.13]	1.19

Standard errors (SE) in parentheses; Significance rates: ***1%, **5%, *10%, sample size = 140 observations

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Code availability On request.

Authors' contributions NS and SL conceived the study design. NS led data collection, statistical analyses and drafted the original paper. NS and SL both contributed in writing the original draft and reviewing and editing and approved the final version.

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Data availability On request.

Compliance with ethical standards

Conflict of interest The authors declare no conflict of interest.

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