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# Effects of co-operatives and contracts on rural income and production in the dairy supply chains: Evidence from Northern Ethiopia

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## Abstract

*Farmer-induced collective action (co-operatives) or buyer-driven contracts are often in place in global agrifood chains. Their economic contribution is well recognised, although the exclusion of smallholders remains. This paper pays particular attention to the impact of co-operatives and contracts on dairy production and the income of dairy farmers in the local food chains in Northern Ethiopia. A structured survey of 415 dairy farmers was undertaken in four districts of Northern Ethiopia. Propensity score matching, regression on observables and regression on propensity scores were implemented to control selection bias. Both models yielded consistent treatment effect estimates, implying that milk production, cow productivity and household income for the members of co-operatives are larger in contrast to dairy farmers employing the spot market. We suggest that strengthening co-operatives may enhance and upgrade the dairy sector/chain, improve the livelihoods of smallholders, and facilitate the link to global food chains.*

**Key words**: Co-operatives, contracts, dairy farmers, income, productivity

## 1. Introduction

Contracts and cooperatives increasingly feature in food supply chains, especially in developing countries, as contracts mitigate production and market risk by ensuring a guaranteed market. They also provide an opportunity for producers to secure immediate market outlets (Reardon *et al*. 2004; Gulati *et al*. 2007; Dries *et al*. 2009; Miyata *et al*. 2009; Abebe *et al*. 2013). Moreover, consumers' increasing focus on food quality and safety encourages contracting by processors and buyers (Boger 2001; Zhang & Hu 2011).

Contracts facilitate the participation of producers from developing countries in global chains and offer economic benefits to participants. They also improve access to markets and resources that facilitate productivity and better market conditions. Processors and supermarket chains provide inputs, technology and extension services to farmers in order to secure standardised produce that fits consumers' requirements. Moreover, actors of such supply chains resolve the information, credit, market and technology constraints that smallholders experience (Bolwig *et al*. 2009; Dries *et al*. 2009; Maertens & Swinnen 2009; Miyata *et al*. 2009; Rao & Qaim 2011; Barrett *et al*. 2012; Abebe *et al*. 2013). Masakure and Henson (2005), who conducted research in Mozambique, also indicate the benefits of contracts in reducing market uncertainty, enhancing knowledge acquisition and increasing farmers' income. Contracting also helps transform subsistence agriculture into market-oriented agriculture in developing countries because producers start to focus on consumers' preferences (Bijman 2008).

Co-operatives are established to reduce transaction costs, improve the bargaining power of smallholders (Bijman & Hu 2011), help minimise the market risk producers face, improve farmers' trust in adopting technology and improve technical efficiency (Abebaw & Haile 2013). They also facilitate better economic gains for farmers owing to their effect on efficiency in collecting produce, creating a stable market, extending the shelf life of produce and facilitating access to credit, inputs and knowledge (Ito *et al*. 2012; Abebaw & Haile 2013).

Despite the economic gains that co-operatives and contracts offer to actors, smallholder exclusion has been identified as a challenge. It is argued that highly consolidated retail and supermarket chains exclude smallholders owing to the latter's failure to meet quality and quantity standards (Ito *et al*. 2012; Oya 2012), while high transaction costs threaten processors' and buyers' involvement in contracts with a large number of smallholder farmers (Key & Runsten 1999).

Existing literature on contracts and co-operatives focuses largely on co-ordination systems that link smallholders with global chains, but with little emphasis on local food chains. In addition, the literature deals with contracts and co-operatives separately, which fails to compare the effect of the two co-ordination systems on smallholders' economic gains in local food chains. Focusing on dairy farmers in Northern Ethiopia, this paper explores the role of contracts and co-operatives in local food chains and how they help achieve economic and production-related objectives.

Livestock in Africa in general, and in Ethiopia in particular, can make an immense contribution to the rural economy in terms of sustainable income and food security (Holloway *et al*. 2000). However, the contribution of livestock (especially the dairy sector) to income and nutrition in Ethiopia is limited, despite the large livestock population, the favourable climate and a potentially large market (Holloway *et al*. 2000). The poor co-ordination system that exists keeps the sector underdeveloped and farmers retain local-breed cows, which offer small amounts of dairy products to market. The subsector remains largely subsistence, not market oriented, which adversely affects farmers' motivation to specialise and their reliance on the subsector (Francesconi *et al*. 2010). The weak market participation is exacerbated by high transaction costs and the poor economic conditions experienced by (smallholder) farmers, thus adversely affecting their ownership of storage and processing technologies. A large proportion of milk is supplied through the informal markets, which dominate the distribution of dairy products (Francesconi *et al*. 2010).

Nevertheless, the increase in population and changes in income are expected to raise demand for dairy, which may in turn stimulate the growth of the subsector (Staal *et al*. 2008). An increasing number of emerging formal dairy chains (supermarkets) are also expected to upgrade the subsector in Ethiopia (Francesconi *et al*. 2010). Moreover, closer co-ordination (co-operatives and contracts) may play a significant role in linking smallholder dairy farmers with buyers and processors. This would enhance access to inputs and high-value markets, thereby increasing productivity and smallholders' income (Dries *et al*. 2009). Dairy farmers in the highlands of Ethiopia and Kenya supply dairy products and their derivatives to spot markets, through contracts and through co-operatives. However, the perishability of the product and the small quantity supplied to the market make spot transactions difficult for farmers, leading them to engage in co-operatives (Staal *et al*. 1997). Hence, a dairy co-operative as a hybrid co-ordination scheme synchronises several stages, such as collection, storage, processing and distribution of quality milk to several buyers (Hendrikse & Bijman 2002).

Smallholders' preference for engaging in co-operatives results from the high transaction costs that emanate from lot size, lack of storage and processing technology or the difficulty in gaining access to credit and inputs (Ortmann & King 2010). The information- and resource-poor dairy farmers also face high transaction costs in accessing markets and technology (Abdulai & Birachi 2008). Consequently, the lack of farm investment and poor market infrastructure result in milk losses and encourage farmers to turn to contracts or co-operatives. The benefits of co-operatives include the fact that they offer a more stable market environment and common ownership of technology to extend the shelf life of milk (Hendrikse & Bijman 2002; Staal *et al*. 2008). In addition, the capacity demands made on farmers encourage the formation of co-operatives, while the close relationships co-operatives establish with farmers facilitate the transfer of farm management skills and technology use (Gadzikwa *et al*. 2006; Abebaw & Haile 2013).

Literature and empirical evidence on the effects of contracts and co-operatives in the context of local food chains are scarce. Therefore, the aim of this paper was to analyse contracts and co-operatives in the dairy sector in terms of their effect on rural households' income and productivity by looking at a sample of farmers from Tigray, Ethiopia. It also compares contracts and co-operatives in terms of their economic consequences (income and production) from the smallholder dairy farmers' perspective.

The remainder of the paper is organised as follows: in section two we discuss the study site and the data collection procedure; in section three we present the results of the descriptive statistics and discuss the results of the empirical model; and we end the paper with conclusions and policy implications.

## 2. Methodology

### 2.1 Research site and data collection

As the paper deals with the analysis of the impact of emerging forms of co-ordination (co-operatives and contracts) in the Ethiopian dairy supply chain, a case study approach was employed using data from Tigray, northern Ethiopia. The situation concerning cattle ownership and dairy production in the northern highlands of Ethiopia is similar to that in the rest of the country. The total cattle population in the region is estimated to be more than 3.6 million cows, of which 93% are indigenous and the rest are hybrid and exotic breeds (CSA 2011). As the aim was to evaluate the different co-ordination mechanisms in the dairy chain, commercial dairy farmers (those farmers who own hybrid cows) were purposively selected. In the first stage of the sampling design, four districts (referred to locally as *woreda*) were selected. The districts with the largest dairy cow population and with actual and potential surplus milk production were identified and selected. The identification of districts was done in consultation with the district livestock experts in the Rural Development Office (RDO).

In the second stage of the sampling design, all the sub-districts (locally called *kebeles* – the smallest administrative unit) in which households participate in the small-scale dairy extension package were nominated. In the region, the government offers different types of extension packages to rural households, one of which is the small-scale dairy extension package. Households are provided with hybrid dairy cows to supply milk and generate income. It is assumed that rural households involved in this extension package are commercial dairy farmers, supplying at least some produce to the market. In the third stage, all households in the small-scale dairy extension package scheme, made up of 415 dairy farmers in 13 sub-districts, were selected. This list of households was provided by the RDO. Details of the number of respondents in each *kebele* are included in the annexure. Using a structured survey instrument, data was collected by trained enumerators in June and July 2010.

### 2.2 Empirical model

The study employed both descriptive and econometric models to analyse the effect of co-operatives, contracts and spot market participation on dairy farmers' productivity and income. The descriptive statistics present a summary of results using tables with corresponding statistical tests. Nevertheless, these descriptive statistics do not necessarily indicate the effect of those co-ordination mechanisms, but rather differences in their productivity and income. To this end, three different analytical models were used to assess the impact of contracts and co-operatives on producers' performance. Firstly, a simple regression model was used. Important differences were subsequently found in terms of observable characteristics between dairy farmers who use contracts, co-operatives and the spot market. This indicates that participation in contracts or co-operatives is not randomly distributed over the population of dairy producers, but is influenced by households' physical, human and social capital endowments, and their access to markets and road infrastructure. To correct for the potential bias that may arise from this non-random selection in terms of contracts and co-operatives, a large set of observable covariates was included as control variables in the following estimation:

$$Y_i = \alpha + \gamma_1 C_{1i} + \gamma_2 C_{2i} + \beta X_i + \varepsilon_i \qquad (1)$$

We looked at five different outcome variables Y: (1) cow productivity (litres), (2) milk production (litres), (3) milk income (birr), (4) total household income (birr) and (5) per capita household income (birr). These variables are log-specified in the model. The variables $C_1$ and $C_2$ represent the different co-ordination mechanisms, contracts and co-operatives, respectively. These are the main variables of interest and the coefficients $\gamma_1$ and $\gamma_2$ are referred to as the treatment effects of contracts and co-operatives respectively. The vector X includes a large set of observable covariates to correct for potential bias resulting from selection on observables: village dummy, distance to rural development offices (RDO), distance to Mekelle (Tigray region's capital city), land size, number of hybrid cows, education, age and household size. Estimation was don using ordinary least squares (OLS).

The second estimation was based on predicted propensity scores – or a conditional probability to contract or to join co-operatives – and used these as additional control variables in the regression model. This model is referred to as *regression on propensity scores*. Using the propensity score (PS) as an additional control variable in the regression further reduced any potential bias created by selection on observable characteristics (Imbens 2004). Because there are two different treatments, contract and co-operatives, that are mutually exclusive,[1] a bivariate probit model was used to estimate the probability for each treatment, conditional on the set of covariates X (Lechner 2002). The model is specified as follows:

$$Y_i = \alpha + \gamma_1 C_{1i} + \gamma_2 C_{2i} + \mu_1 PS_{1i} + \mu_2 PS_{2i} + \beta X_i + \varepsilon_i \qquad (2)$$

with $PS_{1i} = p(C_1 = 1|X)$ and $PS_{2i} = p(C_2 = 1|X)$

Third, the effect of contracts and co-operatives was estimated using a propensity score-matching technique, which is referred to as *matching on the propensity score*. This method is applied widely in the agricultural and development economics literature (e.g. Maertens & Swinnen 2009: Ito *et al*. 2012; Jena *et al.* 2012; Abebaw & Haile 2013) and is a useful approach when observed characteristics are believed to affect programme participation (Khandker *et al*. 2010:53). As Khandker *et al*. (2010: 54) put it, "when a treatment cannot be randomized, the next best thing to do is to try to mimic randomization. … With matching methods, one tries to develop a counterfactual or control group that is as similar to the treatment group as possible in terms of *observed*

[1] This is the case because co-operative members are obliged to sell the entire marketable output to the co-operative and hence cannot engage in other marketing channels.

characteristics". Propensity score matching involves matching treated households with control households that are similar in terms of observable characteristics (Imbens & Angrist 1995; Imbens 2004; Caliendo & Kopeinig 2005). Since matching directly on observable characteristics is difficult if the set of potentially relevant characteristics is large, matching on propensity scores has been proposed as a valid method (Rosenbaum & Rubin 1983). All contract producers and all co-operative producers (the treated observations) in the sample were matched with one or several spot market producers (the control observations) that had similar propensity scores, with propensity scores as defined in equation (2). The effect of contracts and co-operatives on dairy farmers' performance can be calculated as a weighted difference in outcome between treated observations and matched controls:

$$ATE_1 = \mathrm{E}[\mathrm{Y}_1 - \mathrm{Y}_0] = \frac{1}{N_1}\sum_{i \in N_1}(Y_{1i} - Y_{0i})\ for\ C_1 = 1 \quad (3)$$

$$ATE_2 = \mathrm{E}[\mathrm{Y}_2 - \mathrm{Y}_0] = \frac{1}{N_2}\sum_{i \in N_2}(Y_{2i} - Y_{0i})\ for\ C_2 = 1 \quad (4)$$

where $ATE_1$ and $ATE_2$ represent the average treatment effects from contracts and co-operatives respectively; $N_1$ and $N_2$ represent the number of dairy farmers participating in contracts and co-operatives; and $Y_1$ and $Y_2$ represent the outcomes for contract and co-operative farmers, with $Y_0$ the outcome for the control group.

Two different matching procedures were used. The first was nearest-neighbour matching, in which every treated household was matched to the control household with the closest propensity score. This is the most commonly applied matching algorithm in propensity score-matching estimation (Ichino *et al*. 2008). This was complemented by a kernel-matching technique, in which information from all control observations was used to compute the ATE estimate (Caliendo & Kopeinig 2005). For kernel matching, the bi-weight kernel type and the default bandwidth in STATA (0.06) were used. Matching is always done with replacement and only observations in the common support region were used in the analysis. As propensity score-matching methods are sensitive to the exact specification and matching method, the use of different matching techniques serves as a robustness check.

Propensity score matching is based on two assumptions: the conditional independence assumption (CIA) and common support (CS). The first assumption refers to potential outcomes being independent of treatment assignment, given a set of observable covariates *X* (Rosenbaum & Rubin 1983; Dehejia & Wahba 2002; Lechner 2002; Ichino *et al*. 2008):

$$Y_0, Y_1, Y_2 \perp C \mid X \quad (5)$$

The second assumption refers to sufficient overlap in the distribution of the propensity scores for treated and control observations (Rosenbaum & Rubin 1983; Dehejia & Wahba 2002; Lechner 2002; Ichino *et al*. 2008):

$$0 < P\,(C = 1 \mid X) < 1 \quad (6)$$

## 3. Results and discussion

### 3.1 Milk production, marketing and incomes: Descriptive summary

The survey indicated that 44.3% of the farmers were engaged in co-operatives, 24.6% were engaged in contracts, and 24.8% operated in spot markets. Of the hybrid cow owners, 2.9% did not supply milk to the market. Dairy farmers in the study areas are largely members of marketing co-operatives. Twenty-six responses were incomplete and the analysis was based on the remaining 389 respondents. Table 1 indicates that co-operative dairy farmers have more production experience. Furthermore, co-operative members have more hybrid cows, while the number of local-breed cows is declining, thus implying the shift of farmers to market-driven dairy production. Milk production from hybrid cows is larger for co-operative members, who provide more milk to the market via co-operatives.

**Table 1: Milk production and marketing across farmers using different coordination systems**

| Variables | Total sample | Contract participants | Co-operative members | Spot market operators |
|---|---|---|---|---|
| Active family members (no.) | 3.16<br>(0.10) | 3.22<br>(2.07) | 3.19<br>(1.94) | 3.07<br>(1.96) |
| Production experience (years) | 3.99<br>(0.21) | 4.00<br>(0.42) | 4.32 [b]<br>(0.32) | 3.41<br>(0.38) |
| Number of hybrid cows | 1.32<br>(0.04) | 1.49<br>(0.12) | 1.71[b]<br>(0.07) | 1.45<br>(0.12) |
| Number of hybrid cows five years ago (recall) | 0.19<br>(0.03) | 0.22<br>(0.06) | 0.23<br>(0.04) | 0.23<br>(0.07 |
| Number of local-breed cows | 0.36<br>(0.04) | 0.37<br>(0.08) | 0.13[a]<br>(0.03) | 0.28<br>(0.06) |
| Number of local-breed cows five years ago (recall) | 1.06<br>(0.08) | 1.03<br>(0.13) | 1.16<br>(0.14) | 0.91<br>(0.11) |
| Amount of milk produced in litres/ year | 2 530<br>(124) | 1 894<br>(126) | 2 769 [a]<br>(270) | 1 755<br>(172) |
| Amount of milk in litres for the market/year | 2 194<br>(143) | 1 865<br>(244) | 2 740[a]<br>(200) | 1 493<br>(311) |
| Milk per hybrid cow/year in litres | 1 773<br>(61) | 1 527[a]<br>(92.56) | 2 048[a]<br>(96.60) | 1 864<br>(71.95) |
| Number of observations | 389 | 102 | 184 | 103 |

[a, b, c] significant at 1%, 5% and 10% levels for t-test; Values in brackets are standard errors
Source: Calculated from own survey data

The summary statistics in Table 2 also indicate that the income from livestock sales was lower for contract dairy farmers. Income from dairy sales was significantly larger for co-operative members in contrast to spot market operators. Similarly, income from business and wage is larger for co-operative members. Therefore, the total household income for co-operative members differed significantly from that of spot market operators.

**Table 2: Income and sources across farmers using different market channels**

| Variables | Total sample | Contract participants | Co-operative members | Spot market operators |
|---|---|---|---|---|
| Crop income (birr)[2] | 1 837<br>(603) | 499<br>(137) | 2 533<br>(1 069) | 1 918<br>(1 237) |
| Income from livestock sales (birr) | 4 503<br>(1 132) | 1 803[c]<br>(363) | 6 378<br>(2 283) | 3 828<br>(1 207) |
| Income from dairy sales (birr) | 11 826<br>(959) | 8 671<br>(932) | 15 144 [a]<br>(1 618) | 9 023<br>(1 897) |
| Business income (birr) | 4 283<br>(1 090) | 2 761<br>(1 259) | 6 188 [a]<br>(2 108) | 2 390<br>(1 077) |
| Income from wages (birr) | 2 635<br>(368) | 3 084 [c]<br>(1 011) | 3 029[b]<br>(464) | 1 490<br>(482) |
| Other income (birr) | 1 776<br>(426) | 1 316<br>(146) | 1 761<br>(733) | 2 261<br>(926) |
| Total household income (birr) | 25 895<br>(2820) | 18 133 [c]<br>(2 091) | 35 034 [a]<br>(4 795) | 20 910<br>(5 085) |
| Per capita income (birr) | 8 790<br>(956) | 5 905[b]<br>(696) | 11 042[b]<br>(1 590) | 7 622<br>(2 091) |
| Number of observations | 389 | 102 | 184 | 103 |

[a, b, c] significant at 1%, 5% and 10% levels for t-test; Values in brackets are standard errors
Source: Calculated from own survey data

[2] 1 Birr = 0.048 US dollars on 2 July 2015.

### 3.2 Results from the empirical model

The effects of contract and co-operatives on the five performance indicators (cow productivity, milk production, milk income, household income and per capita income) from four alternative estimation techniques (regression on covariates, regression on propensity scores, kernel matching and nearest neighbour matching) are presented in Table 3.[3]

The econometric results confirm that membership of co-operatives results in significantly higher milk production, higher cow productivity and higher farmer income. Taking the most conservative estimates, we found that being a member of a co-operative increases total annual milk production by 62% and cow productivity by 32%. Dairy marketing co-operatives offer services exclusively to members, and members also have easy access to hybrid dairy cows, feed supply, veterinary services, artificial insemination and programmed follow-up by livestock extension experts. The services provided by co-operatives contributed to an increase in milk production and to cow productivity being relatively higher for members.

Co-operatives provide collection, storage, processing and sales for different types of dairy products. Ownership of common storage and processing technology therefore assists dairy farmers to supply surplus milk to the co-operative instead of wasting it at home, thus raising the income from milk sales. Co-operatives also attract organised support from government and NGOs, who supply credit and technology to improve the shelf life of milk. Co-operatives own shops that retail fresh milk and other dairy products directly to buyers, enabling them to add value and increase incomes from milk sales. Accordingly, the model result indicates that membership of a co-operative increases income from milk sales by 60%. Cooperatives also increase household income and per capita income by 48% and 49% respectively.

However, we did not find any effect of contract on milk production, cow productivity, milk income, total household income and per capita income. None of the estimates of contract on milk production, cow productivity, milk income, total household income and per capita income in the four different models thus is significant (Table 3). This may be because contracts in the dairy supply chain are made with buyers such as bars and restaurants, which rarely offer credit and inputs to farmers. Contracting buyers solely provide a product market opportunity, but they are invisible in extension services. During the fasting periods,[4] contractors fail to buy all surplus milk farmers offer to the market, thus reducing the expected income from milk supply. As farmers do not have the individual capacity to hold storage, cooling and processing equipment, the milk spoils and farmers lose out on revenue. In addition, buyers shift to co-operatives because they supply quality milk in bulk with well-established quality control mechanisms. Therefore, we can conclude that co-operatives offer better opportunities to dairy farmers than contracts.

[3] Eight observations (co-operative members) and 10 observations (five treated and five controls) fell outside the common support and were not considered.

[4] There are a minimum of 180 fasting days in a year, and Orthodox Christians abstain from consuming milk. More than 95% of the population are Tigray is Orthodox Christians (CSA, 2008).

**Table 3: Regression and PSM results: effect of contracts and co-operatives on dairy farmers**

| Outcome variables | OLS | | PS regression | | PSM results | | | |
|---|---|---|---|---|---|---|---|---|
| | | | | | Kernel matching | | Nearest neighbour | |
| | Co-operative | Contract | Co-operative | Contract | Co-operative | Contract | Co-operative | Contract |
| Total milk production | 0.77[a] (0.19) | 0.23 (0.18) | 0.77[a] (0.19) | 0.22 (0.18) | 0.62[a] (0.19) | 0.13 (0.22) | 0.64[a] (0.19) | 0.17 (0.23) |
| Milk/cow (hybrid) | 0.50 [a] (0.12) | 0.08 (0.12) | 0.50 [a] (0.12) | 0.06 (0.12) | 0.33[b] (0.14) | 0.09 (0.14) | 0.32[c] (0.15) | 0.12 (0.16) |
| Dairy income | 0.61 [a] (0.22) | -0.21 (0. 22) | 0.60 [a] (0. 22) | -0.23 (0. 21) | 0.73[a] (0.18) | -0.14 (0.25) | 0.77[a] (0.19) | -0.06 (0.26) |
| Household income | 0.48[a] (0.12) | 0.12 (0.11) | 0.48[a] (0.12) | 0.12 (0.11) | 0.51[a] (0.14) | 0.14 (0.13) | 0.52[a] (0.15) | 0.19 (0.14) |
| Per capita income | 0.51 [a] (0.14) | 0.17 (0.13) | 0.51 [a] (0.13) | 0.18 (0.13) | 0.49[a] (0.15) | 0.09 (0.14) | 0.50[b] (0.16) | 0.15 (0.15) |

[a, b, c] significant at 1%, 5% and 10% levels
Source: Calculated from own survey data

In Table 4, the full regression results are given for the regression on covariates and the regression on propensity scores for total household income. The results reveal that, apart from membership of co-operatives, other factors also contribute to household income. For example, farmers located in the Hintalo Wajirat district are better off in terms of income, and the sex of the household head has an association with household income. Also, farmers located closer to Mekelle have a higher income. Moreover, the presence of an active male member of a household in the labour force and the production experience of the household head contribute positively to income. However, land size was found to be negatively associated with income, unless it is larger than 1.5 hectares. The number of hybrid cows is associated with the volume of milk for the market, which in turn generates more income for the household.

**Table 4: Regression on covariates (household income-dependent variable)**

| | Regression on covariates | | Regression on propensity scores | |
|---|---|---|---|---|
| **Covariates** | **Coefficient** | **Std. err.** | **Coefficient** | **Std. err.** |
| Co-operative | 0.48[a] | 0.12 | 0.48[a] | 0.12 |
| Contract | 0.12 | 0.12 | 0.12 | 0.12 |
| PSCo-operative | | | 0.28 | 1.16 |
| PSContract | | | 0.75 | 2.01 |
| Dega temben | 0.52 | 0.36 | 0.51 | 0.36 |
| Endrta | (base) | | (base) | |
| Hintalo Wajirat | 0.64[b] | 0.26 | 0.64[b] | 0.26 |
| Kiltie awulalo | 0.36 | 0.26 | 0.36 | 0.26 |
| Sex, household head | 0.15[c] | 0.11 | 0.15 | 0.12 |
| Age, household head | -0.01 | 0.00 | -0.01 | 0.01 |
| At least primary education | -0.01 | 0.09 | 0.03 | 0.14 |
| Active male | 0.08[c] | 0.04 | 0.06 | 0.06 |
| Active female | 0.08 | 0.05 | 0.07 | 0.07 |
| Production experience in years | 0.02[c] | 0.01 | 0.02 | 0.01 |
| Land size in hectare | -0.48[a] | 0.13 | -0.48[c] | 0.28 |
| Land size$^2$ | 0.16[b] | 0.04 | 0.17[b] | 0.07 |
| Distance to Mekelle in km | -0.02[a] | 0.01 | -0.02[a] | 0.01 |
| Distance to RDO in km | 0.01 | 0.01 | -0.01 | 0.02 |
| Number of hybrid cows (five-year recall) | 0.18[b] | 0.07 | 0.19[b] | 0.07 |
| Tropical livestock units (five-year recall) | 0.02 | 0.01 | 0.02 | 0.02 |
| Constant | 9.91[a] | 0.24 | 9.55[a] | 1.11 |
| Number of observations | 388 | | 388 | |
| F(19,368)/F(21,366) | 8.60[a] | | 7.66[a] | |
| R-squared | 0.28 | | 0.28 | |
| Adjusted R-squared | 0.25 | | 0.25 | |

[a, b, c] significant at 1%, 5% and 10% levels
Source: Calculated from own survey data

### 3.3 Estimating the propensity scores

The estimation of the propensity score was carried out on the basis of a bivariate probit model to determine the conditional probability of participating in co-operatives or contracts. Covariates related to household endowments, human capital and infrastructure were first identified to adjust for selection bias. It was assumed that choosing between the two options (co-operatives and contracts) was mutually exclusive.

**Table 5: Covariates to estimate the propensity score (Model I)**

| Variables | Cooperative | | Contract | |
|---|---|---|---|---|
| | Coefficient | Std. err. | Coefficient | Std. err. |
| Sex, household head | 0.19 | 0.16 | -0.08 | 0.17 |
| Age, household head | 0.00 | 0.01 | -0.01 | 0.01 |
| At least primary education | -0.00 | 0.13 | -0.19 | 0.14 |
| Active male | 0.04 | 0.06 | 0.07 | 0.07 |
| Active female | 0.09 | 0.07 | 0.02 | 0.07 |
| Production experience in years | 0.02 | 0.07 | -0.00 | 0.01 |
| Land size in hectare | -0.95[a] | 0.24 | 0.55[c] | 0.25 |
| Land size$^2$ | 0.29[a] | 0.09 | -0.23[a] | 0.08 |
| Distance to Mekelle in km | 0.00 | 0.00 | -0.00 | 0.00 |
| Distance to RDO in km | -0.08[a] | 0.02 | 0.06[a] | 0.02 |
| Number of hybrid cows (five-year recall) | -0.10 | 0.11 | 0.02 | 0.10 |
| Tropical livestock units[5] (five-year recall) | -0.04[c] | 0.02 | 0.01 | 0.02 |
| Constant | 0.10 | 0.33 | -0.60[c] | 0.35 |
| Number of observations | 388 | | | |
| Wald chi$^2$ (24) | 111.44[a] | | | |
| Wald test of rho = 0 chi$^2$ (1) | .00 | Prob > Chi$^2$ | 0.98 | |

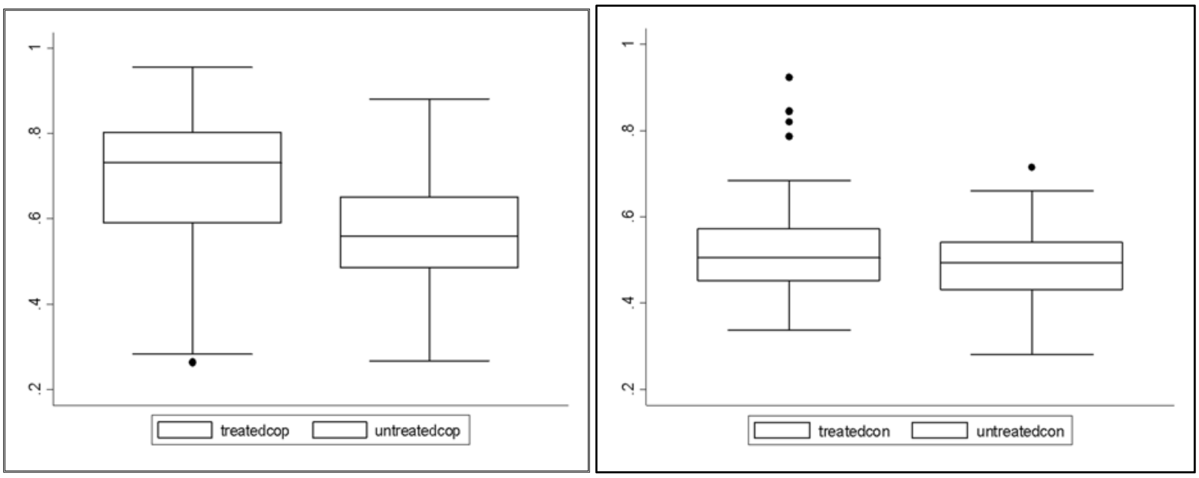
[a, b, c] significant at 1%, 5% and 10% levels
Source: Calculated from own survey data

The results of the bivariate probit model estimating the propensity scores are given in Table 5. The results indicate that household wealth in terms of land size and livestock ownership is negatively related to membership of co-operatives, implying that poor farmers are more involved in co-operatives. By contrast, relatively better-off farmers in terms of land size are more likely to engage in contracts. Dairy farmers who are close to the RDO are more likely to be members of a co-operative. Dairy farmers who did not have hybrid dairy cows ‘five years ago’ are likely to join co-operatives, as it is a source of these cows.

### 3.4 Robustness and sensitivity analysis

Propensity score matching is based on two basic assumptions, and checking the fulfilment of these assumptions improves the reliability of the estimates. One of the important assumptions is the overlapping of the propensity scores between the treated and the control observations. The propensity score estimates lie between 0 and 1 (i.e. 0.267 to 0.880), thus satisfying the common support region. The box plot in Figure 1 supplements the fulfilment of the overlap assumption.

[5] The conversion factor for tropical livestock unit (TLU) is as follows: camel = 1; cattle = 0.7, sheep = 0.1, goat = 0.1, horse = 0.8, donkey = 0.5, mule = 0.7, pig = 0.2, chicken = 0.01 (Jahnke 1982).




Co-operative Contract

**Figure 1: The distribution of the estimated propensity score over treated (left) and control (right) observations**

Source: Own survey data

Related to this is the balance of observable characteristics between treated and matched control observations. The balancing test results in Table 6 reveal that the significant differences in the covariates 'land size', 'distance to RDO' and 'TLU five years ago' between treated and control groups disappear after matching.

**Table 6: Balancing tests**

| Variable | Sample | Mean | | Kernel matching | | | Nearest neighbour matching | | |
|---|---|---|---|---|---|---|---|---|---|
| | | Treated | Control | Percentage bias | Percentage reduction \|bias\| | t | Percentage bias | Percentage reduction \|bias\| | t |
| Sex, household head | Unmatched | .79 | .76 | 7.5 | | 0.61 | 7.5 | | 0.61 |
| | Matched | .77 | .82 | -12.2 | -61.5 | -1.45 | -12.2 | -61.5 | -1.45 |
| Age, household head | Unmatched | 44.28 | 44.92 | -5.4 | | -0.43 | -5.4 | | -0.43 |
| | Matched | 44.17 | 45.36 | -10.0 | -86.3 | -1.58 | -10.0 | -86.3 | -1.58 |
| At least primary education | Unmatched | .56 | .63 | -15.3 | | -1.22 | -15.3 | | -1.22 |
| | Matched | .54 | .67 | -25.7 | -68.0 | -1.88 | -25.7 | -68.0 | -1.88 |
| Active males | Unmatched | 1.58 | 1.55 | 3.4 | | 0.28 | 3.4 | | 0.28 |
| | Matched | 1.55 | 1.59 | -4.5 | -29.5 | -0.52 | -4.5 | -29.5 | -0.52 |
| Active females | Unmatched | 1.57 | 1.47 | 12.2 | | 0.98 | 12.2 | | 0.98 |
| | Matched | 1.56 | 1.58 | -2.5 | 79.5 | -1.09 | -2.5 | 79.5 | -1.09 |
| Production experience | Unmatched | 4.32 | 3.38 | 23.0 | | 1.80 | 23.0 | | 1.80 |
| | Matched | 4.18 | 4.07 | 2.5 | 89.3 | -0.43 | 2.5 | 89.3 | -0.43 |
| Land size | Unmatched | .79 | 1.04 | -32.8 | | -2.58[b] | -32.8 | | -2.58[b] |
| | Matched | .81 | .90 | -12.5 | 61.9 | 0.79 | -12.5 | 61.9 | 0.79 |
| Land size$^2$ | Unmatched | 1.27 | 1.60 | -13.4 | | -1.04 | -13.4 | | -1.04 |
| | Matched | 1.19 | 1.60 | -16.7 | -24.4 | -0.53 | -16.7 | -24.4 | -0.53 |
| Distance to Mekelle | Unmatched | 40.90 | 38.22 | 19.3 | | 1.67 | 19.3 | | 1.67 |
| | Matched | 41.03 | 39.90 | 8.2 | 57.8 | -0.17 | 8.2 | 57.8 | -0.17 |
| Distance to RDO | Unmatched | 2.28 | 3.27 | -36.1 | | -2.77[b] | -36.1 | | -2.77[b] |
| | Matched | 2.36 | 2.66 | -10.9 | 69.9 | 1.83 | -10.9 | 69.9 | 1.83 |
| Hybrid cows (recall five years) | Unmatched | .23 | .22 | 0.8 | | 0.06 | 0.8 | | 0.06 |
| | Matched | .24 | .39 | -23.6 | -3003.1 | -0.87 | -23.6 | -3003.1 | -0.87 |
| Tropical livestock units (recall five years) | Unmatched | 2.41 | 3.32 | -29.1 | | -2.42[c] | -29.1 | | -2.42[c] |
| | Matched | 2.50 | 2.48 | 0.8 | 97.3 | 1.08 | 0.8 | 97.3 | 1.08 |

[a, b, c] significant at 1%, 5% and 10% levels
Source: Calculated from own survey data

A sensitivity analysis on whether or not the CIA is ruled out was also conducted. Data was collected from the same population using identical questionnaires. Covariates affecting both treatment and outcome variables were also included, as well as those covariates determining co-ordination choice, income and production. Furthermore, a sensitivity analysis based on Ichino *et al*. (2008) and Nannicini (2007)[6] was conducted to check whether unobserved covariates affect the treatment effect estimate. The sensitivity analysis was undertaken by introducing a simulated confounding dummy variable to see if it affected the treatment effect estimate. After the inclusion of the neutral confounder, the results indicated similar treatment effect estimates supporting the fulfilment of the CIA and the reliability of the estimate (Table 7).

**Table 7: Sensitivity analysis to check the failure of CIA under simulated confounders (household income)**

| Model type I | Treatment effect | Outcome effect[a] | Selection effect[b] |
|---|---|---|---|
| Baseline | 0.51 | | |
| Neutral confounder | 0.52 | 1.07 | 1.01 |
| Calibrated confounder to mimic sex of household head | 0.52 | 1.88 | 1.32 |
| Calibrated confounder to mimic at least primary education | 0.51 | 0.65 | 0.81 |

[a] the effect of the simulated confounder on outcome (household income); [b] the effect of the simulated confounder on the treatment/selection variable (cooperatives)
Source: Calculated from own survey data

Further sensitivity analysis was also conducted to check the appropriateness of the covariates used to estimate the propensity scores. Two models, the full model and the restricted model, consisting of covariates that significantly determine the probability to contract or co-operative engagement, were applied. The results of the two models provide qualitatively identical and quantitatively similar results, thus confirming the appropriateness of the chosen covariates (Table 8).

**Table 8. Sensitivity testing of the choice of covariates**

| Outcome variable | ATE Model I (full model) | ATE Model II (restricted model) |
|---|---|---|
| Milk production (log) | 0.62[a] (0.19) | 0.57 [a] (0.18) |
| Milk/cow (log) | 0.33[b] (0.14) | 0.31 [c] (0.14) |
| Dairy income (log) | 0.73[a] (0.18) | 0.58 [b] (0.18) |
| Household income (log) | 0.51[a] (0.14) | 0.45 [b] (0.14) |
| Per capita income (log) | 0.49[a] (0.15) | 0.46 [b] (0.15) |

[a, b, c] significant at 1%, 5% and 10% levels
Source: Calculated from own survey data

## 4. Conclusions

This paper identifies three co-ordination systems: marketing co-operatives, contracts and spot markets. Dairy farmers largely use marketing co-operatives because the perishability and demand for a secure market for milk encourages farmers to engage in them. Moreover, government and NGO support to build the capacity of the smallholder dairy farmers is channelled through these organisations. This association with the government and NGOs enables co-operatives to receive processing and quality control technology, which enhances buyers' trust and confidence.

[6] For the reasoning and the applications in STATA, see Nannicini (2007) and Ichino *et al*. (2008).

Co-operatives offer several services to their members, including the processing, cooling, storage and retailing of milk. Elected members also run the co-operatives, which may help reduce operational and management (agency) costs. This, in turn, generates increased economic gains for the members. Co-operatives facilitate access to inputs, feed supply, artificial insemination and veterinary services by the members, which helps improve cow productivity and milk production. Co-operatives also facilitate access to credit and hybrid cows for members, with follow-up from livestock experts at the agricultural and rural development offices. By contrast, contracts in the dairy chain do not involve input and technology provision, just a secured market. However, during fasting periods, contracting retailers refuse to take the entire stock of fresh milk from producers, which threatens dairy farmers' income.

The results confirm a strong causal relationship between marketing co-operatives and milk production, cow productivity and farmers' income. Accordingly, it was found that co-operatives generate higher income gains for members. Policymakers therefore are advised to encourage dairy farmers to belong to co-operatives, as this reduces the high transaction costs and resource constraints facing poor smallholders in rural Ethiopia.

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## Annexure

**Number of respondents by districts and sub-districts**

| District (Woreda) | Tabias (sub-district) | Number of households selected for the survey | Total number of respondents in each district |
|---|---|---|---|
| Dega Temben | Hegreselam | 69 | 87 |
| | Seret | 13 | |
| | Selam | 5 | |
| Enderta | Romanat | 13 | 61 |
| | Didiba | 13 | |
| | Debri | 22 | |
| | Shibtagabir | 13 | |
| Hintalo Wajirat | Adigudom | 69 | 81 |
| | Hiwane | 9 | |
| | Araasgeda | 3 | |
| Kilite Aulalo | Aynalem | 50 | 186 |
| | Genfel | 78 | |
| | Agulae | 58 | |
| Total | | 415 | 415 |