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Adoption of food safety measures: The role of bargaining and processing producer organizations

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ABSTRACT

Increasing demand for safe food in developing countries entails meeting stringent food safety requirements. Food retailers and regulatory bodies impose food safety measures related to production and handling of farm produce. For smallholders to remain competitive in such a system, institutional arrangements are necessary. We examine the role of producer organizations (POs) in influencing safe food production behaviours among farmers. Using data from 11 expert interviews and a quantitative survey involving 595 smallholder dairy farmers in Kenya, a propensity score matching estimation is employed to assess membership effects. We show that membership in POs positively and significantly influences smallholders' adoption of food safety measures related to milk storage and the milking area. We highlight the importance of social incentives in improving food safety adoption among farmers even when price incentives are absent. Our recommendation is that PO policies that alleviate barriers to food safety adoption among farmers will be helpful in scaling up adoption.

1. Introduction

Demand for safe food in developing countries has increased because of two main factors: the modernization of food systems through the rise of supermarkets that impose food safety requirements (Reardon et al., 2019), and the outbreaks of food-borne diseases that, according to World Health Organization report, caused 91 million cases of foodborne diseases and 137,000 deaths in Africa in 2010 (WHO, 2015). Safe food is food without biological (e.g. bacteria), chemical (e.g. veterinary drug residues, disinfectants), or physical hazards (e.g. plastic, metal) (FSA, 2009). Availability and accessibility of safe food products is of particular concern because it increases food security as stated in the 1996 World Food Summit declaration: "Food security exists when all people, at all times, have physical, social and economic access to sufficient, *safe* and nutritious food to meet their dietary needs and food preferences for an active and healthy life (UN/FAO, 1996)". In addition to health benefits, safe food is fundamental for low-income countries' access to increasingly high-value regional and global food markets (Ehrich and Mangelsdorf, 2018). This, in turn, increases the income of smallholder households, which can improve rural livelihoods (FAO, 2017).

Despite the importance of safe food, improvement in food safety remains a major challenge in developing countries because of a lack of knowledge, low incentives to invest in food safety along the food value chain, the weakness of the public institutions responsible for regulatory enforcement and limited empirical knowledge regarding food safety application and food-borne diseases (Hoffmann et al., 2019). Nonetheless, given the perishable nature of agricultural products and the demand for safe food, institutional arrangements that enhance skills and coordination mechanisms are essential to improve food safety compliance in the value chain.

Policymakers and development practitioners consider producer organizations (POs) as critical in influencing food safety (FAO, 2017; IFAD, 2017). POs in developing countries operate in the formal value chain which handles processed and packaged products sold to supermarkets and urban consumers (Kiambi et al., 2018). Literature shows mixed impacts of POs on smallholders' access to high-value markets. On the one hand, additional compliance costs in high-value market chains constitute a burden, posing a threat to smallholders (Ait Hou et al., 2015). On the other hand, if POs facilitate smallholders' compliance with food safety requirements, these farmers gain entry to high-value markets and benefit from higher prices (Narrod et al., 2009). By addressing these mixed impacts, this study will contribute to the debate about POs and food safety.

While the theory provides information on why POs influence food

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safety, not much has been done to understand when these organizations achieve impact. The objective of this paper is to analyse the impact of membership in POs on the adoption of food safety measures. We argue that the type of PO influences members' adoption depending on the organization's functional and organizational structures. Recent research has emphasized considering these differences in evaluating the effect of POs for rural development (Kormelinck et al., 2019). Here, we distinguish between bargaining and processing POs. A typical bargaining PO collects and bulks members' products, mostly sells to traders, has a small membership size and is controlled by members (Bijman et al., 2016). Small membership size and member control are associated with a high level of trust among members and between members and the leaders (Nilsson et al., 2012). Trust improves members' commitment (Feng et al., 2016), including commitment to comply with food safety requirements. However, because a bargaining PO does not provide technical assistance, has low food safety requirements and applies non-professional management, it cannot easily influence members' adoption of food safety measures.

A processing PO collects, bulks, processes and packages members' products which are sold to supermarkets and high-end consumers (Michalek et al., 2018). The functions of this organization are complex, membership is large and management is often carried out by professional staff (Bijman et al., 2016). Complex business functions and shifting of decision rights from members to professional staff may lead to dissatisfaction, lack of trust, low member involvement and low commitment (Nilsson, 2018). This, in turn, negatively impacts food safety adoption. However, a processing PO confers benefits to smallholders in terms of access to technical assistance, information, credit and inputs, which are central for adoption of food safety measures (Naziri et al., 2014). Additionally, tight monitoring, coordination and food safety evaluation services linked to a processing PO facilitate adoption (Moustier et al., 2010; Cai et al., 2016). Profit motives and competitive behaviour of processing organizations can also drive investment in food safety when organizations seek to protect brand reputation (Hoffmann and Moser, 2017).

Our paper is a contribution to the scarce literature analysing the effect of PO membership on the adoption of food safety measures among smallholders. We use the Kenyan dairy value chain as our case study. Most research on food safety issues in Kenya focuses on the value chain actors' compliance with food safety requirements in the bulking, processing and consumer nodes shows a low level of compliance (Bebe et al., 2018; Nyokabi et al., 2018). Little information is available on the safety practices at the farm level, yet many food safety risks originate at the production stage (Lemma et al., 2018). Potential channels of milk contamination reported in Kenyan farms include inefficient personnel hygiene and udder cleaning (Mwangi et al., 2016), the use of plastic containers that are not easy to clean (Wafula et al., 2016) and the lack of adherence to withdrawal periods after treating cows with antibiotics (Orwa et al., 2017).

Kenya is an interesting case as the government and development practitioners remain highly proactive and decisive in improving smallholder farmers' market participation through POs (GoK, 2013; SNV, 2015). In the dairy sector, where collective marketing and food safety concerns have been growing, the government has made considerable efforts in restructuring traditional value chains and supporting POs to increase food safety compliance (KDB, 2017). The government released the "Code of hygienic practice for milk and milk products" in 2000 in which good hygienic production practices were developed to enhance compliance (KEBS, 2015). It is interesting to understand farmers' compliance with food safety in the country especially because compliance involves costs. Yet, markets in Kenya do not reward for food safety.

While our paper focuses on the role of POs in supporting the adoption of food safety measures, POs provide broader societal benefits. They have been found to promote the development of social capital in the farming community (Vo, 2016), by facilitating information exchange and trust building (Tregear and Cooper, 2016). They are also known for their democratic decision-making procedures, which provide participants an opportunity to practice democracy (Gwiriri and Bennett, 2020), which then benefits the community as a whole (Burchi and Vicari, 2014).

For our case study, we use empirical data from 11 experts and a quantitative survey involving 595 smallholder farmers to answer two objectives: i) To assess whether and to what extent membership in POs affects dairy farmers' adoption of food safety measures, and ii) To examine the potential heterogeneity effects of membership in POs on farmers' adoption of food safety measures across bargaining and processing POs and farm-level characteristics.

2. The dairy value chain in Kenya

The dairy sector in Kenya is important to the economy as it contributes 12% to the agricultural gross domestic product (KDB, 2016). Kenya has about 700,000 smallholder farmers, owning on average 0.4–1.6 hectares of land, and 1–3 cows, and producing about 80% of the national output (Makoni et al., 2014). Food safety issues in the country have become a matter of growing concern because of increasing demand for dairy products in the cities that have led to longer and food safety risk-prone value chains (Ndambi et al., 2019).

Dairy can be an important source of foodborne diseases and milk can be contaminated from the farm itself. The dominance of rural smallholder production farms in Kenya's dairy sub-sector present challenges to the effective monitoring and enforcement of food safety measures at the farms (ILRI, 2018). Constraints of smallholder dairy farmers' adoption of food safety measures are a lack of equipment, knowledge, and skills in food safety and a lack of access to professional and financial services (ILRI, 2018).

The dairy market in Kenya is composed of formal and informal value chains (Appendix 1). The informal value chain consists of dairy enterprises that evade regulation and engage in minimal value addition activities (Kiambi et al., 2018). This chain handles about 70 percent of the marketed milk in Kenya (KDB, 2017), generates 70 per cent of the 40, 000 jobs in dairy marketing and processing and supports nearly a million people (Alonso et al., 2018).

Typically, in the informal value chain, milk is collected from farms by traders who sell to milk bar operators, shops, kiosks and roadside vendors, who in turn sell to rural consumers or poor urban consumers. Traders perform milk collection and transportation activities during the night or very early in the morning, away from the official working hours of the Kenya Dairy Board (KDB) inspectors (Kiambi et al., 2018). Therefore, there is minimal compliance with milk safety standards. Minimal compliance is further hindered by a lack of knowledge and testing equipment (FIintrac and USAID-KAVES, 2014), exposing consumers to a high risk of contracting milk-related diseases. Traders pay farmers in flexible terms, that is daily, weekly, or bi-weekly, depending on farmers' preferences.

The informal value chain plays a key role in helping meet the nutrition needs of many households. However, increasingly, the government in Kenya is developing and implementing policies to repress the informal sector as a way to promote availability of safe milk (Alonso et al., 2018). For example, in 2015 the government of Kenya launched a campaign to promote the consumption of "processed (pasteurized), packaged milk" in an attempt to promote formalization of the national dairy sector.

The formal value chain consists of dairy enterprises that are formally under inspection and licensing (Kiambi et al., 2018). The formal value chain represents 30 percent of the marketed milk, which is mostly in processed form (KDB, 2017). The cow milk intake in this chain is growing at an average rate of 7 percent per year (Rademaker et al., 2016), indicating its' growing importance. This chain mainly includes dairy POs, milk processing companies and cottages (a type of node where milk is produced, processed, branded and packaged at the farm, mainly for high-class users and large hotels). POs act as intermediaries

between farmers and processors or as processors themselves (Makoni et al., 2014). Both bargaining and processing POs are found in the formal value chain in Kenya (Ton et al., 2016).

POs organize milk collection from the farm gate. Milk is then transported to collection centres through a variety of transport modes. Transportation from the collection centres to the POs is also organized by these organizations, but the costs are transferred to farmers by deducting from their monthly revenues. After reaching the PO facility, milk is cooled before being sold to private processors. Where cooling facilities are not available, milk is sold directly to traders. In advanced POs, milk is processed to final products that are sold to supermarkets, wholesalers, large institutions and sometimes directly to consumers through PO-owned shops and milk bars. POs control food safety at the farm, collection centres, cooling centres and at the processing nodes. POs pay farmers on their milk deliveries at the end of the month (roughly after 35 days) through the farmer's bank account.

3. Theoretical framework

One possible way to improve food safety in dairy is through smallholder's membership in POs. Farmers benefit from POs services related to food safety including training, coordination of milk collection, monitoring and evaluation of food safety measures, and provision of milk storage equipment (Ndambi et al., 2019). In the next section, we explain the theory relating PO membership to the adoption of food safety measures and add nuance to the role of different types of POs.

We hypothesise that depending on the functions and organizational structures, POs can influence members' adoption of food safety measures. A social control, process control, and output control framework is used to illustrate the effect of PO membership on food safety adoption (Fig. 1). Social control refers to the social mechanisms in a PO that directly or indirectly influence members' behaviour. Members have a common interest in complying with the food safety requirements of the buyer, but individually they may not assume the cost of adopting food safety measures (Nilsson et al., 2012). This encourages free-riding, that is, an individual provides low-safe milk in the hope that other farmers provide safe milk. In contrast, social capital, in particular trust, which is high in the relationship between farmers and the PO as opposed to that in the relationship between farmers and trader, enhances commitment (Lu et al., 2010), and this commitment can be on food safety compliance.

Process control is process monitoring and input control that lead to changes in food safety. Monitoring helps POs to gather information about members' compliance with food safety requirements (Hueth et al., 1999). If there is an indication of inadequacy in food safety, POs may provide advice or training. Training enhances farmers' knowledge and skills to apply food safety measures (Lindahl et al., 2018). In Vietnam, members of a vegetable PO improved food safety at the farm after receiving technical assistance from the organization (Naziri et al., 2014). Furthermore, process control of inputs is implemented when POs provide specific inputs and equipment for member farmers (Zhou et al., 2019).

Output control refers to the direct assessment of product safety, for instance through subjecting milk to laboratory tests. PO's evaluation of milk safety may encourage members to adopt food safety measures to minimise milk rejection. Besides, by employing a quality-based payment system, a PO can award farmers implementing food safety measures (Hueth et al., 1999).

The type of PO may influence farmers' adoption of food safety measures. Focusing on social control, we argue that in a large PO there is an opportunity for members to free ride on product safety and quality because of the anonymity of members (Pennerstorfer and Weiss, 2013; Naziri et al., 2014). Moreover, professional management of a processing PO is more autonomous, and members have limited influence on PO decision making (Bijman et al., 2014). Such low members' control weakens members' trust in the organization (Deng and Hendrikse, 2013), which can lead to a low commitment to complying with food safety requirements. In a small PO, social control is stronger which reduces free ridership. More so, members influence decision-making, which increases their feeling of attachment to the organization and trust in leadership.

Process control differs between processing and bargaining organizations in that processing POs enhance adoption of food safety practices through information exchange that is facilitated by tight coordination, monitoring and access to information, training and inputs (Bijman and Bitzer, 2016). Such input and training services are often lacking in bargaining POs. Further, processing POs may put more emphasis on output control measures than bargaining POs because of protecting brand reputation and increasing processing efficiency.

4. Methods and data

4.1. Farm survey

We conducted a survey in Kenya between October and December 2018. We purposively selected one sub-county in Meru and two sub-counties in Nyandarua, on condition that they were having a mixed pattern of collective and individual milk marketing channels. At the sub-county level, we used stratified sampling with three strata: bargaining POs, processing POs, and non-members. Two processing POs out of the seven and one bargaining PO out of seven in the Imenti-south sub-county in Meru were chosen. One processing PO operating in the Kinangop and Ol-kalou sub-counties in Nyandarua was selected as it was the only one available; it has members in both sub-counties. We selected one bargaining PO out of the seven present in Ol-Kalou sub-county in Nyandarua. We purposively selected the POs based on accessibility, receptiveness of the PO staff and representativeness of either bargaining or processing POs in the counties. The processing and bargaining POs selected are representative as they share similar characteristics with excluded POs in terms of size, resource capacity, functions and services. We used reports from the Kenya Dairy Board, Agriterra (Kagathi, 2014), and from a joint study by Wageningen University and Research and the Food and Agricultural Organization (Ton et al., 2016) as well as journal articles (O'Brien and Cook, 2016) to verify the representativeness of selected POs. Further support information was given by the government

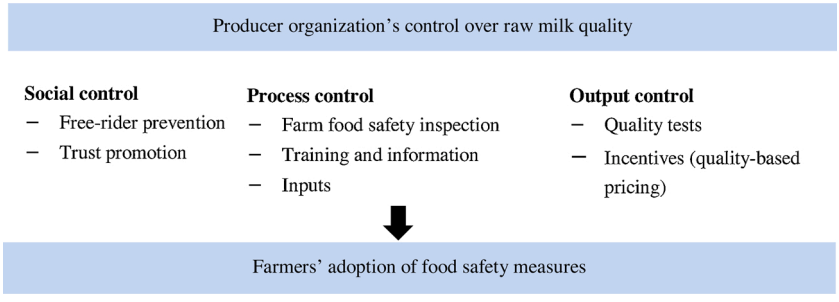

Fig. 1. A conceptual framework on PO control over members' food safety behavior.

staff from the selected counties.

The biggest challenge in a cross-sectional survey is to get a random sample of households. We could not identify members from the PO register because the contact details of the members were either missing or not updated. To ensure a random sample, we obtained a list of milk collection routes from the POs. Seven enumerators followed a different route every morning. The first enumerator started to identify households at the start of the collection route. Along the same route, the next enumerator started to identify households at least four kilometres from where the previous enumerator was left. We used the following technique to identify households belonging to the targeted PO: when the first household was identified, enumerators were required to skip five households to pick the next household. For the selection of non-members, we first identified areas in which traders were operating. In regions with POs, trader activities were minimal. Thus, we also sampled non-members from areas in which POs were not active. Trader-dominated areas had similar geographical characteristics as areas with active POs. We first identified the village from which traders were collecting milk. Then enumerators converged in the village centre and followed a particular milk-collection route followed by traders. A similar identification procedure as that of PO members was used. We sampled 375 PO members (112 in the bargaining POs and 263 in the processing POs), and 220 non-members. Data were collected using the one-on-one interviewing technique.

4.2. Adoption measures

After carefully reviewing the code of hygienic measures for milk and milk products (FAO/WHO, 2011; KEBS, 2015), and manuals about hygienic milk production practices (Lore et al., 2006; Pandey and Voskuil, 2011; Goopy and Gakige, 2016), we identified a total of 42 food safety measures on a dairy farm. Then, we consulted experts (Appendix 2) with experience in food safety issues in Kenya to identify the relevant measures in the study context. A total of 21 food safety measures were retained, grouped into four broad categories; i) milking— the health of the milker and hygiene followed during milking (9), ii) milk storage–-storage of milk, type of milking equipment and cleaning of equipment (7), iii) milking area–structure and cleaning of milking area (2), and iv) animal health–care of veterinary and microbiological aspects (3). Farmers scored each food safety measure on a scale of 1–100 depending on their perceived level of adoption, where 0 means lowest level of adoption and 100 means highest level of adoption. These measures are described in Table 1.

We developed an adoption index using a framework proposed by Kumar et al. (2017). We calculated the average score of the food safety measures practiced in each category. However, the contribution of food safety measures in the hygienic milk production process may not be similar across four categories of food safety measures. Thus, we computed for each farm, the food safety index in each of the four categories. Using expert interviews, weights of the four categories were obtained with reference to their relative importance in ensuring milk safety (Appendix 2). These weights sum to 1.

The adoption index (AI) for each category for the *i*th farm was calculated by;

$$AI = w_j p_j \quad (1)$$

where w_j is the weight assigned to the *j*th food safety practice category, and p_j is the average score of food safety measures practiced in the *j*th category. Column 2 of Table 2 provides the definition of all key variables including the four food safety categories, which are the outcome variables.

4.3. The evaluation method: propensity score matching

Cross-sectional studies risk the presence of selection bias, as characteristics that affect outcomes can also influence an individual's decision to join a PO. We use the propensity score matching (PSM) method to minimize observable selection bias by matching members and non-members with similar observed time-invariant characteristics (Rosenbaum and Rubin, 1983). The PSM is modelled in two stages. In the first stage, a logit model for membership in PO is estimated to calculate the propensity score for each observation. Then, each member is matched to a non-member with comparable propensity score values. Members for whom an appropriate match cannot be found, as well as non-members not used as matches, are dropped from further analysis.

We make two critical assumptions to use the propensity score. The first is the conditional independence assumption, which means that, conditional on the observable covariates (X), membership (the treatment) and food safety adoption (the outcome) are independent (Caliendo and Kopeinig, 2008). This means X can only contain observable characteristics. The second assumption is the presence of common support: there must be sufficient overlap in the propensity scores of the member and non-member groups to run analyses that compare individuals with similar scores.

This study uses nearest neighbour and kernel methods of matching members and non-members. In the nearest neighbour matching, each treated individual is matched with the control individual that has the closest propensity scores(s). In the kernel method, all treated subjects are matched with a weighted average of all controls, using weights that are inversely proportional to the distance between the propensity scores of the treated and control groups. A matching estimator is considered good if it does not eliminate too many of the original observations from the final analysis while at the same time yielding statistically equal covariate means for member and non-member units (Caliendo and Kopeinig, 2008).

The second stage of PSM involves calculating the Average Treatment Effect on the Treated (ATT) of PO membership on the outcome variable

Table 1
Average level of adoption of food safety measures.

Food safety measure	%
Milking	
The milker does not milk when suffering from communicable diseases such as cough, cold, diarrhoea	69
The milker washes his/her hands with soap up to the elbow before initiating milking	82
After washing the hands, the milker dries his/her hands with a cloth/towel	84
The udder and teat of the cow are washed before milking	94
A clean, dry towel is used to wipe the udder dry after washing	86
The milker uses only one towel per cow	66
The milker checks for mastitis before milking	74
The cows are milked fast but gentle, without any interruptions	92
After milking, the teats are dipped or sprayed with an antiseptic solution	42
Milk storage	
Milk is filtered immediately after milking	93
The cloth/strainer is disinfected after use	71
After milking, milk is stored in clean sealed containers	85
Where the milk is stored for more than two hours, cooling to 10 degrees or below is undertaken	74
The milking vessels and equipment are made from approved material e.g. steel, aluminium	69
The milking vessels and equipment are sterilised with boiling water or dairy sanitizing solution after cleaning	81
The milking vessels and equipment are put upside down on a drying rack, in the sun, after cleaning	92
Milking area	
The floor of the milking area is made of concrete	51
The milking area is cleaned thoroughly after every milking	49
Animal health	
The cows being milked are free from diseases such as tuberculosis, brucellosis, mastitis	90
The cows suffering from mastitis are milked last and their milk is discarded	90
If the cow is on antibiotics, the milk from such cows is not consumed until the withdrawal period is over	89

N = 595.

Table 2
Summary statistics.

Variable name	Description	Full sample N = 595	Non-members (1) N = 220	Bargaining PO (2) N = 112	Processing PO (3) N = 263	All members (4) N = 375	*t* -test (2)-(1)	*t* -test (3)-(1)	*t* -test (4)-(1)
Age	Age of the farmer in years	49.11	47.28	51.29	49.72	50.19	2.48**	2.03**	2.60***
Male	If a farmer is male = 1, 0=otherwise	0.50	0.44	0.56	0.52	0.53	2.18**	1.85*	2.29**
Education	Years of formal schooling	9.37	8.85	9.16	9.90	9.68	0.73	3.33***	2.77***
Household size	Number of household members	4.07	4.05	4.10	4.09	4.09	0.26	0.26	0.30
Hired labour	If a farmer has a casual or permanent worker on the dairy farm = 1, 0=otherwise	0.41	0.32	0.50	0.46	0.47	3.18***	3.10***	3.60***
Logarithm of milk production	The log of the total amount of milk produced kg/farm/year	8.46	8.16	8.57	8.65	8.63	5.24***	7.26***	7.61***
Number of cows	Total number of cows owned	2.22	1.76	2.40	2.52	2.49	4.56***	4.38***	4.76***
Pure breed cows	If the farmer has pure breed cows = 1, 0=otherwise	0.52	0.45	0.51	0.59	0.56	0.94	2.89***	2.56**
Farm size	The size of the farm of the farmer in acres	3.61	3.33	3.43	3.92	3.78	0.10	0.82	0.72
Ownership of transport	If the farmer has transport means = 1, 0=otherwise	0.35	0.31	0.37	0.37	0.37	1.04	1.38	1.46
Training about farm hygiene	If the farmer has received formal training on hygiene in the past 3 years = 1, 0=otherwise	0.48	0.26	0.61	0.59	0.60	6.35***	7.65***	8.25***
Nyandarua County	If the farmer is in Nyandarua county = 1, 0=otherwise	0.53	0.55	0.52	0.51	0.51	−0.48	−0.70	−0.73
Distance to collection point	The distance to the nearest PO milk collection centre in km	0.74	1.12	0.65	0.44	0.51	−1.71*	−3.76***	−3.93***
Milking	Index of adoption of milking measures in percentage	76.31	74.01	76.61	78.11	77.66	1.65*	3.27***	3.14***
Milk storage	Index of adoption of milk storage measures in percentage	80.63	74.52	82.54	84.91	84.21	4.78***	8.58***	8.50***
Milking area	Index of adoption of milking area measures in percentage	49.93	34.39	51.39	62.31	59.04	3.79***	8.14***	7.57***
Animal health	Index of adoption of animal health measures in percentage	89.74	89.21	89.80	90.15	90.04	0.39	0.74	0.72

*, **, and *** denote significance at the 10%, 5%, and 1% level, respectively; the t-value is presented under *t*-test.

Y using the matched observations of members and non-members. The PSM estimator of the ATT is the difference in outcomes between the treatment and control group appropriately matched by the propensity score:

$$\mathrm{ATT} = \mathrm{E}(Y_1 - Y_0/U_i = 1) = \mathrm{E}(Y_1/U_i = 1) - \mathrm{E}(Y_0/U_i = 1) \quad (2)$$

where Y_1 is the outcome (food safety adoption index) in the treated condition; Y_0 is the outcome in the control condition; and U_i indicator variable (treatment status) denoting membership in the PO.

5. Results and discussion

5.1. Descriptive statistics

The adoption level of each practice is presented in Table 1. Farmers self-scored level of adoption is high for most of the food safety measures, which is consistent with the study of Kumar et al. (2017) about the adoption of food safety measures among dairy farmers in India. Of the nine measures included in the milking category, washing hands with soap before milking, drying hands after washing, cleaning the udder and teat of the cow before milking and milking without interruptions are highly adopted measures. A measure that is less adopted (<50%) is dipping or spraying of teats with an antiseptic solution after milking, which is an indication of low availability of antiseptics or a lack of knowledge among farmers.

Seven measures are included in the milk storage category. Filtering of milk immediately after milking and drying of milk vessels in the sun after cleaning are the highly adopted measures. Milking area measures are important since dairy farm surroundings can promote spread of pathogens and diseases if unclean. Farmers rarely use a concrete milking floor, which partly explains why they are less likely to clean the milking area because of the difficulties in cleaning non-concrete floors.

The three measures related to animal health i.e. ensuring cows being milked are free from diseases, discarding milk from cows suffering from mastitis, and non-consumption of milk from cows on antibiotics, are highly adopted.

Table 2 presents the food safety adoption indexes across the four categories. Higher adoption is reported for milking, milk storage and animal health measures than for milking area measures. Kumar et al. (2017) support our findings by reporting that dairy farmers in India report a higher adoption of measures related to milking and milk storage than milking area. Distinguishing by membership status, the adoption level is high for members compared to non-members with regard to milking, milk storage, and milking area measures. However, the mean differences presented in this section do not account for confounding factors. We will deal with this problem later by employing the propensity score matching method.

The experts' ranking of the importance of the food safety adoption categories in influencing milk hygiene are presented in Appendix 3. Milking is the most important category (0.31), followed by milk storage (0.26), animal health (0.25), and milking area (0.18). One of the experts explained that milking is vital as it serves two objectives: it contributes to the production of clean milk (by following recommended cleaning

procedure) and to maintain good cow health (by checking for mastitis).

Summary statistics of variables used to create propensity scores are presented (Table 2). The explanatory variables include a set of social and economic factors that could influence membership and adoption of food safety (Fischer and Qaim, 2012; Chagwiza et al., 2016; Mojo et al., 2017; Wossen et al., 2017). An average dairy farmer in the study sample is 49 years, with 9 years of formal education and owns about 2 cows. A higher percentage of men are members compared to women. Besides, a farmer belonging to a PO is older, has high farm milk production and number of cows compared to a non-member. A member of a processing PO has higher education, owns more pure breed cows, is better trained on farm hygiene, and lives in a less remote area compared to a non-member.

5.2. Propensity score matching

5.2.1. Logit model on determinants of PO membership

To derive the propensity scores to match members and non-members, we estimated three logit models comparing the determinants of farmers' membership in a bargaining PO versus non-membership, membership in a processing PO versus non-membership and membership in any of the two POs versus non-membership (Table 3). The dependent variable of the logit model takes a value of one for members and zero for others.

As the main aim of estimating the logit model is to obtain propensity scores, we will not elaborate on the determinants of membership. However, it is noteworthy to mention that training and farm milk production factors positively influence membership in POs. Furthermore, older and more educated farmers join processing POs. The distance to the milk collection point has an inverse relationship with membership, which is expected because of transportation costs.

After obtaining the predicted propensity scores from the logit model, we use the scores to match members to non-members. Details on the effectiveness of the matching quality between members and non-members are presented in Appendix 4–6.

Table 3
Determinants of PO membership (logit model).

	Membership in a bargaining PO versus non-membership	Membership in a processing PO versus non-membership	Members versus non-members
Variable	Coefficient (SE)	Coefficient (SE)	Coefficient (SE)
Age	0.031 (0.06)	0.121**(0.054)	0.085* (0.045)
Age squared	0.000 (0.001)	−0.001*(0.001)	−0.001 (0.000)
Male	0.208 (0.284)	0.106 (0.221)	0.13 (0.203)
Education	0.017 (0.040)	0.059* (0.034)	0.049* (0.030)
Household size	−0.016 (0.079)	−0.028 (0.062)	−0.013 (0.057)
Hired labour	0.512*(0.290)	0.215 (0.253)	0.282 (0.226)
Log of milk production	0.957***(0.251)	0.779***(0.186)	0.807*** (0.175)
Pure breed cows	−0.302 (0.282)	0.108 (0.222)	−0.041 (0.204)
Farm size	−0.032** (0.016)	−0.029**(0.013)	−0.029** (0.013)
Training on farm hygiene	1.377***(0.279)	1.525***(0.250)	1.413*** (0.221)
Distance to collection point	−0.174* (0.105)	−0.347***(0.096)	−0.308*** (0.084)
Ownership of transport	−0.448 (0.308)	−0.138 (0.236)	−0.266 (0.220)
Nyandarua County	−0.053 (0.287)	0.385 (0.250)	0.170 (0.221)
Constant	−10.293*** (2.387)	−10.785***(1.937)	−9.572*** (1.717)
Pseudo R^2	0.172	0.196	0.18
LR Chi2 (13)	73.02	130.13	140.56
Prob > chi2	0	0	0
Observations	332	483	595

***, **, * denote significance at 1% level, 5% level, and 10% level, respectively; SE is the standard error; numbers in parenthesis are the standard errors.

5.2.2. The overall treatment effects of PO membership

We report the PSM estimates on the effect of PO membership, using a sample of all members and non-members, on the adoption of food safety measures in Table 4. The nearest neighbour matching and kernel matching indicators yield almost similar results. PO membership improves smallholders' adoption of food safety of two outcome categories, that is, milk storage and milking area. Specifically, members achieve higher adoption of milk storage and milking area measures by 5.8 and 12.7 percentage points, respectively compared to non-members. Since most POs sell to supermarkets and urban modern retail chains that have superior food safety control systems than informal chains (Kiambi et al., 2018), members supplying to the organizations abide by food safety measures. Another factor that explains higher adoption among member-farmers compared to non-members is trust between the farmers and the POs. Previous research has shown that trust induces commitment to a trading relationship, including commitment to food safety (Lagerkvist et al., 2013). Farmers trust their PO because it is a recognized institution with well-known collection centre and office, and farmers have repeated transactions with the organization. Contrary, we noted that there is little information on the identity of traders operating in a village. A trader may default on a farmer and move to a different village where he/she is not known.

5.2.3. Estimating treatment effects across producer organizations

So far, the treatment variable in this analysis combines different types of POs. Examining how the effects vary across POs reveals some interesting results (Table 5). We compare the effect of membership in bargaining POs versus non-membership and membership in a processing POs versus non-membership. We find very small changes in the statistical significance of the ATT and in the magnitude of the effect of membership in bargaining POs as compared to membership in processing POs on the adoption of milk storage measures. Membership in these POs leads to an adoption increase of 5–6 percentage points regarding these measures. However, some heterogeneity is observed in the effect of membership across POs on the adoption of milking area measures. Specifically, households that are members of a bargaining PO increase adoption of milking area measures by 13 percentage points. The result is weakly significant (at 10 percent). The effect of membership in a processing PO is also positive but the statistical significance of the ATT is stronger (at 1 percent) and has a higher effect size (16 percentage points) compared to the effect of membership in bargaining POs.

Investing in farm structures to reduce food safety risks requires a high initial fixed cost which can be a burden for smallholders (Unnevehr, 2015). Members of a processing PO access financial credit, hence they are better able to invest in concrete milking floors than members of bargaining POs. A study in Kenya supports this finding by stating that

Table 4
The overall treatment effects of PO membership.

	Full sample	
Dependent variable	Nearest neighbour	Kernel
Milking	−0.722 (1.891)	−0.023 (1.224)
Milk storage	5.790*** (1.875)	5.830*** (1.625)
Milking area	11.897*** (4.535)	12.680** (4.967)
Animal health	0.804 (2.190)	0.967 (2.118)
Balancing property satisfied	Yes	Yes
Common support imposed	Yes	Yes
Number of observations	595	595
Members	375	375
Non-members	220	220

*, ** and *** denote significance at the 10%, 5%, and 1% level, respectively; numbers in parenthesis are the standard errors.

Table 5
Heterogenous effects across producer organizations.

Dependent variable	Bargaining PO membership		Processing PO membership	
	Nearest neighbour	Kernel	Nearest neighbour	Kernel
Milking	0.830 (2.640)	−0.931 (1.844)	1.786 (2.042)	0.537 (1.729)
Milk storage	5.158** (2.531)	4.954** (2.027)	6.019*** (2.066)	6.090*** (1.447)
Milking area	12.977* (7.521)	6.947 (6.513)	17.708*** (6.309)	16.256*** (4.620)
Animal health	3.568 (2.661)	0.990 (2.224)	2.460 (2.877)	1.115 (2.337)
Balancing property satisfied	Yes	Yes	Yes	Yes
Common support imposed	Yes	Yes	Yes	Yes
Total observations	332	332	483	480
Members	112	112	263	260
Non-members	220	220	220	220

*, ** and *** denote significance at the 10%, 5%, and 1% level, respectively; numbers in parenthesis are the standard errors.

smallholders' capacity to invest in concrete sheds on the farm is boosted by joining POs that provide financial support (Okello and Swinton, 2007). Value chain coordination, monitoring and technical advice of processing POs could also be linked to increased members' adoption of food safety measures. Fieldwork evidence shows that extension officers of processing POs visit member farms from time to time to monitor food safety production practices.

5.2.4. *Heterogeneous effects across other indicators*

The above computations of ATTs assume a common treatment effect among members. However, in reality the treatment effects can vary with farmers' characteristics. Thus we conduct additional analyses using data from different subsamples. Four variables including education, age, training and the distance to milk collection point are assessed (Table 6). Consistent with earlier studies, we find that there is heterogeneity of the effect of membership on the adoption of food safety measures across farmers' characteristics (Abebaw and Haile, 2013; Shumeta and D'Haese, 2016; Wossen et al., 2017).

PO membership increases the adoption of milking area measures among less-educated farmers. Our findings differ from the common argument that less-educated farmers are less likely to adopt improved farm production technologies because of their limited ability to understand and interpret new information (Mudhara and Sinyolo, 2018). We argue that less-educated farmers depend on PO's training on food safety as the training is probably tailored to the farmers' level of understanding.

The results show that the effect of PO membership on food safety measures varies with farmers' age. In particular, the adoption of milk storage and milking area measures increases significantly for younger farmers. Contrary, Shumeta and D'Haese (2016) found that PO membership benefits older member farmers in the coffee sector in Ethiopia. Our findings may indicate that POs are less effective in improving adoption of food safety measures among older farmers. If the majority of the members are old then this poses a challenge to the competitiveness of POs in a market where food safety requirements are growing.

6. Conclusion and policy implications

The main aim of this study was to assess the effect of membership in a PO on the adoption of food safety measures. We contribute to the literature on the role of POs in developing countries on food safety improvement. We conducted 11 expert interviews and a quantitative household survey with 595 smallholder dairy farmers in Kenya. We identified four categories of dairy food safety measures related to production; milking, milk storage, milking area, and animal health, and empirically evaluated the effect of membership on the adoption of the food safety measures across the four categories. Using the PSM technique, our results show that membership positively and significantly improves smallholders' adoption of food safety measures related to milk storage and milking area. The magnitude of the effect ranges from 6 to 12 percentage points. We attribute the increase in adoption to the social and process control measures of POs.

The issue of social incentives versus economic incentives of POs in influencing member behaviour has been a long-standing debate (Borgen, 2004; Deng and Hendrikse, 2017). We contribute to this debate by highlight the importance of social incentives in improving food safety adoption among member farmers even when price incentives are absent. One policy lesson is that smallholders can cope with food safety requirements of high-value chains if collective organizations are being strengthened. However, social incentives may not be sustainable in the long term. We recommend that the government could play a key role in enforcing economic incentives for food safety compliant farmers.

Notably, the estimation of the membership effects across POs reveals some heterogeneity with members of processing POs achieving higher adoption of milking area food safety measures than members of bargaining POs. The effects of membership in processing POs are larger and statistically stronger than those in bargaining POs. These results suggest a linkage between adoption of food safety measures and the functional and organizational structures of POs. Higher adoption among processing

Table 6
Heterogenous effects across other indicators.

	Education		Age		Training		Distance to the collection point	
	1−8 years	>8 years	<60 years	=>60 years	No	Yes	< = 0.5 km	>0.5 km
Milking	2.160 (1.933)	−1.892 (2.015)	2.083 (1.822)	−7.224 (4.345)	1.769 (1.654)	−0.832(2.176)	−1.020 (1.624)	−2.474 (5.263)
Milk storage	5.843*** (1.798)	5.873*** (2.170)	5.670***(1.779)	5.372(4.218)	7.294*** (2.274)	5.070*** (1.949)	4.200** (1.916)	8.115** (4.078)
Milking area	19.336*** (6.048)	9.382 (7.776)	12.088*** (3.644)	10.814 (15.798)	10.997** (5.413)	15.364** (6.457)	9.714*(5.222)	15.037 (15.793)
Animal health	0.478 (2.541)	2.083 (3.838)	2.121 (2.172)	−2.427 (5.130)	−2.123 (1.991)	3.173 (4.074)	−0.591 (2.071)	5.482 (6.547)
Balancing property satisfied	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Common support imposed	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Total observations	284	311	474	121	310	284	452	143
Members	158	217	299	46	150	225	297	78
Non-members	126	94	175	45	161	59	155	65

*, **, and *** denote significance at the 10%, 5%, and 1% level, respectively; Kernel matching was used; numbers in parenthesis are the standard errors.

PO members can be related to higher value chain coordination, as well as monitoring and technical and financial service delivery. The finding supports the organizational theory that associates food safety compliance with more integrated value chains, and increased process and output control measures by collective organizations (Hueth et al., 1999; Borgen, 2011).

Lastly, we find that the effects of PO membership are heterogenous across several household characteristics. Farmers who are less educated and younger perform better in the adoption of food safety measures associated with milk storage and milking area. Results imply that membership in POs alleviates the technical and financial barriers of less educated and younger farmers. For a long time, POs and similar collective organizations have proven useful for promoting the interests of less privileged members of society (Majee and Hoyt, 2011). The organizations train and educate their members and promote group effort to address individual needs. Empowering less educated members can have spill-over effects in the community as such members gain confidence and develop skills to negotiate in market and political spheres (Thorp et al., 2005; Hannan, 2014). Our recommendation is that PO policies that alleviate barriers to food safety adoption among farmers will be helpful in scaling up adoption and can in the long run promote community development.

Finally, although our study focuses on the POs that operate in the formal value chains, the food safety concerns can spill over to the informal sector, which has weak food safety enforcement and where consumers purchase raw milk. The importance of such spill over effects has been underscored in previous studies (Leksmono et al., 2006; Roesel and Grace, 2014). Improving food safety in the formal chain may subsequently lead to food safety improvement in the informal chain as consumers' awareness of food safety increases. Higher compliance in the formal chain, however, will increase the supply of unsafe food in the informal chain as milk that is rejected in the formal chain ends up in the informal chain, on which the majority of the consumers depend (Kiambi et al., 2018). We recommend, therefore, that policies promoting the adoption of food safety measures in both chains are important.

This study has some limitations. The propensity score matching method used only controls for selection bias based on observable factors but not on unobservable factors. A randomised control approach is recommended to address the unobservable issues, where one can assess farmers' adoption of food safety measures at the early stages of the formation of a PO and compare it with their adoption at later periods. We do not capture information on feed-related measures that can influence food safety–a gap that needs to be filled. Further research could assess the effect of the adoption of food safety measures on farmers' livelihoods.

Declaration of Competing Interest

The authors report no declarations of interest.

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Appendix A. Supplementary data

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