Economic Incentives for Collective Action in Agriculture: Evidence from Agricultural Co-operatives in Tigray, North Ethiopia

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Abstract:

Collective action via smallholder co-operatives is extensively discussed in the literature as an institutional solution to overcome market failures in developing countries. In some cases, however, the establishment of farmer groups incurs transaction costs that imply farmers may be better off not organizing. The success of collective action depends on the ability of individuals to make credible commitments and participation. Technical and human skills are also important for a group to succeed. In Ethiopia, co-operatives are actively promoted by the government to play a role in the agricultural sector. However, in the country in general and Tigray region in particular, the situation with co-operatives doesn't seem to be favorable for the full exploitation of the benefits of collective action: the majority of the co-operatives are established under the impulse of external partners without regard to the farmers' real needs and interests. Applying insights from game theory, this study examines the existence of economic incentives for farmers' collective action in the study area by testing for the condition of cost subadditivity in service provision. Findings show that costs would drop by 28.32 - 92.3% if farmers join hands in relatively big rather than small co-operatives.

Acknowledgement: We are greatly indebted to VLIR UOS, Belgium for the financial support that made this article a reality.

JEL Codes: D71, Q12

#1087

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1. INTRODUCTION

Collective action is a voluntary action taken by a group of individuals who invest time and energy to pursue shared objectives (Markelova et al., 2009; Meinzen-Dick and Di Gregorio, 2004). It plays an important role in the context of family farms and agricultural production. For example, co-operative organizations have helped to maintain the dominance of family farms in developed countries by offsetting some of the disadvantages related to size and bargaining power (Valentinov, 2007). In developing countries, the disadvantages of family farms are further exacerbated by various forms of market failure, which are particularly severe in areas with poor infrastructure and communication networks. As a result, smallholders face high transaction costs that significantly reduce their incentives for market participation (Poulton et al., 2010). Collective action has become an important strategy for smallholders in developing countries to remain competitive in rapidly changing markets (Fischer and Qaim, 2014). Through achieving economies of scale, farmer groups can countervail some of the disadvantages (Robertson and Tang, 1995). Smallholder organization is seen as a possible institutional solution to overcome high transaction costs and other market failures in developing countries (Markelova et al., 2009). Recently, the promotion of farmers' collective action has gained high popularity in the context of the agro-food system transformation (Narrod et al., 2009). The expectation from forming a coalition (collective action) is that by working together and choosing a joint strategy, members will be able to improve their results overall (McCain, 2008). As co-operation possibly leads to more efficient use of resources, total gain from farm production is likely to increase. Clearly, a farmer is only inclined to join a co-operative if the expected return is higher than when producing alone (Gerichhausen et al., 2008), implying gains from the collective action.

The benefit of co-operation is extensively discussed in the literature. However, farmer groups are not always successful, and there is a need to better understand under what conditions collective action is useful and viable (Markelova et al., 2009; Poulton et al., 2010). In some cases, the establishment of farmer organizations incurs transaction costs that imply farmers may be better off not organizing (Stockbridge et al., 2003). Since the benefits of collective action emerge primarily through the exploitation of economies of scale, low participation rates in joint activities may put a serious threat to the success and viability of farmer groups. The intensity of participation may crucially affect group success as well since active members contribute much more to shared goals than passive members. Moreover, the success of collective action depends on the ability of individuals to make credible commitments. Individuals with higher levels of commitment to collective action are more likely to contribute towards the achievement of shared goals (Fischer and Qaim, 2014). Technical and human skills are also important for a group to handle its tasks. If a marketing scheme, for example, involves specialized skills and knowledge that is not available to the group, the lack of skills may hinder activities, nullifying the incentives for collective action (Stringfellow et al., 1997).

In Ethiopia, co-operatives have been actively promoted by the government in the last two decades (Francesconi and Heerink, 2010) to play a role in developing the agricultural sector (Bernard et al., 2013). However, the situation with co-operatives doesn't seem to be favorable for the full exploitation of the benefits of collective action in the country. The majority of the co-operatives are created under the impulse of external partners, such as *woreda* co-operative offices, NGOs or others (Bernard et al., 2010), without regard to the farmers' real needs and interests. The co-operatives are perceived primarily as a means to channel resources, such as inputs to farmers, who tend not to display a deep involvement or interest in the functioning of these groups. Ethiopian co-operatives remain quite far from the type of collective action that many informed observers argue must lie at the heart of agricultural development for the country (Bernard et al., 2013). In Tigray, the prevalence of *kebeles* (villages) with a co-operative grew from 57 to 98% during the period 1998 to 2011, two times higher growth rate than the national average (Bernard et al., 2013). This has something to say about the size of the co-operatives in the region, with implications for gains from economies of scale. Bernard et al. (2013) find the small size of the co-operatives to be a limiting factor for the prospects of economies of scale in the region. What's more, in Tigray, access to co-operative services regardless of one's membership status is an important reason why some farmers do not join a co-operative (Bernard et al., 2013), implying a free-rider problem which leads to suboptimal collective provision of services (Fischer and Qaim, 2014). Generally, although co-operative participants face two interrelated issues: (1) identifying objectives that yield benefits of joint action; (2) finding an a stable allocation of the benefits thereof (Staatz, 1983), empirical analysis of the former (whether there are gains from joint action), has largely been ignored.

The purpose of this paper is, thus, to examine whether there are real gains (cost savings) from farmers' joint action via agricultural co-operatives in Tigray. Specifically, the paper will contribute to policy issues by answering the question: Given the aforesaid hindrances, are the incentives for farmers' collective action via agricultural co-operatives really existent in the study area? We argue that steps to establish, merge, or split co-operatives should be preceded by an *ex ante* empirical investigation of the existence of incentives for collective action. Economic efficiency, and not "politics", should dictate the establishment, merger, or split of co-operatives. This paper is an attempt to challenge the status quo in the field of agricultural co-operation in Ethiopia. Methodologically, it takes the first step to introduce the concept of cost subadditivity to analyze the presence of incentives for collective action in agriculture in the context of a developing country. Policy wise, findings are expected to provide some fresh insights to development practitioners and policy makers (e.g. Ethiopian Federal Co-operative Agency) as to whether agricultural co-operatives should grow in size (via merger and/or open membership) or in number (via split and/or closed membership) to harness underutilized opportunities for growth and development of agriculture in the country.

The rest of the paper proceeds as follows: Section 2 presents a brief overview of agricultural co-operatives in Ethiopia; Section 3 outlines the methodological approaches; Section 4 presents and discusses results; and Section 5 concludes.

2. OVERVIEW OF CO-OPERATIVES IN ETHIOPIA

2.1. General

Using collective action to deal with social and economic challenges has a long tradition in Ethiopia (Lemma, 2008). Currently, the government of Ethiopia (GoE) recognizes the importance of co-operatives for improving the socio-economic conditions of the rural poor. Starting from 1994, the GoE has designed various policies to strengthen the development and operation of co-operatives (Bernard et al., 2010). A Federal Co-operative Agency (FCA) was established in 2002 to promote co-operatives throughout the country. It plays a crucial role in registration, legalization, auditing, certifying, and monitoring co-operatives (MoFED, 2006). The country's recent Growth and Transformation Plan (GTP) foresees a central role for agricultural co-operatives in increasing the productivity and household incomes of smallholder farmers (MoFED, 2010; ATA, 2012). The Agricultural Transformation Agency (ATA) is another important government agency that promotes co-operatives at federal level (ATA, 2012). At district level, two agencies are supporting co-operatives: the Woreda Bureau of Agriculture and the Woreda Co-operative Promotion Office (Berhanu and Poulton, 2014). The latter has the assignment of directly promoting primary co-operatives and co-operative unions. This office is responsible for the provision of co-operative education to farmers. Next to governmental agencies, many NGOs are actively supporting unions and primary co-operatives.

In Ethiopia, agricultural co-operatives are seen as critical in achieving the government's development targets. They help farmers solve a collective action problem, i.e., how to procure inputs most efficiently and market their outputs on more favorable terms. They procure agricultural inputs from suppliers and sell them to members at prices and reliability enabled by collective action. Agricultural co-operatives are the dominant distributors of seed and fertilizer to farmers. For the 2010 and 2011 cropping seasons, for example, the share of co-operatives in fertilizer marketing was 93% and 95%, respectively. Co-operatives are currently playing a critical role in input procurement and distribution to all farmers (ATA, 2012). In Tigray, there are 4,265 registered co-operatives. Of these, 2,255 (76.6%) are specialized (single-purpose) agricultural co-operatives, 690 (16.18%) multipurpose co-operatives engaged in both agricultural input supply and marketing activities, 949 (22.25%) savings and credit co-operatives, and the remaining 371(8.70%) are service co-operative (TCPMDA, 2017). Many primary co-operatives have formed unions (second-tier co-operatives); some successful co-operatives have setup fertilizer blending plants. The number and membership of co-operatives increased tremendously in the past few years. Agricultural co-operatives in the region are visible at all stages of the agricultural value chain (production, processing, marketing, and credit) and help farmers obtain improved agricultural technologies and access to credit. They also facilitate marketing of members' outputs and offer training and technical advice to members.

2.2. Overview of surveyed co-operatives

The survey addresses seven types of agricultural co-operatives: (1) Multipurpose co-operatives (MPCs) purchase farm inputs (such as fertilizer, improved seed, pesticides), farm tools (such as sickle), farm implements (such as motor pump, treadle pump), and consumer goods (such as sugar, oil, coffee) mainly from a union and distribute them to members and nonmembers at a preset margin. They mainly serve as a distribution channel of items that the government wants the farmers to use; (2) Livestock fattening co-operatives (LFCs). Members of these co-operatives purchase oxen and cows, fatten (in some co-operatives jointly on common land, in others individually on individual land) and resell them. The ownership of the cattle is common in some cases, and individual in others; (3) Beekeeping co-operatives (BKCs) produce honey (some collectively on common land and beehive, others individually on individual land and beehive, still others on common land but individual beehive) and sell it (some individually, some jointly) to a union, traders, or consumers. In some cases, members are organized to work on a plot of land (usually a mountain side) over which they don't have a clear user-right, and have to face challenges from farmers who claim to rightfully own the land; (4) Sheep and goat fattening co-operatives (SGCs) purchase sheep and/or goats, fatten (some collectively on common land, some individually on individual land) and resell them; (5) Dairy co-operatives (DRCs) collect milk from members (some from nonmembers as well) and sell it at a small margin, in some cases converting it to cheese and yoghurt; (6) Irrigation co-operatives (IRCs) produce fruit and vegetables (some jointly on common land, others individually on individual land) and sell them (some jointly, others individually) in the market; (7) Natural resource co-operatives (NRCs) produce seedlings, grass, and other NR-related products on common land and sell them collectively.

For co-operatives other than MPCs (which hire accountants, cashiers, and guards), the number of members is equivalent to the amount of labor used in each co-operative in most cases. In the case of IRCs and BKCs, for example, it is the members themselves who invest labor in production. In rare cases, IRCs, and BKCs hire guards as well. Generally, members mainly join hands just to secure one or more of: land, credit, and donation in a way that helps them maximize benefits from their individual farming and/or other activities. Co-operative formation in the study area does not seem to be demand-driven. In most cases, the idea to form a co-operative comes from a donor, or the government in an attempt to address youth unemployment. In doing so, the promoters of co-operative formation pay no attention to the interests (what to do co-operatively) and preferences (with whom to co-operate) of the members. This, ultimately, leads to lack of solidarity and commitment on the members' part, which makes the co-operative only nominal, with no clear goals and preferences. The majority of the co-operatives exist only because members want them as a means of accessing support schemes targeting organized labor, or there is a joint debt to be repaid.

3. METHODOLOGY

3.1. Data and Sampling

This paper is part of a larger project, the VLIR-Coop TEAM Project, which addresses seven types of agricultural co-operatives in Tigray region, Ethiopia. The TEAM project covers all zones in the region except Mekelle (which has no agricultural co-operatives), with a focus on 12 districts (among 35). Multistage random sampling was employed to select a sample of 500 co-operatives. In the first stage, we randomly selected 12 districts (three from each zone): *Atsbi-Wenberta*, *Ganta-Afeshum*, and *Gulomkeda* from the Eastern zone; *Abergele*, *DeguaTembien*, and *Mereb-Leke* from the Central zone; *Alaje*, *Enderta*, and *Samre* from the South & Southeastern zone; *Asigede-Tsimbela*, *Tsegede*, and *Wolqayt* from the West & Northwestern zone. In the second stage, 223 *tabias* (*tabia* = the lowest administrative, below district) were randomly selected from each district proportionately, accounting for the type and number of agricultural co-operatives. In the third stage, using the probability proportion to size technique, we apportioned the 500 co-operatives among the 223 *tabias*, based on the number of each type of co-operative in each *tabia*. Finally, using the list of *tabias* and the number of each type of co-operative they have, we selected the sample co-operatives randomly.

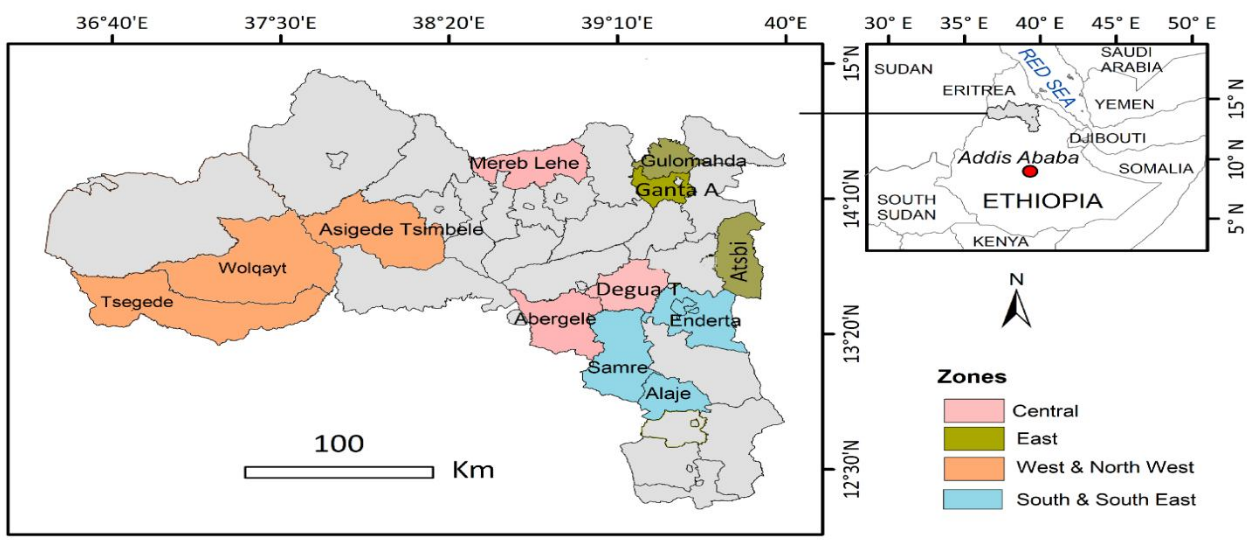

Figure 1.2: Location of the study area in Tigray region, Ethiopia

A semi-structured questionnaire was used for the survey. We conducted the data collection using the *Qualtrics* survey software. In addition to the questionnaire, we also made extensive review of readily available co-operative bylaws, audit reports, and co-operative periodic activity reports (including financial statements and strategic plan documents). Prior to conducting the full scale survey, a pre-test of the questionnaire was carried out on 65 randomly selected sample agricultural co-operatives. In the final sample, MPCs account for 35.23%, LFCs 4.7%, BKCs 24.66%, SGCs 5.87%, DRCs 4.11%, IRCs

21.72%, and NRCs account for 3.72%. Geographically, 26% of the co-operatives are from the Eastern zone, 23.48% from the Central zone, 25.79% from the South & Southeast zone (S&SE), and 24.74% from the West & Northwest (N&NW) zone. This indicates that the sample co-operatives are almost uniformly distributed across zones. The age of the surveyed co-operatives ranges from 1 year to 38 years, MPCs being the oldest. Total membership ranges from a minimum of 10 to a maximum of 1431 members in 2006; 8 to 2154 in 20015; and 4 to 2550 in 2016, with a yearly average membership of about 202; 315; and 381, respectively.

3.2. Model specification

Co-operatives have been studied from several theoretical perspectives, game theory being one among them. Co-operative game theory is applicable whenever the players in a game (group members) can form coalitions that choose a common strategy to improve their payoffs (McCain, 2008). It is used to analyze whether there are incentives to co-operate and allocate costs (or profits) from the co-operation among the participating players (Drechsel, 2010). Since co-operative formation typically involves many agents, this process falls naturally within the domain of n-person games. Such games are often conveniently summarized in a *characteristic function*, which is a real-valued function that defines the value of the game for each subset of players (Sexton, 1983). It shows the minimum payoff that each group or individual can guarantee itself, either by acting alone or by forming coalitions with other individuals within or outside the co-operative (Clark, 1923). In a cost game (a joint action where the objective is cost minimization), the characteristic function refers to the cost that arises when a coalition chooses to co-operate (Pardalos et al., 2008). In this case, the main condition imposed on the characteristic function is *subadditivity* (Zakharov and Shirokikh, 2017)**,** a property in which the total cost of any coalition is not larger than the sum of costs of any disjoint partitions (Kimms and Kozeletskyi, 2016a).

Subadditivity is the necessary condition for the co-operation of players who try to minimize their costs (Zakharov and Shirokikh, 2017)**,** and is important to ensure that the grand coalition can provide a better outcome for the players (Kimms and Kozeletskyi, 2016b). That is, it indicates whether two players or disjoint coalitions have an incentive to co-operate because of lower costs while co-operating compared to individual activity. If the (cost) characteristic function is subadditive, there is an incentive to co-operate and it is always profitable to form large coalitions (Pardalos et al., 2008). From a practical point of view, subadditivity can be interpreted as economies of scale or scope (Drechsel, 2010). Scale and scope are the standard measures to describe production economies but they are only descriptive measures. The relevant technological measure from a policy perspective is subadditivity of the cost function. It is subadditivity (and not scale or scope) which finally determines whether an output can be produced more cheaply by a single firm than by any group of firms (Ivaldi and McCullough, 2008). If the cost of joint service provision by a co-operative to its members is not subadditive (i.e. the joint cost is greater than the sum of stand-alone costs for the same level of service), members will have an incentive to secede from the grand co-operative and act in smaller coalitions or individually. Cost subadditivity is sufficient to produce common cost savings (Young, 1985). When a co-operative game (collective action) does not satisfy the property of subadditivity, co-operation would not be advisable. There needs to be an incentive to co-operate, otherwise, co-operation will not occur and the outcome will be inefficient. To test whether the players have an incentive to co-operate, subadditivity should be verified (Drechsel, 2010).

Evans and Heckman (1984) develop a local test for cost subadditivity, and define a cost function $c(q)$ to be subadditive at the output level q if and only if:

$$c(q) < \sum_{i=1}^{n} c(q_i) \tag{1}$$

where, for $q_i \geq 0$, $\sum_{i=1}^{n} q_i = q$ with at least two vectors q_i nonzero for all q_i; n = the number of firms. Measuring for cost subadditivity entails comparing the actual cost structure of the existing firm with the cost structure that would apply to an *n*-firm (hypothetical) configuration of the industry (Gordon et al., 2003). To accomplish this, Evans and Heckman (1984) determine an admissible output region of the new configuration by imposing the restriction that the *n*-firm output vectors be within the range of output vectors actually observed in the data. Operationally, this implies that no firm in the alternative configuration of the industry is permitted to produce less (more) output than the lowest (highest) observed output level in the sample. To meet this, they impose the constraint that output levels (of the hypothetical *n*-firm scenario) be at least twice the minimum and at most equal to the maximum observed output in the sample.

Adhikari and Gur-Gharana (2014) apply the Evans and Heckman (1984) approach to a single-output, two-firm case to test for cost subadditivity. Applying insights from the above two studies, we adapt the approach to the concept of co-operation in agriculture. In the context of farmer co-operatives, subadditivity of a cost function means that it is cheaper to provide a service to the members as a whole than to individuals or subgroups. It is subadditivity of the cost function that makes joint provision of a service *q* to a group more economical than providing the same level of service to subunits of the group (Staatz, 1985), and is expressed mathematically as:

$$c(S \cup T) < c(S) + c(T) \tag{2}$$

for any $S, T \subseteq N$ and $S \cap T = \varnothing$ where N = grand coalition; $c(S \cup T)$ = the total cost at which S and T could jointly avail service *q*; $c(S)$, $c(T)$ = the stand-alone costs of S and T, respectively for the same aggregate level of service (S and T can be singletons).

In this study, the necessary and sufficient conditions (constraints) for the cost subadditivity test require that the admissible co-operatives (those to be used in cost estimation) have number of members: (1) at least twice the minimum; (2) at most equal to the maximum observed membership size in the sample. Since the co-operatives under consideration have a substantial difference in membership size, we treat each co-operative type separately when imposing the minimum and maximum membership restrictions, with no obvious loss of generality. Our test proceeds by splitting the number of members of each co-operative into two parts: the minimum observed membership M (within each co-operative type) and the residual membership size R (total membership of the i-th co-operative minus the minimum within that co-operative type). After splitting the number of members into two, the cost of each observed co-operative is compared against the sum of the costs of the two hypothetical (split) co-operatives. Since the level of service a co-operative provides has cost implications, not only membership size, but also level of service q (proxied by the level of sales) is kept constant in the test. Thus, our modified definition of subadditivity follows:

$$c_i(N;q) < c_{iM}(M;q_{iM}) + c_{iR}(R;q_{iR}) \tag{3}$$

where $c_i(N;q)$ = cost of the i-th observed co-operative providing q level of service to its N members; $c_{iM}(M;q_{iM})$ = cost of the first hypothetical co-operative (split from the i-th co-operative) providing q_M level of service to its M (the minimum in the sample) members; $c_{iR}(R;q_{iR})$ = cost of the second hypothetical co-operative providing q_R level of service to its R (=N-M) members; $N = M + R$; $M \cap R = \varnothing$; $q = q_M + q_R$. Since N and q are positively correlated in the sample (r = 0.37; p = 000), q_M and q_R are determined based on the proportion of M and R in N. Using Eq.3, the degree of cost subadditivity can be measured as follows:

$$dCS_i = \frac{c_i(N;q) - \sum_j c_{ij}(j;q_{ij})}{c_i(N;q)} \tag{4}$$

where dCS_i = degree of cost subadditivity of the i-th co-operative; $j = M, R$. If $dCS < 0$, the data suggest cost subadditivity in the cost structure. To practically test for subadditivity of the cost function of the co-operatives under study, we estimate a single-output (sales) and three-input (*labor = l*, *capital = k,* and *materials = m)* cost function. Our subadditivity test is based on the assumption that the hypothetical co-operatives (of a kind) can access the same technology, so that their cost properties can be revealed by a single cost function, as Sueyoshi (1996) argue. Since our sample contains different co-operatives producing different products, we use sales as an output, as in Soboh et al. (2012), that is a proxy for service. Implicitly, the cost function is represented as:

$$c = c(q, p, N, c, z; \alpha) \tag{5}$$

where q = sales (birr = Ethiopian currency); p = a vector of input prices of labor (p_l), capital (p_k), and materials (p_m); N = number of members; c and z = vectors of cooperative and zone dummies, respectively allowing for neutral cost shift among different types of co-operatives and zones, as in Akridge and Hertel (1992); α = vectors of parameters to be estimated. Since the cooperatives are price takers with regard to inputs (input prices are either competitive or preset by a union or the government) and outputs (output prices are determined based on the exogenous input prices), the problem of endogeneity is unlikely. Similarly, the number of members of a co-operative is exogenously determined by its membership policy (open or closed) adopted *a priori*.

3.4. Functional form

The translog functional form (Eq.6) is used to represent Eq.5 and generate an estimable form of the cost function. The translog form has the advantage of flexibility with only few restrictions on its input data. It relaxes, for example, the restrictions that inputs be only substitutes (Cobb-Douglas) or substitutes and/or complements (CES) on a constant basis, and allows the degree of complementarities and substitution to be different between different sets of inputs (Malmsten and Lekkas, 2010). The translog specification has, as well, been extensively used as it has proven to be the most flexible form in bridging the gap between theoretical and empirical research (Tsegai et al., 2009).

$$\ln c(q, p, N, c, z; \alpha) = \alpha_0 + \alpha_q \ln q + \frac{1}{2}\alpha_{qq}(\ln q)^2 + \sum_i \alpha_i \ln p_i + \frac{1}{2}\sum_i \sum_j \alpha_{ij} \ln p_i \ln p_j + \sum_i \alpha_{iq} \ln p_i \ln q + \alpha_n N + c'\alpha_c + z'\alpha_z + \varepsilon \tag{6}$$

where $\ln$ = natural logarithm; $i,\ j = l(labor), k(capital), m(materials)$; ε = error term; others as defined above.

Generalized cost functions, like the translog, allow us to test for specific characteristics of technology, which are not required as prior assumptions. As a sensible cost function, the translog form is: linearly homogenous, continuous, and concave in input prices; non-negative and non-decreasing at all prices and output levels; and twice differentiable with respect to input prices and products (Adelaja and Hoque, 1986). It provides a second order approximation to the true underlying (but unknown) technology (Christensen et al., 1973); it does not impose any technological restrictions, and allows economies of scale and size to vary with output (Hailu et al., 2005).

4. RESULTS AND DISCUSSION

4.1. Descriptive statistics

Yearly data on total cost (birr) and sales (birr) were collected for the year 2016. Total cost includes costs of fixed assets, labor, and materials (feed, seeds, farm tools, pesticides, fertilizer, and consumer goods). Sales refers to revenue of each co-operative from the sale of goods and/or services in 2016. The price of labor was calculated as the ratio of total monthly payroll to total monthly number of hours worked. In all co-operatives other than MPCs, work is done by members themselves. However, as there are no hired employees (except a guard in some cases), no salaries and wages were paid by these co-operatives. Therefore, in a bid to avoid potential biases due to the neglect of labor, we imputed labor cost (opportunity cost) for the co-operatives with missing payroll based on their number of active members and the labor price calculated from MPCs. Likewise, the price of materials was calculated as the average of the ratio of total cost to total quantity of each item in the materials category. Theoretically, the price of capital is determined as the sum of depreciation rate and interest rate (Pindyck and Rubinfeld, 2001). Yet, it was hard to find documented depreciation costs. So, price of capital is approximated by interest rate, which varies from co-operative to co-operative on the basis of the source and purpose of the loan.

Table 4.1 presents the descriptive statistics. The average co-operative was found to spend close to 1.2 million birr/year to avail services to its members. The very high standard deviation (S.D) of total cost indicates a considerable scale difference among the co-operatives: the size of the sample co-operatives ranges from 4 to as high as 2550 members, on average. Average sales stand at about 0.73

million birr/year with an S.D of close to 1.6 million birr. Average prices of labor, capital, and materials are, respectively 2.20 (birr/hour), 10.31 (birr/100-birr-worth-capital/year), and 1162 (birr/unit). The input cost shares (proportion of total cost accounted for by each input) at the bottom of Table 4.1 indicate that capital costs (fixed assets) take about 50% of the total cost while labor and materials account for 2% and 48% of total cost, respectively.

Table 4.1: Descriptive statistics (n=419)

Variable	Description (Unit)	Mean	S.D
c	Total cost (1000 birr/year)	1212.37	5227.02
q	Sales (1000 birr/year)	727.34	1622.41
p_l	Price of labor (birr/hour)	2.20	1.24
p_k	Price of capital (interest rate/year)	10.31	2.55
p_m	Price of materials (birr/unit)	1162.26	3695.92
lshare	Labor cost share/year	0.02	0.11
kshare	Capital cost share/year	0.50	0.31
mshare	Material cost share/year	0.48	4.78
#Members (N)	Total number of members	451.35	580.50

4.2. Econometric results

Parameter estimates and asymptotic standard errors (S.E) for the translog cost function are given in Table 4.2. The number of significant coefficients compares favorably with those of other translog cost estimates in that close to 72% are significant at conventional levels. The R-sq of 52.76% shows a reasonable power of the model in explaining the dependent variable (lnc = the natural logarithm of total cost). We tested the estimated cost function for certain regularity conditions: linear homogeneity, monotonicity, and concavity in input prices. Linear homogeneity was already imposed during estimation; monotonicity in input prices is satisfied since the fitted input cost shares turn out to be positive at each data point; concavity is met at each data point (each input's elasticity with respect to its own price turned out to be negative), suggesting that the estimated cost function is well-behaved. The signs and statistical significance of the coefficients of co-operative dummies imply that cost of service provision varies from one co-operative type to the other.

The significant coefficients lead to differences in the intercepts of the cost functions for different co-operatives, capturing co-operative-specific fixed effects. All else held constant, MPCs (the base category), BKCs, DRCs, and NRCs (with statistically insignificant coefficients) are found to incur the highest cost of service provision to their members. On the other hand, SGCs, IRCs, and LFCs (with negative and statistically significant coefficients) are found to incur the second highest to the lowest cost of service provision in that order. While statistically insignificant difference between the costs of DRCs and MPCs (represented by their respective intercepts) seems acceptable (both co-operative types have comparable fixed assets), the implied lack of difference between the costs of MPCs, BKCs, and NRCs is counterintuitive, given the relatively low observed fixed assets of the latter two. The significant and negative coefficients of the dummies for the Central and W&NW zones, on the one hand, and the positive and insignificant coefficient of the dummy for the S&SE zone, on the other, suggest the variability of cost of co-operative services across zones. Given the same levels of service, input prices, number of members, and type of co-operative, findings show that costs are the highest in the Eastern (base category) and S&SE zones, and the lowest in the W&NW zone.

Table 4.2: Parameter estimates of the translog cost function: Dependent variable = lnc

Variable	Coefficient	S. E	z	P>|z|
Constant	2.9992	0.3590	8.35	0.000***
lnq	-0.2082	0.1074	-1.94	0.052*
$\ln p_l$	0.2888	0.0379	7.61	0.000***
$\ln p_k$	0.7359	0.0515	14.29	0.000***
$\ln p_m$	-0.0247	0.0588	-0.42	0.674
lnq*lnq	0.0295	0.0106	2.78	0.005***
$\ln q*\ln p_l$	-0.0138	0.0044	-3.16	0.002***
$\ln q*\ln p_k$	-0.0371	0.0071	-5.25	0.000***
$\ln q*\ln p_m$	0.0510	0.0090	5.63	0.000***
$\ln p_l*\ln p_l$	0.0137	0.0062	2.21	0.027**
$\ln p_l*\ln p_k$	-0.0056	0.0125	-0.45	0.654
$\ln p_l*\ln p_m$	-0.0218	0.0064	-3.41	0.001***
$\ln p_k*\ln p_k$	0.0137	0.0078	1.76	0.079*
$\ln p_k*\ln p_m$	-0.0217	0.0109	-2.00	0.045**
$\ln p_m*\ln p_m$	0.0218	0.0067	3.26	0.001***
N	0.0002	0.0001	1.21	0.226
Co-op dummies[a]				
LFCs	-0.9516	0.2715	-3.51	0.000***
BKCs	-0.1737	0.1898	-0.92	0.360
SGCs	-0.7625	0.2644	-2.88	0.004***
DRCs	0.1105	0.2952	0.37	0.708
IRCs	-0.8254	0.1784	-4.63	0.000***
NRCs	0.4223	0.3550	1.19	0.234
Zone dummies[b]				
Central	-0.2218	0.1247	-1.78	0.075*
S&SE	0.1340	0.1275	1.05	0.294
W&NW	-0.2728	0.1248	-2.19	0.029**

Note: R-sq=52.76%; ***Significant at 1%, **Significant at 5%, *Significant at 10%; N = 419; [a]Multipurpose co-operative (MPCs)= bases category; [b]Eastern zone =base category

4.3. Estimation of degree of cost subadditivity (*dCS*)

The condition of cost subadditivity is examined by simulating single-output and multiple-co-operative costs, using membership-cost relationships (keeping service constant at *q*) estimated from a statistical cost function. Single-co-operative and two-co-operative costs are estimated by splitting membership into a unique vector of two membership sizes (M and R) for each of the observations under each co-operative type. Using the parameters of the cost function (Table 4.2), we estimate the fitted costs serving all (N), the minimum (M), and the residual (R) number of members. Then, *dCS* was calculated based on Eq.4 for each co-operative. If *dCS* < 0, the bigger co-operative (that serves N members) is more cost-efficient in the provision of the observed level of service than the two smaller co-operatives. By extension, this implies that there are economic incentives for collective action rather than unilateral actions. That is, farmers have incentives to work in bigger groups rather than in smaller groups; and in smaller groups rather than unilaterally.

Despite the animosity of the environment they function in, all the co-operatives are found to exhibit cost subadditivity in their service delivery (*dCS* < *0* for all co-operatives), implying that there are cost savings from joint action in bigger rather than smaller cooperatives. Virtually all observations (and all co-operative types) show single-co-operative costs to be lower than the sum of two co-operative costs. The condition of subadditivity is met for 100% of the observations, with no case for (super)additivity, implying that the cooperatives (in Tigray) are too small to exhaust scale economies. The projections suggest that a single (but larger)-co-operative scenario would bring a minimum of 28.32% (in MPCs) to a maximum of 92.3% (in NRCs) cost advantages over the two-co-operative scenario. This assertion can be confirmed by the magnitudes and signs of the *dCS* estimates documented in the last column of Table 4.3. The negative values of the *dCS* show a percentage cost savings as a result of farmers' organization in a single co-operative instead of in two smaller ones. That is, it is less costly to provide services with a single co-operative rather than splitting service provision up between two or more smaller co-operatives.

Table 4.3: Total costs and degree of subadditivity (S.E in parenthesis)

Co-op Type	c(N)* = a	c(M) = b	c(R) = c	*dCS* = (a-b-c)/a
Aggregate	867.27	262.94	833.18	**-0.5528**
	(1973.11)	(544.54)	(1831.11)	(0.2974)
Multipurpose (MPC)	1466.44	347.81	1445.04	**-0.2832**
	(1343.84)	(218.50)	(1337.12)	(0.1348)
Livestock (LFC)	408.06	124.41	401.67	**-0.4110**
	(471.67)	(52.11)	(472.21)	(0.1324)
Beekeeping (BKC)	158.89	136.93	152.24	**-0.8531**
	(80.66)	(57.78)	(72.71)	(0.1173)
Sheep & goats (SGC)	109.71	88.50	101.73	**-0.7524**
	(36.83)	(24.16)	(34.64)	(0.1126)
Dairy (DRC)	2045.66	1123.37	1597.54	**-0.6166**
	(5332.30)	(2763.84)	(3980.44)	(0.2131)
Irrigation (IRC)	577.06	167.80	550.69	**-0.6739**
	(3220.77)	(465.17)	(3072.12)	(0.2267)
Natural resource (NRC)	558.37	326.94	539.46	**-0.9230**
	(762.26)	(188.14)	(736.83)	(0.3792)

*c(N) = cost of serving all (N) members; c(M) = cost of serving the minimum (M) number of members; c(R) = cost of serving the residual (R = N - M) number of members.

Given the single-output case under consideration, economies of scale might underlie the subadditivity of the cost function of the co-operatives. However, insights from Joskow (2007) suggest that it may still be less costly for a service to be provided by a single co-operative rather than multiple co-operatives even if the output of the single co-operative has expanded beyond the area of economies of scale. A cost function can still be subadditive even beyond the point where economies of scale are exhausted and until demand is large enough to make it economical to add a second co-operative. This is because the market (farmers') demand may not be large enough to support efficient service provision by two co-operatives. On average (across all co-operatives), cost is shown to drop by 55.28% (*dCS* = -0.5528) if the current level of service is provided by a single bigger co-operative (serving N number of members) rather than by two smaller co-operatives (one serving M and the other R number of members). Conversely, cost will increase by 55.28% if collective action is taken via smaller co-operatives. This implies that a single co-operative can serve all its members at a lower cost than would two or more smaller co-operatives. Thus, it is more cost effective to let the existing co-operatives grow in size to support the agricultural sector rather than to organize more co-operatives, or split the existing ones into smaller co-operatives. This finding supports the formation of bigger rather than smaller co-operatives till the optimal co-operative size is reached, beyond which smaller may be better.

From the definition of cost subadditivity, the higher (in absolute value) the *dCS*, the more beneficial collective action becomes. From this view point, a simple comparison can be made among co-operative types. Of the co-operative types under study, NRCs (*dCS* = -0.9230), BKCs (*dCS* = -0.8531), and SGCs (*dCS* = -0.7524) were found to have the highest potential gains (cost savings) to be reaped from a larger scale of operation. IRCs (*dCS* = -0.6739), DRCs (*dCS* = -0.6166), LFCs (*dCS* = -0.4110), and MPCs (*dCS* = -0.2832) exhibit the next highest to the lowest cost advantages. The variability of the degree of cost savings among co-operatives can be related to their relative size. For example, since MPCs have the biggest membership size, the lowest *dCS* (in absolute value) they have may reflect the fact that they are the closest to the efficient point of service provision (note that, with size, it is the total rather than the marginal efficiency gain that increases).

Table 4.4. Correlation between *dCS* and co-operative size (N = number of members)

	MPCs	LFCs	BKCs	SGCs	DRCs	IRCs	NRCs
Correlation	-0.460	-0.767	-0.298	-0.482	-0.315	-0.532	-0.522
p-value	0.000**	0.001**	0.002**	0.050*	0.318	0.000**	0.150
N	986	123	37	20	36	57	63
Max.	2550	1605	1140	48	73	466	210
Min.	20	1	4	7	12	6	12
Range	2530	1604	1136	41	61	460	198

** Sig. at 1%, * sig. at 10%; Members=av. # of members, Max. (Min.)= maximum (minimum) number of members

Table 4.4 reports the correlation between co-operative size and the absolute value of *dCS*, with varying statistical significance across co-operative types. The correlation (between N and dCS) is significant for MPCs, LFCs, BKCs, SGCs, and IRCs at conventional levels. The insignificant correlation between size (N) and *dCS* for DRCs and NRCs may probably be a reflection of the lower within-variability of size in these co-operatives (they have relatively low range = maximum - minimum). Generally, however, there appears to be a negative correlation between size and potential efficiency gains (from scale merits) across all co-operative types. This is an indication that larger co-operatives (in terms of membership size) are operating at a more efficient scale than smaller ones. To better reap scale efficiencies, mergers and/or open membership policy would likely be cost-reducing and benefit-enhancing strategies.

The finding that bigger cooperatives are more cost efficient than smaller ones can safely be extended to argue in favor of farmers' collective rather than unilateral action in Tigray. That is, farmers will be better off working together rather than taking unilateral actions. If the cost of serving a larger number of members by a single co-operative is lower than the cost of providing the same level of aggregate service by two or more smaller co-operatives, then unilateral actions are unlikely to be cost-efficient. This is an implication for the presence of economic incentives for collective action in agriculture in the study area. When cost is subadditive, co-operative formation and membership expansion (bigger cooperatives) are beneficial.

4.4. Implications for the stability of co-operatives

Theoretically, once formed, no co-operation will exist any longer if players think they could do better without the other participants in the co-operative. To assure stability, no player or sub-coalition should be better off when defecting from the grand coalition (Drechsel, 2010). In section 4.3, it is confirmed that the agricultural co-operatives in the study area have a subadditive cost function, implying potential gains from collective action. However, cost subadditivity is not a sufficient condition for a co-operative to be stable. Even though members can gain by working together, this does not mean they will continue working together in a stable co-operative. For joint actions to continue, not only must the total payoff (cost savings in this case) be greater than the sum of the payoffs that would result from individual actions, but also each individual member's share of the joint "pie" must be greater than the payoff each could achieve by acting independently. That is, a set of feasible allocations of the gains that gives all participants an incentive to remain within the co-operative (the core) must exist. More than one set of feasible cost allocations may lie within the core, and which set of cost allocations should be implemented has to be decided upon through a bargaining process in the co-operative. As Staatz (1983) notes, however, in reality a member's external market opportunities and co-operative cost functions are likely to be known only very imprecisely, so the bargaining will take place in an atmosphere of uncertainty. This is particularly true in the present study area where research on the behavior of costs and opportunities is very limited, if any at all.

It is more difficult to find a stable allocation of costs that gives everyone an incentive to stay in the co-operative in a more heterogeneous membership. In MPCs, for example, there seem to be tendencies of dissatisfaction among long-time members with the uniform treatment they get as new members. In such circumstances, differential pricing of services may be necessary to preserve the stability of the co-operative. Failure to choose an allocation that gives members a benefit more than what they can get somewhere else puts the stability of the co-operative at risk. Reality, however, may not be so harsh since members are unlikely to precisely know the benefits from the alternatives open to them. In this sense, Staatz (1983) argues, uncertainty about what is in one's best interest may reduce defection from the co-operative. To the extent that members receive non-pecuniary benefits from remaining in the co-operative, bargaining over the allocation of monetary benefits and costs (Staatz, 1983) and dissatisfactions arising thereof may also be muted. However, uncertainty may also act in the reverse direction: ambiguity about external opportunities may lead to defection form a cooperative. For example, we have observed cases where some youth, discouraged by "a very extended" payback period of their joint action, break away from their co-operatives and go to Arab countries as if there is "free lunch" there, which is not generally true. Therefore, uncertainty should not be counted on to see stable co-operatives.

Generally, to be stable, a co-operative must maximize its members' welfare. This requirement implies marginal-cost pricing (MCP) of its services. However, MCP is incompatible with the service-at-cost (break-even) principle of co-operatives (that is, price = average cost). This problem, however, can be circumvented by co-operatives thanks to their unique financial structure, which often involves membership fees as well as per-unit charges. The fees can be adjusted to satisfy the breakeven constraint under MCP. Importantly, they can also be structured in a manner likely to generate core payoff vectors. As such, a co-operative can attain a Pareto-optimum allocation in situations in which other organizational forms may be unable to (Sexton, 1983).

5. CONCLUSIONS

This study empirically investigates the cost structure of agricultural co-operatives in Tigray, North Ethiopia. Specifically, it examines whether the sector provides incentives for collective action as a result of scale benefits by testing for the condition of cost subadditivity. All the chosen co-operatives in this study were found to exhibit cost subadditivity in their service delivery to members. Given the scale benefits reflected by the subadditive cost function, bigger co-operatives are likely to avail services to their members at a lower cost than would smaller co-operatives or unilateral actions. Findings suggest that splitting a co-operative into two (which we observed in some cases during the survey) would result in cost disadvantages. Therefore, policies favoring fewer but larger co-operatives would be beneficial from a cost perspective. Collective action via (larger) co-operatives will help farmers reap more of the available scale economies in the sector. These results have important policy implications: larger co-operatives are more cost efficient than smaller co-operatives (and by extension unilateral actions) in agriculture in the study area. Regulations that inhibit growth of co-operatives (in size rather than in number) are, therefore, inimical to efficiency.

There are a couple of *caveats*, however, that apply to our findings. First, the test for the condition of cost subadditivity we employed is a local test done by splitting the observed output of each co-operative just into two hypothetical components (while this can be done in an infinite number of ways). Thus, there may be a need for a further test of the condition using different hypothetical outputs so as to make the case more conclusive. Second, though findings support the assertion that collective action (in bigger groups) is beneficial in agriculture in terms of cost savings, this approval should not lead to an automatic policy decision towards co-operative mergers. The scale benefits to be reaped from larger co-operatives are conditional on, at least, as good technical and human skills as what the currently existing co-operatives have. Otherwise, managerial inefficiencies in larger co-operatives might nullify the benefits of potential scale efficiencies. Generally, we believe that this study paves the way for uncovering the economic benefits of collective action in agriculture. However, to get more conclusive findings with better policy implications, the importance of addressing the above declared limitations cannot be overemphasized.

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