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Big is Efficient: Evidence from Agricultural Cooperatives in Ethiopia

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Abstract

In Ethiopia, there is a renewed interest in agricultural cooperatives as an institutional tool to improve the welfare of smallholder farmers. One of the pathways through which cooperatives benefit their members is scale economies. However, the establishment of cooperatives in Ethiopia seems to pay little attention to the size of the organizations. This paper aims at
investigating the effect of size on cost efficiency of agricultural cooperatives. More specifically, the purpose is to examine whether a single cooperative can serve a given number of farmers at a lower cost than two or more smaller cooperatives could. We employ the concept of cost subadditivity to compare the cost efficiency of large versus small cooperatives, and by extension unilateral actions. We estimate a flexible production technology using cross-sectional cooperative-level data. Findings show that costs would drop by 78 to 181% if farmers join hands in relatively large rather than small cooperatives.

*JEL classifications:* J54, O13, Q13

*Keywords:* Agricultural cooperatives; Cost efficiency; Cost subadditivity; Scale economies; Ethiopia

1. Introduction

Cooperatives are an organizational form for social and economic development. Their role is increasing in response to market imperfections (Getnet and Anullo, 2012). In developing countries, especially in areas with poor infrastructure, family farms are disadvantaged by various forms of market imperfections. Smallholders face high transaction costs that significantly reduce their incentives for market participation (Poulton et al., 2010). There is a renewed interest in cooperatives as an institutional tool to improve market participation of smallholder farmers, increase farm incomes, and reduce rural poverty (Bernard and Taffesse, 2012; Fischer and Qaim, 2012; Verhofstadt and Maertens, 2015). Cooperatives are often
thought to be more inclusive and poverty-reducing than other types of institutional innovations, such as contract farming (Verhofstadt and Maertens, 2015). They enable small farmers to aggregate production, capture the benefits of downstream economies of scale and reduce transaction costs (Ito et al., 2012; Reardon et al., 2009; Soboh et al., 2009; Holloway et al., 2000; Saitone et al., 2018). Essentially, farmers form cooperatives to generate larger profits or incomes by obtaining inputs and services at lower costs than they could obtain elsewhere, and by marketing their products at better prices or in markets that are not accessible for individual farmers (Ortmann and King, 2007). A farmer is inclined to join a cooperative if the expected return is higher than when producing alone.

A large body of literature provides evidence on the relative advantage cooperative members have over nonmembers (e.g., Abebaw and Haile, 2013; Fischer and Qaim, 2012; Ito et al., 2012; Vandeplas et al., 2013; Ma and Abdulai, 2016; Chagwiza et al., 2016; Mojo et al., 2017; Wossen et al., 2017; Ma and Abdulai, 2018; Ma et al., 2017; Verhofstadt and Maertens, 2014). These studies mainly highlight a positive impact of cooperatives on different performance indicators, such as farm income, farm profits, producer prices, poverty, market participation, and technology adoption. These observed effects are attributable to various possible pathways through which cooperatives can benefit their members. One such channel is exploiting economies of scale and reducing the cost of operation (Wossen et al., 2017). Several conceptual studies highlight the cost advantage of size in agricultural cooperatives (e.g. Barton et al., 1993; Fulton and King, 1993; Trechter, 1996). Yet, only a few studies (Arcas et al., 2011; Lerman and Parliament, 1991) empirically investigate the effect of size on performance.

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In this paper, we focus on size and empirically examine whether it is cost efficient for farmers to organize in relatively small or large agricultural cooperatives, or act unilaterally. While cost efficiency may not capture overall economic efficiency, it is an important objective of cooperatives to minimize cost of service delivery to their members. We focus on determining whether a single cooperative can provide a given level of service at a lower cost than two or more smaller cooperatives could, and, by extension, than unilateral actions. Our focus is complementary to studies on the impact of cooperative membership as it allows to understand how efficient cooperatives are in creating member benefits. In addition, this focus is particularly relevant in our study area where cooperatives are very widespread – with 98% of villages having at least one cooperative (Bernard et al., 2013). In this context, comparing the performance of cooperative members and non-members is less relevant (and difficult as a good control group is lacking). Policy decisions regarding the size of agricultural cooperatives, whether by governments, NGOs, communities or cooperatives themselves, require information on size-cost relationships and the advantages of size (Arcas et al., 2011).

In addition, the cooperative landscape in Tigray is very heterogeneous with the remains of the pre-1991 government-controlled cooperative system and new (post-1991) bottom-up collective action initiatives (Bernard et al, 2010; 2013). This implies that the efficiency of cooperatives – and how it relates to size – is important in this region.

This study contributes some methodological innovations. First, it introduces the Evans and Heckman (1984) test for cost subadditivity to analyze the presence of incentives for cooperation in agriculture in the context of a developing country. Several studies (e.g., Adhikari and Guru-Gharana, 2014; Ivaldi and McCullough, 2008; Sánchez, 2000) apply this
approach to electric, railway, and banking industries (to analyze cost savings from splitting a company into two or more entities), but no study has applied it to the agricultural sector. In this study, we use this approach to examine economies of scale in the joint provision of services to farmers; i.e., whether the cost of service provision is subadditive. Second, while previous studies keep only output constant in testing for cost subadditivity, this study adapts the approach to cooperatives by keeping both membership size and output (service) constant to capture the cost implications thereof. Another contribution of the paper is the use of a flexible model that allows for the estimation of cooperative type-specific technologies. Policy wise, findings provide insights on whether agricultural cooperatives should grow in size – via merger and/or open membership – or in number – via split and/or closed membership – to harness underutilized opportunities for agricultural growth and development in Ethiopia. Results serve as an ex ante empirical investigation of size-performance relationships before steps to establish, merge, or split cooperatives are taken, and pave the way for economic efficiency (and not politics) to guide cooperative policies.

2. Sampling and data

For this study, the six zones in Tigray (excluding Mekelle zone) were categorized into four zones. A multistage random sampling technique was used to select 511 cooperatives from the four zones. In the first stage, we randomly selected 12 districts, three from each zone (Fig. A1 online appendix). In the second stage, 223 tabias (the smallest administrative unit) were randomly selected from each district proportionately, accounting for the type and number of agricultural cooperatives. In the third stage, using the probability proportion to size technique, we apportioned the 511 cooperatives among the 223 tabias, based on the number
and the type of cooperatives in each *tabia*. Finally, using the list of *tabias* and the number of each type of cooperative, we randomly selected 511 cooperatives.

A semi-structured questionnaire was used for the survey. We conducted the data collection using *Qualtrics* survey software. In addition to the questionnaire, we also extensively reviewed cooperative bylaws, audit reports, and periodic activity reports (including financial statements and strategic plan documents). Prior to conducting the actual survey in April to August 2017, a pre-test was carried out with 65 randomly selected cooperatives. In the final sample, multipurpose cooperatives account for 35.23%, cattle fattening cooperatives for 4.7%, beekeeping cooperatives for 24.66%, sheep & goat fattening cooperatives for 5.87%, dairy cooperatives for 4.11%, irrigation cooperatives for 21.72%, and forest and grass cooperatives for 3.72%. Geographically, 26% of the cooperatives are from the Eastern zone, 23.48% from the Central zone, 25.79% from the South & Southeastern zone, and 24.74% from the West & Northwestern zone, indicating that sampled cooperatives are almost uniformly distributed across zones.

A detailed overview of the surveyed cooperatives and their characteristics is provided in the online appendix. For the purpose of this paper we classify the cooperatives in four broader categories: (1) multipurpose cooperatives (MPC); (2) livestock & dairy cooperatives (LDC), including cattle and sheep & goat fattening, and dairy cooperatives; (3) beekeeping cooperatives (BKC); and (4) natural resource cooperatives (NRC), including irrigation cooperatives and forest cooperatives.

3. Methodology
3.1. Conceptual framework

The most important reason for cooperative formation is economies of scale, which farmers cannot realize individually (Cazzuffi and Moradi, 2012). Organizational economics explains agricultural cooperatives through their ability to economize on transaction costs and develop countervailing power (Bonus, 1986; Staatz, 1987; Hansmann, 1988; Valentinov, 2007). Increasing returns to scale imply that larger firms are more competitive. However, large firms (groups) may face coordination problems that lead to inefficient use of resources. Smaller groups may be better able to overcome this problem, as better information and social sanctions help to ensure cooperation and offset negative effects from profit-sharing and free-riding. Larger groups may find this more difficult as monitoring members’ commitment is more costly and social sanctions less effective. At a certain point, group interaction problems may outweigh gains from economies of scale, resulting in an inverted-U shaped relation between membership size and efficiency (Cazzuffi and Moradi, 2012). This theoretical size-performance relationship motivates our question: is the current average size of agricultural cooperatives in the study area smaller than what would be efficient in terms of cost?

In a joint action where the objective is cost minimization, the main condition imposed on the cost function is subadditivity (Zakharov and Shirokikh, 2018), a property in which the total cost of any coalition is not larger than the sum of the costs of any disjoint partitions (Kimms and Kozeletskyi, 2016a) or singletons. Subadditivity is a necessary condition for cost minimization (Zakharov and Shirokikh, 2018), and it is important to ensure that the grand coalition (a larger cooperative) can provide a better outcome for its members (Kimms and Kozeletskyi, 2016b) than two or more smaller ones. If the cost function is subadditive, there
is an incentive to form larger cooperatives (Chinchuluun et al., 2008). Subadditivity of a cost function can be interpreted as economies of scale or scope (Drechsel, 2010). But, it is subadditivity – and not scale or scope – which finally determines whether an output can be produced at a lower cost by a single larger firm (cooperative) than by any group of smaller ones (Ivaldi and McCullough, 2008). Evans and Heckman (1984) develop a local test (that does not require global information on cost functions) for cost subadditivity which avoids the need to extrapolate the estimated cost function outside the available data in the sample. A cost function $C(q)$ is subadditive at the output level $q$ if:

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

(1)

$$\sum_{i=1}^{n} q_i = q$$

(2)

where $q_i \geq 0$, with at least two vectors $q_i$ nonzero for all $q_i$ satisfying (2), and $n$ = the number of firms (cooperatives). Measuring 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. 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 the maximum observed output in the sample. The Evans and Heckman (1984) approach has been applied to the electric, railway, and banking industries to test for cost subadditivity by Adhikari and Gur-Gharana, (2014), Ivaldi and McCullough (2008), Sanchez (2000), and Hunter et al., (1990). Applying insights from these studies, we adapt the approach to the concept of cooperation in agriculture. In the context of farmer cooperatives, subadditivity of a cost function means that it is cheaper to provide a given level of service to a group of members as a whole than to smaller subgroups or individuals. It is subadditivity of the cost function that makes joint provision of a service to a group more economical than providing the same level of service to subunits of the group (Staatz, 1985).

3.2. Application to cooperatives in Ethiopia

In this study, we model agricultural cooperatives as service\(^1\) providers that seek to minimize costs subject to the prices of labor, capital, and material inputs, the prevailing production technology, and the level of service they provide. Following the value added criterion that regards outputs as items that entail operating costs (Park and Meyer, 1994; Berger and Humphrey, 1991), output is proxied by the level of sales. A necessary and sufficient condition for cost subadditivity is that cooperatives used in the cost estimation have at least twice the minimum and at most the maximum observed membership size in the sample. Since our sampled cooperatives differ substantially in membership size, we treat each cooperative

\(^{1}\) Service refers to supply of tangible products (farm inputs, farm tools, and consumer goods) and does not include provision of intangible services (e.g. market information).
type separately when imposing the minimum and maximum membership restrictions. We split up the number of members of each cooperative into two parts, thereby creating three cooperatives of different sizes: (1) larger cooperative \((N\text{-coop})\) with \(N\) number of members, where \(N\) equals at least twice the minimum membership size observed in the sample; (2) smaller cooperative \((M\text{-coop})\) with \(M\) number of members, where \(M\) equals the minimum membership size observed in the sample; (3) a hypothetical complementary\(^2\) cooperative \((R\text{-coop})\) with \(R\) number of members, where \(R\) equals the residual membership size \(\text{(i.e. } R=N-M\text{)}\). After estimating the parameters of the cost function using the observed data of the \(N\text{-coop}\), the cost of the \(N\text{-coop}\) is compared against the sum of the costs of the \(M\text{-coop}\) and the \(R\text{-coop}\). Since cooperative service provision has cost implications, not only membership size but also the level of output is kept constant in the test. Our modified definition of cost subadditivity is as follows:

\[
C_i(N; q_i) < C_{iM}(M; q_{iM}) + C_{iR}(R; q_{iR})
\]

\((3)\)

where \(C_i(N; q_i)\) is cost of the \(i\)th \(N\text{-coop}\) providing \(q_i\) level of service to its \(N\) members; \(C_{iM}(M; q_{iM})\) is cost of the \(i\)th \(M\text{-coop}\) providing \(q_{iM}\) level of service to its \(M\) members; \(C_{iR}(R; q_{iR})\) is cost of the \(i\)th \(R\text{-coop}\) providing \(q_{iR}\) level of service to its \(R\) members; and \(N = M + R\); \(M \cap R = \emptyset\); \(q_i = q_{iM} + q_{iR}\). Since \(N\) and \(q\) are positively correlated in the sample \((r = 0.37; p=0.00)\), \(q_{iM}\) and \(q_{iR}\) are determined based on the proportion of \(M\) and \(R\) in \(N\). Thus, using equation \((3)\), the degree of cost subadditivity can be measured as:

\(^2\)Complementary refers to the \(R\text{-coop}\) containing all the members of the \(N\text{-coop}\) that are not in the \(M\text{-coop}\).
$$dCS_i = \frac{C_i(N;q_i) - \sum_j C_j(j;q_j)}{C_i(N;q_i)}$$

(4)

where $dCS_i$ = degree of cost subadditivity of the $i$th cooperative; $j = M, R$. If $dCS < 0$, the data suggest subadditivity in the cost structure. To practically test for subadditivity of the cost function of the cooperatives under study, we estimate a single-output and three-input ($labor = l$, $capital = k$, $materials = m$) cost function. Our subadditivity test is based on the assumption that the hypothetical cooperatives of a kind can access the same technology, so that their cost properties can be represented by a single cost function, as Sueyoshi (1996) argues. Implicitly, the cost function (of the $N$-coop) is represented as:

$$C = C(q, p, N; \beta)$$

(5)

where $q$ = sales; $p$ = a vector of prices of labor ($p_l$), capital ($p_k$), and materials ($p_m$); $N$ = number of members; $\beta$ = a vector of parameters to be estimated. To estimate the costs of the $M$-coop and the $R$-coop, $N$ will be replace by $M$ and $R$, respectively in the predicted model.

Empirical estimation of equation (5) entails the choice of an appropriate functional form and decision on a model of the underlying production technology. In this study, the translog functional form, which has the advantage of flexibility with few restrictions on its input data, is used. The translog specification has been extensively used as it has proven to be the most flexible form in bridging the gap between theoretical and empirical research. 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 form provides a second order approximation to the true underlying (but unknown) technology; it does not impose any technological restrictions, and allows economies of scale and size to vary with output (Hailu et al., 2005; Christensen et al., 1973).

Our sample spans a range of cooperative types whose production technologies may differ with the nature of activity they are engaged in. So, it may be an undue restriction to impose a common underlying production technology for all the cooperative types. The assumption of a common technology when heterogeneous technologies are present will potentially lead to biased estimates of costs. On the other hand, a separate regression approach assumes the existence of different technologies without allowing the possibility of hypothesis testing with regard to whether this assumption is valid (Triebs et al., 2016). Therefore, following Triebs et al. (2016), we use a translog cost model where technology can be fully flexible across cooperative types. The approach is a generalization of separate regressions allowing for the restriction and testing of a common technology assumption. Using the same functional form for each of the technologies with parameters of their own, the model is given with the use of cooperative type dummies as:

\[
\ln C(q, p, N; \beta) = m \times \ln C^m(q^m, p, N^m; \beta^m) + \ell \times \ln C^\ell(q^\ell, p, N^\ell; \beta^\ell) \\
+ b \times \ln C^b(q^b, p, N^b; \beta^b) + r \times \ln C^r(q^r, p, N^r; \beta^r)
\]

(6)

where \( \ln C = \) natural logarithm of total cost; \( m, \ell, b \) and \( r \) are dummies for MPC, LDC, BKC and NRC, respectively; superscripts refer to the cost, output, number of members, and
parameters of each cooperative type; others as specified above. This model represents a cooperative-type flexible production technology and allows the parameters to vary among the four cooperative types. It also allows for testing the common technology assumption through imposition of appropriate parameter restrictions. Applying a translog form to equation (6), we estimate the following model:

$$\ln C = m \times [\beta_0^m + \beta_q^m \ln q^m + 1/2 \beta_{qq}^m (\ln q^m)^2$$

$$+ \sum \beta_i^m \ln p_i + 1/2 \sum \beta_j^m \ln p_j \ln p_i \ln q^m$$

$$+ \sum \beta_{ij}^m \ln p_i \ln p_j \ln q^m + \sum \beta_{ij}^m N]$$

$$+ \ell \times [\beta_0^\ell + \beta_q^\ell \ln q^\ell + 1/2 \beta_{qq}^\ell (\ln q^\ell)^2$$

$$+ \sum \beta_i^\ell \ln p_i + 1/2 \sum \beta_j^\ell \ln p_j \ln p_i \ln q^\ell$$

$$+ \sum \beta_{ij}^\ell \ln p_i \ln p_j \ln q^\ell + \sum \beta_{ij}^\ell N]$$

$$+ b \times [\beta_0^b + \beta_q^b \ln q^b + 1/2 \beta_{qq}^b (\ln q^b)^2$$

$$+ \sum \beta_i^b \ln p_i + 1/2 \sum \beta_j^b \ln p_j \ln p_i \ln q^b$$

$$+ \sum \beta_{ij}^b \ln p_i \ln p_j \ln q^b + \sum \beta_{ij}^b N]$$

$$+ r \times [\beta_0^r + \beta_q^r \ln q^r + 1/2 \beta_{qq}^r (\ln q^r)^2$$

$$+ \sum \beta_i^r \ln p_i + 1/2 \sum \beta_j^r \ln p_j \ln p_i \ln q^r$$

$$+ \sum \beta_{ij}^r \ln p_i \ln p_j \ln q^r + \sum \beta_{ij}^r N] + \varepsilon$$

(7)

where \(i, j = l\) (labor), \(k\) (capital), \(m\) (materials); \(\varepsilon\) = error term; others as defined above. The cost function is required to satisfy the following symmetry (8) and linear homogeneity in input prices (9) constraints:

$$\beta_{ij} = \beta_{ji} \text{ for } m, \ell, b, \text{ and } r$$

(8)

$$\sum_i \beta_i = 1; \sum_i \beta_{ij} = 0; \sum_j \beta_j = 0 \text{ for all } j;$$

$$\sum_j \beta_{ij} = 0 \text{ for all } i; \sum_i \sum_j \beta_{ij} = 0 \text{ for all } m, \ell, b, r$$

(9)
Using Shephard’s lemma and the symmetry constraint (8), we obtain cost share equation (10) for each input \( i = l, k, m \):

\[
S_i = m \times [\beta_{i}^m + \sum_j \beta_{ij}^m \ln p_j + \beta_{iq}^m \ln q^m] \\
+ \ell \times [\beta_{i}^\ell + \sum_j \beta_{ij}^\ell \ln p_j + \beta_{iq}^\ell \ln q^\ell] \\
+ b \times [\beta_{i}^b + \sum_j \beta_{ij}^b \ln p_j + \beta_{iq}^b \ln q^b] \\
+ r \times [\beta_{i}^r + \sum_j \beta_{ij}^r \ln p_j + \beta_{iq}^r \ln q^r] + v_i
\]

(10)

where \( v_i \) = error term. To get more efficient estimates, we estimate the cost function (equation 7) and share equations (equation 10, except the materials cost share to avoid singularity) as a system using the iterated seemingly unrelated regression (SUR) technique (Zellner, 1962). The symmetry (equation 8) and linear homogeneity (equation 9) constraints are imposed during the estimation. Our model regresses cost on sales (which is a function of quantity sold and output price) and input prices. Price variables are likely exogenous in the study area: input prices are either competitive or preset by a union; and output prices are determined as the sum of the input prices and a preset margin. Yet, a simultaneity problem may arise in relation to output quantities. As we find it difficult to control for this, we interpret our results as correlations rather than causations.
4. Results and discussion

4.1. Descriptive statistics

Our econometric model uses data on total cost (C), sales, input prices, and input cost shares. The paper considers costs and sales revenues related to the purchase and resale of supplies, including farm inputs, farm tools, consumer goods, and livestock to members and nonmembers. Yearly cooperative-level data on total cost (ETB) and sales (ETB) were collected for the year 2016. While the values of total cost and sales were taken from cooperative documents, input prices and input cost shares (proportion of total cost accounted for by a given input) are the result of own calculation. Total cost includes labor cost, capital cost (cost of fixed assets), and materials cost. Capital cost includes the monetary value (at purchase price) of fixed assets such as buildings, office furniture, motor and treadle pumps, modern and traditional beehives, and dairy equipment. Capital cost also includes interest paid on borrowings. Materials cost includes the yearly expenditure on farm tools, farm inputs (pesticides, fertilizer, seeds), consumer goods (sugar, coffee, salt, flour, oil, milk), livestock and feed, and transport in 2016. Sales refers to the revenue from the resale of the above mentioned farm inputs, farm tools, consumer goods, merchandise, livestock and livestock products, and natural resource products, such as grass, seedlings, and trees in 2016.

For MPC, the price of labor was calculated as the ratio of total monthly payroll to total monthly number of hours worked. In cooperatives other than MPC, work is done by members themselves. As there were no paid employees (except guards in some cases), no salaries and

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3 ETB is the Ethiopian currency: 1 ETB ≈ 0.04 USD at the time of the study.
wages were paid by LDC, BKC and NRC. To avoid potential bias due to neglecting labor, we imputed labor (opportunity) cost for the cooperatives with missing payroll based on the number of their active members and the labor price calculated for MPC. The price of materials was calculated as the average of the ratio of total yearly cost to total yearly quantity of each item in the materials category. For example, we calculate the unit cost of fertilizer by dividing the yearly amount of money spent on fertilizer by the yearly number of quintals of fertilizer purchased. This procedure was repeated for each item in the materials category, and the average of the unit costs of all the items was calculated to get the unit price of materials, on average. Theoretically, the price of capital is determined as the sum of the depreciation rate and the interest rate (Pindyck and Rubinfeld, 2001). Due to lack of data on depreciation costs, price of capital is proxied by the interest rate, which varies among cooperatives based on the source and purpose of the loan. Labor (lcost), capital (kcost), and materials (mcost) cost shares are calculated as the proportion of the cost of each input in total cost.

Table 1 presents descriptive statistics of the variables used in the cost estimation. The average cooperative was found to spend close to 1.1 million ETB per year to supply farm inputs, farm tools, consumer goods, etc. to members and nonmembers; especially MPC are not allowed to discriminate between members and nonmembers. The very high standard deviation (S.D=4964) of total cost indicates a considerable scale difference among cooperatives: cooperative size ranges from 4 to 2550 members. Average sales are 0.72 million ETB per year; average prices of labor, capital, and materials are 2.17 ETB per hour, 10.29 ETB per 100 ETB of capital per year, and 1169 ETB per unit, respectively. Capital costs take about 45% of the total cost while labor and materials account for 8% and 47%, respectively.
The variance of the price of materials is very high, which probably relates to the fact that the data are derived from very diverse cooperatives in a rather large area and that heterogeneous items are included under materials. Table A1 (online appendix) highlights the link between membership size and different cost items for each cooperative type, pointing to a rather mixed relation between size and cost. In the cost analysis, membership size is fixed, such that costs per member rather than total costs give better insights on size-cost relations. Except for two cases in MPC and one in LDC and NRC, per-unit costs (C/N, lcost/N, kcost/N, and mcost/N) tend to decrease with cooperative size. Moreover, the per-unit costs indicate that keeping the number of members constant at two, the sum of the costs of the two smaller cooperatives is larger than twice the cost of the large cooperative\(^4\), indicating the cost efficiency of relatively large cooperatives.

4.2. Econometric results

Table 2 presents the results of three models: Model 1 reports the estimates of a joint regression of equations (7) to (10), allowing for flexible technology; Model 2 reports the estimates for a common-technology model; and Model 3 reports the estimates of separate regressions for each cooperative type, allowing for type-specific technologies. To get more efficient parameters, we estimate the cost functions and cost share equations (except mcost) as a system using the iterated SUR technique (Zellner, 1962). All variables are standardized such that the first order coefficients of the translog function can be interpreted as elasticities at the sample mean. We perform the standard likelihood ratio test to test hypotheses of a

\(^4\) For example, for NRC the two smaller cooperatives can serve two members at a total cost of about ETB 29 while the larger cooperative can serve the same two members at a total cost of about ETB 11 (=2×5.49).
common technology across all pairs of cooperative types, by imposing equality restrictions across corresponding parameters of the cooperative-specific cost functions (Table 3). The null hypothesis of a common technology is rejected for any pair of cooperative types at the 1% significance level. Moreover, the goodness of fit of Model 1 ($R-sq=0.72$) is better than that of the other models. So, we base our subsequent discussion and conclusions on this model after testing it for linear homogeneity, monotonicity in output and input prices, positivity and concavity.

The linear homogeneity and symmetry constraints were already imposed during estimation. Monotonicity in input prices is satisfied: the fitted input cost shares are positive at each data point. Positivity is satisfied at each data point. Concerning monotonicity in output, there are only about 5% violations. Concavity is not satisfied for only about one-third of the observations, with the highest violation rate in capital inputs followed by labor and materials. A possible explanation for this violation is that a cooperative does not necessarily choose the optimal combination of inputs if factor prices change, e.g., due to borrowing constraints (Ogawa, 2011). Moreover, concavity will be violated if an input is quasi-fixed and a cooperative incurs additional adjustment costs in changing input levels. This may explain the highest rate of violation for the capital input. Imposing concavity either globally or locally may not solve the problem, because such an approach is based on the implicit assumption that all cooperatives in the sample are minimizing production costs, and that inputs can be adjusted flexibly. If some cooperatives are not able to minimize production costs, imposing concavity conditions on the cost function yields inconsistent estimates of the parameters (Ogawa, 2011).
Some coefficients of the prices of labor and capital are negative, which is not consistent with the property of a cost function, and might relate to multicollinearity problems (Filippini, 1996). Variance inflation factors (VIF) suggest that there are multicollinearity problems for the price of labor in Model 1 for LDC (VIF=51.17) and BKC (VIF=61.55), and in Model 3 for BKC (VIF=50.84); and for the price of capital in Model 1 for NRC (VIF=16.23). A possible cause relates to the difficulty in calculating the labor and capital variables and their prices. Consistent with the rejection of the common technology assumption, parameters in Model 1 are similar to parameters in Model 3, except for MPC. This could relate to the large number of MPC in the sample (n=179) and in the pooled Model 2. We find that a 1% increase in output increases cost by 0.51, 0.65, 0.19, and 0.23% for MPC, LDC, BKC, and NRC, respectively, implying that cost is most elastic with respect to output for LDC, and least for BKC. Returns to scale at the sample mean for each technology are given in Table 4. All models point to evidence of increasing returns to scale (IRS). Except for LDC, the degree of scale economies under Models 1 and 3 are closer to each other than those under Models 1 and 2.

The larger-than-unity values of returns to scale imply that the typical cooperative operates under IRS. In a competitive market, IRS lead to economies of scale (Gelles and Mitchell, 1996). However, if a cooperative is so large that its input purchase drives unit prices up, it could have diseconomies of scale even under IRS. Conversely, if the cooperative is able to get bulk discounts on its input purchase, it could have economies of scale even under

---

5 For LDC about 67% and for BKC and NRC about 60% of Model 1 parameters are more similar to those of Model 3. For MPC only close to 27% of Model 1 parameters are more similar to Model 3 parameters.

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decreasing returns in production. Since IRS are not a necessary condition for economies of scale (Bell, 1988), the effect of returns to scale on cost efficiency of cooperatives depends on the nature of the market.

4.3. Estimation of degree of cost subadditivity (dCS)

Using the parameters of the cost functions, we estimate the fitted costs of the \textit{N-coop}, \textit{M-coop}, and \textit{R-coop} and calculate \(dCS\) for each cooperative based on equation (4). A negative \(dCS\) suggests that a larger cooperative is more cost-efficient than two smaller cooperatives. Table 5 reports the estimated \(dCS\) for each cooperative type derived from alternative models. Findings show that there are cost savings from a joint action in larger cooperatives. All observations and all cooperative types show single cooperative costs to be lower than the sum of two cooperative costs, given the same membership size and level of service (see Table A2, online appendix, for a detailed cost comparison). A single larger cooperative is more cost efficient in providing a given level of service to farmers than two or more smaller cooperatives. This implies that cooperatives in the study area are too small to exhaust scale economies. A possible reason relates to the membership base of cooperatives being limited to a specific district or \textit{tabia}.

Estimates of Model 1 show that a given number of farmers would realize a cost advantage of 78 to 181\% if organized in a single larger rather than in two smaller cooperatives. Mainly due to regulation and/or limited demand, the sampled cooperatives have no market power. The evidence for IRS suggests that economies of scale likely underlie the cost efficiency of larger cooperatives. Moreover, larger cooperatives can exercise bargaining

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power in accessing farm inputs, tools and credit; limit transaction costs; and spread fixed costs, such as management costs over more items. The presence of scale economies implies that smaller cooperatives are not competitive and would be driven out of the market if government support and regulation would be removed and market competition would prevail (Wheelock and Wilson, 2011). Competitive pressure among cooperatives and from other types of enterprises is likely to encourage further growth in cooperative size (Wheelock and Wilson, 2011). This implies there are economic incentives for farmers to organize in relatively large rather than small cooperatives, and in small cooperatives rather than taking unilateral actions. Yet, economies of scale have limits and policies regarding cooperative size should be cautious of not exceeding the optimal size.

On average, cost drops by 117% (Model 1) in the single-cooperative as compared to the two-cooperative scenario. That is, a level of service that a single larger cooperative can provide at a cost of ETB 1.00 would be provided by two smaller cooperatives at a cost of ETB 2.17. Findings focus on the cost advantages at cooperative level. But we argue that members of larger cooperatives are better off than members of smaller cooperatives because providing services at a minimum cost is consistent with members’ welfare maximization (Park and Meyer, 1994). Economies of scale likely underlie the subadditivity of the cost function of the cooperatives. However, insights from Joskow (2007) suggest that it may be less costly for an output to be provided by a single cooperative rather than multiple cooperatives even if the output of the single cooperative has expanded beyond the area of economies of scale. A cost function can be subadditive beyond the point where economies of scale are exhausted, until demand is large enough to add a second cooperative. This may be

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because the market demand is not large enough to support efficient service provision by two cooperatives. Though coordination costs increase with cooperative size, the cost efficiency of larger cooperatives implies that the typical cooperative has not reached the size beyond which an increase in coordination costs counterbalances the gains from economies of scale. The conclusion is that in the study area, with the current size of cooperatives, positive effects of membership expansion outweigh the negative ones. It is more cost efficient to increase the size of existing cooperatives than to establish new cooperatives or split up existing ones.

Another insight from the findings is that cost savings decrease with cooperative size. Table 6 presents the correlation between cooperative size and the absolute value of percentage cost savings within and across cooperative types. The negative correlation coefficients imply that percentage cost savings decrease with cooperative size. However, the absolute magnitude of the cost savings of smaller cooperatives may be lower or higher than that of larger cooperatives, depending on the actual cost of service provision. The relationship between cost savings and size can be extended to size differentials across cooperative types. Though not statistically strong, the negative correlation coefficients across cooperative types also suggest a negative relationship between cost savings and size.

Generally, there is a negative correlation between size and potential efficiency gains from scale across all cooperative types. For example, MPC have the largest membership size and the lowest percentage cost savings, which suggests that these cooperatives are closest to an efficient scale and that there is not much gain from increasing membership size. This is an indication that larger cooperatives are operating at a more efficient scale than smaller ones. Therefore mergers and/or open membership policies would be cost-reducing. This can be
extended to argue in favor of cooperation rather than unilateral action. Farmers are better off working together than alone because unilateral actions are likely to be less cost-efficient than joint actions under any cooperative size. This explains the presence of economic incentives for collective action via cooperatives. When cost is subadditive, cooperative formation and membership expansion are beneficial. Our conclusions can be related to studies that use the same approach in different industries. For example, Evans and Heckman (1984) reject the hypothesis that the U.S bell system's cost function is subadditive at the output levels produced, and support its decentralization (split) into smaller specialized systems. Sanchez (2000) rejects cost subadditivity for larger railway companies, suggesting that separate supply of freight and passenger transportation by two independent companies is more efficient than supply of both by a single firm. For smaller companies, results support the hypothesis of subadditive cost, implying that freight and passenger transport by a single railway company is more cost-efficient. Our results contradict some earlier results that smaller agricultural cooperatives perform better. Divergent results can be explained by heterogeneity of regions, cooperatives and samples and different measures of size and performance (Kyriakopoulos et al., 2004; Guzmán and Arcas, 2008; Arcas et al., 2011).

4.4. Implications for cooperative stability

Cost subadditivity is a necessary but not a sufficient condition for a cooperative to be stable and does not guarantee that members will continue to cooperate. Each individual member's share of the joint gain must be larger than the gain they could achieve by operating in a smaller cooperative or independently. The cost advantage of a larger cooperative must be
allocated in such a way that all members have an incentive to remain in the cooperative. There may be different ways to do this but failure to choose an allocation that gives members a benefit that is larger than what they can get somewhere else puts the stability of the cooperative at risk. A stable allocation that gives everyone an incentive to stay in the cooperative might be more difficult if members are more heterogeneous.

On the other hand, some factors may deter membership defection. Members may simply continue their cooperative affiliation because they do not precisely know the benefits from alternative options, which forces the bargaining process to take place in an atmosphere of uncertainty. As Staatz (1983) argues, uncertainty about what is in one's best interest may reduce defection from the cooperative. In the study area, information on costs and benefits of external opportunities is not well established. Cooperatives are often not demand-driven but established by donors or the government to combat youth unemployment or distribute farm inputs, without taking into account the interests and preferences of members. This leads to lack of commitment and problems of defection.

5. Conclusion

This study empirically investigates the cost structure of agricultural cooperatives in Ethiopia. Specifically, it examines whether the sector provides incentives for cooperation by testing for the condition of cost subadditivity. The sampled cooperatives were found to exhibit cost subadditivity in service delivery to members. Given the scale benefits reflected by the subadditive cost function, larger cooperatives are likely to avail services to their members at a lower cost than would smaller cooperatives or unilateral actions do. Findings suggest that splitting up cooperatives results in cost disadvantages. Collective action in larger
 cooperatives can help farmers to reap more economies of scale in the sector. Therefore, policies favoring fewer but larger agricultural cooperatives would be beneficial in Tigray, while the current one-cooperative-per-neighborhood kind of approach is cost inefficient.

Some caution is needed finally. First, the test for the condition of cost subadditivity is a local test done by splitting the observed output of each cooperative into two hypothetical components. Further tests of the condition using different hypothetical outputs could result in more conclusive evidence. Second, though findings support the assertion that in agriculture, collective action (via larger cooperatives) is beneficial in terms of cost savings, policies towards cooperative mergers should pay attention to managerial issues as well. The scale benefits to be reaped from larger cooperatives are conditional on technical and human skills to be at least as good as what the currently existing cooperatives have. Otherwise, managerial inefficiencies in larger cooperatives might nullify the benefits of potential scale efficiencies.

Acknowledgement

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Table 1: Descriptive statistics of variables

<table>
<thead>
<tr>
<th>Variable</th>
<th>Definition (unit)</th>
<th>Mean (S.D)</th>
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</thead>
<tbody>
<tr>
<td><strong>Dependent variables</strong></td>
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<td></td>
</tr>
<tr>
<td>$C$</td>
<td>Yearly total cost of service provision of the $N$-coop* (1000 ETB)</td>
<td>1121.97 (4964.34)</td>
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<tr>
<td>$l_{share}$</td>
<td>Labor cost share: Yearly proportion of labor cost in total cost</td>
<td>0.08 (0.13)</td>
</tr>
<tr>
<td>$k_{share}$</td>
<td>Capital cost share: Yearly proportion of capital cost in total cost</td>
<td>0.45 (0.31)</td>
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<tr>
<td>$m_{share}$</td>
<td>Materials cost share: Yearly proportion of materials cost in total cost</td>
<td>0.47 (4.53)</td>
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<tr>
<td><strong>Independent variables</strong></td>
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<tr>
<td>$q$</td>
<td>Yearly total sales of the $N$-coop (1000 ETB)</td>
<td>721.78 (1613.83)</td>
</tr>
<tr>
<td>$p_l$</td>
<td>Price of labor (ETB/hour)</td>
<td>2.17 (1.18)</td>
</tr>
<tr>
<td>$p_k$</td>
<td>Price of capital (ETB/100-ETB-worth capital/year)</td>
<td>10.29 (2.50)</td>
</tr>
<tr>
<td>$p_m$</td>
<td>Price of materials (ETB/unit)</td>
<td>1169.62 (3606.33)</td>
</tr>
<tr>
<td>$N$</td>
<td>Number of members of the $N$-coop</td>
<td>413.05 (564.67)</td>
</tr>
<tr>
<td>$M$</td>
<td>Number of members of $M$-coop</td>
<td>10.65 (7.19)</td>
</tr>
<tr>
<td>$q_m$</td>
<td>Yearly total sales of the $M$-coop (1000 ETB)</td>
<td>2.34 (3.43)</td>
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<tr>
<td>$R = N - M$</td>
<td>Number of members of hypothetical $R$-coop</td>
<td>373.69 (548.28)</td>
</tr>
<tr>
<td>$q_r = q - q_m$</td>
<td>Yearly total sales of the $R$-coop (1000 ETB)</td>
<td>680.98 (1569.75)</td>
</tr>
</tbody>
</table>
*N-coop* is the larger cooperative with at least twice the minimum membership size (\(N\)) observed in the sample; *M-coop* is the smaller cooperative with the minimum number of members (\(M\)) observed in the sample; *R-coop* is the hypothetical complementary cooperative with the residual (\(R=N-M\)) number of members. (Source: Field survey and own calculations)

Table 2: Parameter estimates of the translog cost functions

<table>
<thead>
<tr>
<th>Variable</th>
<th>(m/\ell)</th>
<th>(b/r)</th>
<th>(\ln q)</th>
<th>(\ln p_l)</th>
<th>(\ln p_k)</th>
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<td>BKC</td>
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<td>(m/\ell)</td>
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<tr>
<td>(b/r)</td>
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<td>0.725**</td>
<td>1.034**</td>
<td>1.232**</td>
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<td>(0.224)</td>
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<tr>
<td>(\ln q)</td>
<td>0.514**</td>
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<td>0.188</td>
<td>0.232**</td>
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<td>(0.099)</td>
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<th>ln$p_m$</th>
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<th>ln$q(lnp_m)$</th>
<th>ln$p_l(lnp_l)$</th>
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<td>NRC</td>
<td>BKC</td>
<td>NRC</td>
<td>NRC</td>
</tr>
<tr>
<td>Chi2</td>
<td>193.89</td>
<td>50.49</td>
<td>88.48</td>
<td>91.47</td>
<td>56.76</td>
<td>65.77</td>
</tr>
<tr>
<td>df</td>
<td>34</td>
<td>11</td>
<td>12</td>
<td>11</td>
<td>12</td>
<td>11</td>
</tr>
<tr>
<td>p</td>
<td>0.000</td>
<td>0.000</td>
<td>0.000</td>
<td>0.000</td>
<td>0.000</td>
<td>0.000</td>
</tr>
</tbody>
</table>

MPC = Multipurpose cooperatives, LDC = Livestock & dairy cooperatives; BKC = Beekeeping cooperatives; NRC = Natural resources cooperatives. Standard errors are reported in parentheses. ln stands for natural logarithm. Models 1, 2, and 3 represent flexible technology, common technology, and cooperative-type-specific regression models, respectively. Significance levels are reported as *** $p<0.01$, ** $p<0.05$, * $p<0.1$. 

**Table 3: Test on common technology across cooperative types**
Table 4: Returns to scale at sample means by technology and cooperative type

<table>
<thead>
<tr>
<th>Cooperative category</th>
<th>MPC</th>
<th>LDC</th>
<th>BKC</th>
<th>NRC</th>
</tr>
</thead>
<tbody>
<tr>
<td>Model 1: Flexible technology</td>
<td>1.95</td>
<td>1.53</td>
<td>5.32</td>
<td>4.31</td>
</tr>
<tr>
<td>Model 2: Common technology</td>
<td>2.44</td>
<td>2.44</td>
<td>2.44</td>
<td>2.44</td>
</tr>
<tr>
<td>Model 3: Separate regressions</td>
<td>1.81</td>
<td>2.14</td>
<td>3.27</td>
<td>13.16</td>
</tr>
</tbody>
</table>

MPC = Multipurpose cooperatives, LDC = Livestock & diary cooperatives; BKC = Beekeeping cooperatives; NRC = Natural resources cooperatives.

Table 5: Estimated degree of cost subadditivity ($dCS$) by technology and cooperative type

<table>
<thead>
<tr>
<th>Cooperative category</th>
<th>All</th>
<th>MPC</th>
<th>LDC</th>
<th>BKC</th>
<th>NRC</th>
</tr>
</thead>
<tbody>
<tr>
<td>Model 1: Flexible technology</td>
<td>-1.17</td>
<td>-0.78</td>
<td>-1.37</td>
<td>-1.18</td>
<td>-1.81</td>
</tr>
<tr>
<td></td>
<td>(0.86)</td>
<td>(0.97)</td>
<td>(1.04)</td>
<td>(0.13)</td>
<td>(0.57)</td>
</tr>
<tr>
<td>Model 2: Common technology</td>
<td>-0.92</td>
<td>-0.68</td>
<td>-1.13</td>
<td>-1.08</td>
<td>-1.10</td>
</tr>
</tbody>
</table>

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Model 3: Separate regressions

<table>
<thead>
<tr>
<th>Cooperative type</th>
<th>Model 1</th>
<th>Model 2</th>
<th>Model 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Across All</td>
<td>0.58***</td>
<td>0.75***</td>
<td>0.75***</td>
</tr>
<tr>
<td>Within MPC</td>
<td>0.44***</td>
<td>0.65***</td>
<td>0.47***</td>
</tr>
<tr>
<td>LDC</td>
<td>-0.19</td>
<td>-0.35**</td>
<td>-0.36**</td>
</tr>
<tr>
<td>BKC</td>
<td>0.69***</td>
<td>0.31***</td>
<td>0.67***</td>
</tr>
<tr>
<td>NRC</td>
<td>0.66***</td>
<td>0.70***</td>
<td>0.83***</td>
</tr>
</tbody>
</table>

MPC = Multipurpose cooperatives, LDC = Livestock & dairy cooperatives; BKC = Beekeeping cooperatives; NRC = Natural resources cooperatives. Models 1, 2, and 3 represent flexible technology, common technology, and cooperative-type-specific regression models, respectively. Significance levels are reported as *** p<0.01, ** p<0.05, * p<0.1.