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The Hidden Impact of Cooperative Membership on Quality Management: A Case Study from the Dairy Belt of Addis Ababa

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ABSTRACT

During the last decade Ethiopia has been witnessing a return to agricultural cooperatives as means to unleash the national agri-food market. Using primary bio-economic data from Ethiopia, this study evaluates the impact of cooperative membership on milk production, productivity, quality and safety. To do so we compare the performance of cooperative and individual milk farmers sampled from the dairy belt of Addis Ababa. We use both instrumental variable regression and propensity score matching methods to control for pre-existing differences between the two groups of farmers and isolate the "cooperative impact". Findings are consistent across the two methods in suggesting that cooperative membership has a positive impact on milk production and productivity, no significant effect on milk hygiene and a negative impact on milk quality. The study concludes with implications for policy and for further research.

KEY-WORDS

ETHIOPIA, MILK, COOPERATIVES, IMPACT, INSTRUMENTAL VARIABLE REGRESSION, PROPENSITY SCORE MATCHING.

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1. Introduction

Although Ethiopia has favorable ecological conditions for agricultural production, malnutrition and rural poverty are still widespread.[1] The increase in global food prices observed since 2008 represents both an opportunity and a desperate call to unleash the agricultural potential of Ethiopia. This perception has induced the Ethiopian government to return to agricultural cooperatives as a means to link farmers to emerging urban markets (see Francesconi et al. 2010; Francesconi and Heerink 2010). Similar trends are observed in many other developing countries around the world (World Bank 2007). A mainstream argument is that collective action can simultaneously reduce transaction costs and improve the bargaining power of smallholder farmers vis-à-vis the market (Bonin et al. 1993; Munckner 1988; Dulfer 1974). Based on similar arguments, Ethiopian policy makers have been actively promoting the formation of agricultural cooperatives since the beginning of the new millennium (Bernard et al. 2008).

As far as dairy production is concerned, previous studies in Ethiopia (D'Haese et al. 2006; Ahmed et al. 2003; Holloway et al. 2000; Nicholson 1997) suggest that farmers' participation in dairy cooperatives results in a significant increase in milk production and productivity. The objective of this study is to further test the latter hypothesis, as well as to highlight additional undocumented impacts related to the formation of dairy cooperatives in Ethiopia. In particular, we argue that changes in production technology, if any, might be associated with simultaneous changes in product quality. In other words, participation in dairy cooperatives is expected to induce modifications also in the quality attributes of the milk produced by Ethiopian farmers, with important implications for the well-being of Ethiopian consumers.

Milk is a potential key source of energy, essential amino acids and micronutrients, particularly needed in less-developed countries, where diets are mainly based on staple grains or root crops (Fitzhugh 1999). Yet, milk is a perishable product and thus a potential source of food poisoning and diarrhoeal diseases, which are major causes of illness and death in developing countries (O'Connor 1995). It is thus important that efforts aiming to increase milk production and productivity in Ethiopia pay further attention to on-farm quality management. In other words, it is important to re-align production and productivity objectives with nutritional and health outcomes, as increasingly pointed out by food security experts (Hawkes and Ruel 2006). It is important to do so not only for ethical reasons, but also from an economic point of view, since commercialization depends on buyer satisfaction (Weaver and Kim 2001).

Therefore, this study aims to fill this knowledge gap through the incorporation of milk quality indicators in the following analysis of the impact generated by a major Ethiopian dairy cooperative organization on farmers' performance. The remainder of this paper is structured as follows: section two presents some background information about the area and the dairy cooperative under analysis; section three describes the survey techniques; section four defines the data and analytical methods used to control for intrinsic differences between cooperative farmers and neighbouring individual farmers, in order to isolate the impact of cooperative membership; section five presents the findings and section six discusses them and derives implications for policy and further research.

[1] http://data.worldbank.org/topic/poverty; http://data.worldbank.org/topic/health

2. Organizational Setting

According to Ethiopian proclamation number 85 from 1994, cooperatives are defined as "associations established by individuals on a voluntary basis, to collectively solve economic and social problems and to democratically manage them". In order to achieve legal recognition Ethiopian cooperatives cannot have less than ten members and must enforce internal democracy based on the principle of one member one vote. Compared to the previous generation of cooperative, which proliferated in the former century under the highly centralized Derg regime, nowadays the definition and distribution of property rights in agricultural cooperatives have been almost completely deregulated (proclamation number 147 from 1998).

According to the current law, any individual has the right to join a cooperative organization, as long as he/she can afford to pay the entrance fee, and to purchase at least one share of the collective endowment. Fees and shares are set on the basis of regular evaluations made by the board and approved by the majority of members. Shares are redeemable, i.e. the cooperative buys members out when these decide to quit, but cannot be traded, not even internally (among members). Furthermore, a fixed percentage (10 percent) of members' revenues, generated by selling milk through the cooperative, is retained by the cooperative itself to build up equity capital and cover running costs.

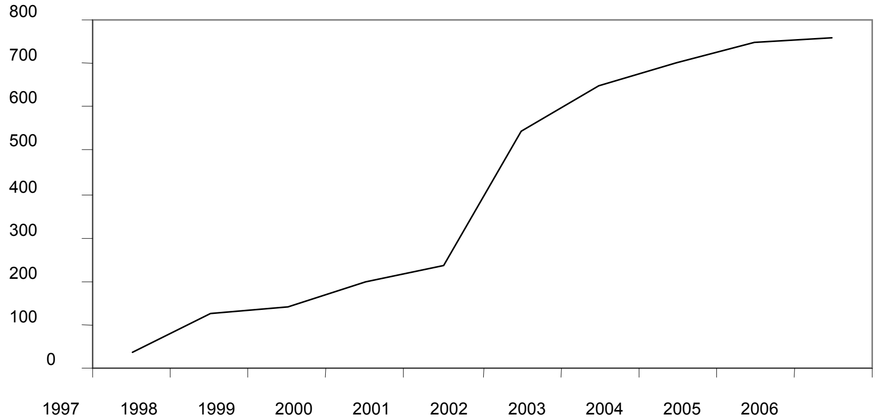
The cooperative selected for this study is located in and around Debre Zeit, a town of approximately 40,000 people located 50 km south of the capital, Addis Ababa. In addition to the cooperative and its 800 members (the biggest dairy cooperative of Ethiopia), this area comprises more than 1000 independent small dairy farmers (according to the Ministry of Agriculture), three large commercial dairy farms, two dairy processing plants, and the experimental dairy unit of the International Livestock Research Institute (ILRI). Overall the area of Debre Zeit represents the most important milk-shed of Ethiopia, a key source of milk and dairy products for the capital Addis Ababa.

The milk-shed of Debre Zeit is located on the border of the central Ethiopian plateau and the Rift Valley, at an altitude of approximately 1600 meters above sea level. Biophysical attributes, like the availability of vast grazing areas, mild slopes, temperate climate (0-30°C), and abundant rainfalls (1000-1900 mm/year) offer a relatively disease-free environment with high potential for animal feeding and for the use of high-yielding dairy cows (Ahmed et al. 2003). Besides production potential, the milk shed of Debre Zeit is also witnessing increasing opportunities at the market of Addis Ababa, where dairy industries and supermarkets are rapidly growing (see Francesconi et al. 2010).

According to primary and secondary (Tegegne 2003) information, the Ada'a Liben Woreda Dairy and Dairy Products Marketing Association was established in Debre Zeit in 1997-98 by 34 retired officers of the national Air Force (also located in Debre Zeit). Since its establishment, the number of cooperative members has increased considerably to almost 800 (Figure 1). Such a rapid growth in the number of members depends on several factors, including access to state subsidies, facilitated credit, and international donations. Although today the cooperative includes a large and heterogeneous group of farmers, executive power has remained strongly in the hands of the military clan that established it. The current manager of the cooperative is an ex-colonel of the Ethiopian air-force with a Masters degree in business administration, and the cooperative board is dominated by ex-officers of the same air-force batallion.

The cooperative has a federated structure based on 11 collection centres placed in strategic sites in and around the town of Debre Zeit. On a daily basis, cooperative farmers deliver whole raw milk to these centres, share information, and procure inputs. Like most dairy cooperatives in Ethiopia, this cooperative represents a preferential channel for dairy farmers to procure subsidized artificial insemination and high yielding cows.

Figure 1: Growth in membership, Ada'a Liben Woreda Dairy and Dairy Products Marketing Association



Output services involve quality control, milk collection and bulking, cooling and processing, transportation and commercialisation. All these activities are undertaken twice a day, seven days a week. Before collection, all milk supplies (which come only from coop-members) are screened using instantaneous tests (alcohol test and specific gravity test), which measure milk quality as good or bad, but do not provide continuous grading.[2] Milk supplies that do not comply with the standards set by these tests are meant to be rejected, even if the rejection rate appears to be negligible. Approved milk supplies are weighted, recorded and bulked.

Approximately 50 percent of the milk collected by the cooperative is sold from the collection centres directly to local consumers, without undergoing any cooling process. Most of this is sold in the form of crude milk, without undergoing any other heat treatment or packaging process, the rest is transformed into cottage cheese (ayb), sour milk (ergo) and fermented butter (kebe').

The other half of the milk supply is immediately transported (without cooling facilities, and at the expense of the cooperative) and transferred to manufacturing firms upon compliance with industrial quality standards and other written or verbal agreements. It is important to note that the quality standards set by the industry are usually low and flexible since the supply of milk is usually insufficient to satisfy industrial demand. These industrial firms produce pasteurised and packed products such as whole, partially skimmed, and skimmed milk, butter, cottage and cheddar cheese, yoghurt, etc., which are then distributed to supermarkets, and to a lesser extent to kiosks and specialised dairy shops in Addis Ababa. Interestingly, the price of milk in the area of Debre Zeit appears to be lower, almost half of the milk price observed in the rest of the country, especially where no cooperatives are found (Francesconi 2007). Finally, it should be mentioned that at the time of this survey no national grades and standards were applied to monitor

[2] The alcohol test is a low cost, instantaneous technique to evaluate the status of the milk colloidal suspension. When one part of alcohol is added to one part of milk with major alterations in the colloidal suspension, the solution precipitates, indicating that the milk is old or contaminated (O'Connor 1995). The specific gravity test is a low cost, instantaneous technique to compute milk density, given milk temperature (O'Connor 1995). This test makes use of a floating device and a thermometer, and allows one to infer about major variations in fat and protein content, in particular those associated with water addition and/or cream removal.

and regulate Ethiopian dairy cooperatives and supply chains. Ethiopia's Quality and Standard Authority (EQSA) has defined a set of grades and standards for milk but it does not have the means and capacity to enforce them. This is because the resources available to public institutions for food inspection, certification and auditing are not sufficient to ensure adequate quality control along dairy supply chains. In a similar vein, private, third party certification schemes were not found in Ethiopia's dairy supply chain at the time in which this study took place.

3. Survey

The sample of farm households used in this study includes 50 cooperative farmers and 50 individual farmers, all located within the woreda (i.e. municipality) of Debre Zeit. Each farmer was interviewed using a structured questionnaire regarding farm-household characteristics and performance. Two samples of milk were also collected from each farmer, and subsequently analysed using classic chemical and microbiological lab-tests. The available dataset provides a unique combination of biological, technological and socio-economic information about dairy farming in Ethiopia.

Out of the total sample of 100 farmers, 20 cooperative farmers and 20 individual farmers were randomly selected (on the basis of a list provided by the Ministry of Agriculture) and interviewed in July-August 2003. The sampling area included the urban as well as the rural areas of Debre Zeit. Both areas included both coop-members and individual farmers, even if in different proportions.

In order to expand the number of observations we then conducted a second survey round in 2006. Due to difficulties in tracing the same farmers interviewed in 2003 (some quit the cooperative, others died or stopped producing milk, etc.), 30 cooperative farmers and 30 individual farmers were again randomly selected from the original list and sampling areas considered in 2003. This second survey was also conducted between July and August in order to minimize seasonality effects. It is also important to note that this second survey was conducted using the same enumerators, identical questionnaires and milk sampling procedures as in the first survey.[3] Finally, all milk samples collected during the two surveys were analysed in the laboratory of ILRI Debre Zeit, by the same technicians, using consistent grades and standards.[4]

4. Material and Methods

The first step in impact analysis is to select appropriate impact indicators. In particular, this study defines four indicators referring to milk production, productivity, nutritional value and hygiene:

a) Milk production is measured as the average quantity (litres) of milk produced by a farm, on a daily basis, over the last 12 months.

[3] In both surveys (2003-2006), milk samples were gathered and analysed within a one-month period, so as to reduce the influence of climate variations. Sampling steps: sanitize the equipment (planger and diper) with running water, and operator hands with alcohol (70 percent); stir milk bulk; collect a milk sample and pour it into a sterile container properly labeled; immediately store the sample in an icebox (0-4° C).

[4] Total Bacteria Count (Standard Plate Agar), Milk Fat Content (Gerber method), and Milk Protein Content (Protein Formaldehyde Titration).

b) Milk productivity is measured as the ratio between milk production and the number of milking cows available per farm. Given that the average farm in our sample has 2.1 milking cows, with average cooperative herds of 2.7 cows and average individual farms (non cooperative members) owning 1.5 cows.
c) Milk nutritional value is measured on the basis of standard laboratory grades indicating fat and protein content (i.e. percentage of fat and protein in milk collected at the farm gate).[5]
d) Milk hygiene is measured on the basis of standard laboratory grades indicating total bacteria count (i.e. the number of bacterial colonies per unit of milk, in milk collected at the farm gate).[6]

Given these four performance indicators, the objective of this study is to compute the average treatment effect on the treated (ATT), i.e. the impact of cooperative membership on the performance of cooperative farmers. As posed by Ravallion (2001) and Godtland et al. (2004) the empirical problem we face is the typical absence of data concerning the counter-factual: how would the performance of cooperative farmers have been if these farmers had not joined the cooperative? Our challenge is to identify a suitable comparison group of non-cooperative farmers whose performance - on average - provides an unbiased estimate of the performance that cooperative members would have had in the absence of the cooperative. However, due to farmer self-selection and the characteristics of the sample available (cooperative and individual farmers were sampled from the same area), there are three potential sources of bias in comparing performances of cooperative and individual farmers.

The first source of bias is related to diffusion or spill-over effects across cooperative and individual farmers. In particular, since the two groups of farmers were selected from the same woreda (i.e. municipality), the comparison of these two groups is likely to underestimate the cooperative's impact. Since diffusion bias cannot be controlled for or measured when target and control farmers come from the same area, as in this case, all we can do is to openly acknowledge the likely presence of diffusion bias, as well as the possibility that our findings will underestimate cooperative's impact (whether this is positive or negative).

The second and third sources of bias are related to selection on observable and unobservable farm household characteristics. Given farmer self-selection in the cooperative, a simple comparison of performance indicators between participants and non-participants (naïve analysis) would yield biased estimates of cooperative impact. Coop-members are likely to differ from individual farmers in the distribution of observable (such as age, education, household composition, etc.) and unobservable characteristics (e.g. farmer ability and motivation). These differences must be taken into account in comparing the two groups, since they might have an influence on performance even in the absence of the cooperative.

Following Bernard et al. (2008) and Godtland, the observable characteristics included in this analytical model are: the level of formal education (in years) and the age (in years) of the household member responsible for dairy production; household size; and the percentage of children (below 14 years old) and women in the household. Figures 2a-e show that even if there are differences in the distribution of observable characteristics across cooperative and individual farmers, a common support (area where box-plots overlap) is observed between the two groups, for each and every characteristic. This provides the basic conditions to justify the use of individual farmers as control group, given the variables observed.

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[5] Milk is a complex emulsion with high density of nutritients (Walstra 2006). Variability among milk components is largely inter-dependent, but the widest variations occur in fat and protein content (gr/ml), making these the two most common indices used for the quantitative evaluation of milk nutritional value (O'Connor 1995).

[6] Milk is an ideal terrain for bacterial growth, condition that makes total bacteria count (TBC, measured in CFU/ml) a widely used test for the quantitative evaluation of general milk hygiene (O'Connor 1995).

In order to control for selection bias due to unobservable characteristics we identified two instrumental variables. The first is a dummy for enrolment in the local military air force. Theoretically this variable is a valuable instrument for farmer ability and motivations since the cooperative was originally established by a group of retired military officers, previously employed by the national air force based in Debre Zeit, who are still in charge of the cooperative's management. Table 1 shows that 42 percent of cooperative households comprise an officer (or ex-officer) of the air force, against the 10 percent of individual farm-households. This suggests that households affiliated with the air force do have more incentives to participate in the cooperative. The second variable is a dummy for rural (equal to one) or urban (equal to zero) location of farm-households. Table 1 shows that 51 percent of individual farms are located in rural areas, as opposed to only eight percent of cooperative farms. Since cooperative centres for milk collection and input distribution are located within or in proximity to the urban area, rural farm households have less incentives

Figure 2a: Education of the household member responsible for dairy (years of schooling)

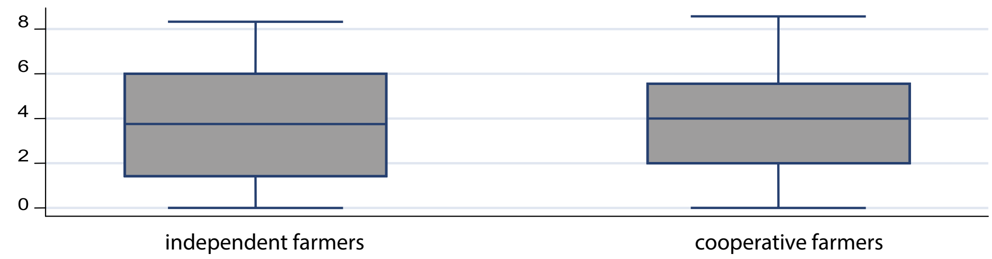
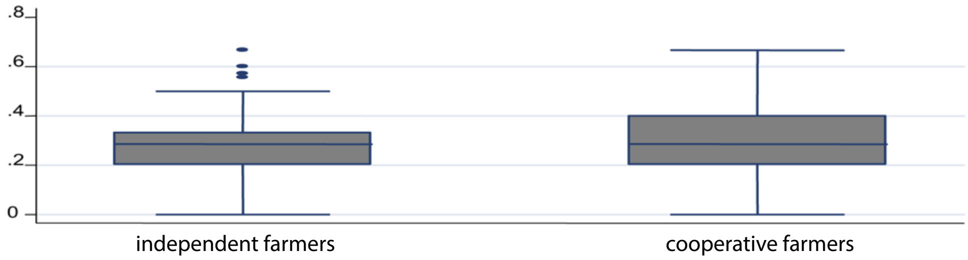


Figure 2b: Age of household member responsible for dairy (in years)

Figure 2c: Household size (number of members sharing the same food-stock)

Figure 2d: Percentage of children < 14 years old in the household

Figure 2e: Percentage of adult females in the household



to join the cooperative.

It is therefore reasonable to assume that military affiliation and urban location provide farmers with strong incentives to join the cooperative. Furthermore, it is reasonable to rule out the possibility that these two factors may simultaneously explain farmers' performance. Although military officers might have received a better education, they are also expected to have little experience or interest in farming. Although urban farming can benefit from better access to modern inputs, rural farmers have better access to pastures and land, which guarantee higher animal welfare (i.e. cows are not constantly kept inside the barn). This justifies, from a theoretical point of view, the use of military affiliation and farm location as instrumental variables, since they are expected to explain cooperative membership but cannot be reasonably expected to explain agricultural performance. The validity of this hypothesis is further tested below using statistical techniques.

Based on the analytical approach specified above, this section presents two distinct techniques for impact assessment: 1) instrumental variable regression (IVREG) and 2) propensity scores matching (PSM). In both cases, the starting point is the estimation of a Probit regression (see Table 2) where both observable and unobservable characteristics are used to explain the household decision to join the cooperative. Table 2 shows that besides military affiliation and rural location, also farmer age and household dependency

Table 1: Military affiliation and rural location, Debre Zeit, 2003/06

Groups\Variables	Military Affiliation				Rural Location			
	Mean	Stand. Dev.	Min.	Max.	Mean	Stand. Dev.	Min.	Max
Cooperative farmers [50 obs.]	0.42	0.50	0	1	0.08	0.27	0	1
Individual farmers [50 obs.]	0.10	0.31	0	1	0.51	0.51	0	1

ratio are significant in explaining membership. In particular the probability of being a member of the cooperative increases with age, up to a certain threshold, after which the relationship turns negative. Further, cooperative membership becomes less likely when the percentage of children in the household increases.

Consequently, the PSM technique involves the estimation of the propensity (or predicted probability) of each household to participate in the cooperative, and the matching of cooperative and non-cooperative households on the basis of similar propensity scores. According to the PSM model, once cooperative farm-households have been matched with otherwise similar individual farm-households, we can proceed in computing average differences in performance indicators (ATT). In order to improve the robustness of the PSM method, we restricted matches to farm households with propensity scores that fell in the area of common support (as defined by Smith and Todd 2000). Consequently, farm households with propensity scores falling outside the common support were dropped and the number of valid observations reduced

Table 2: Probability of cooperative membership (Probit), Debre Zeit, 2003/06 [Tab.1]

Explanatory Variables	Cooperative Membership	
	Probit	Marginal Effects
Dummy for Survey Year (2006=1 & 2003=0)	-0.10(0.30)	-0.04(0.12)
Observable Household Characteristics:		
Farmer Education (years)	0.14(0.09)	0.05(0.04)
Squared term of Farmer Education	-0.00(0.01)	-0.00(0.00)
Farmer Age	0.13(0.07)**	0.05(0.03)**
Squared term of Farmer Age	-0.00(0.00)*	-0.00(0.00)*
Household Size	0.14(0.15)	0.06(0.06)
Squared term of Household Size	-0.01(0.01)	-0.00(0.00)
% of Children (< 14 years old)	-1.25(0.76)*	-0.50(0.30)*
% of Women	-0.98(1.00)	-0.39(0.40)
Unobservable Household Characteristics:		
Dummy for Military Affiliation	0.63(0.39)*	0.25(0.14)*
Dummy for Rural Location	-1.21(0.40)**	-0.44(0.12)**
Pseudo R-squared	0.3132	
Log pseudolikelihood	-46.65	
Correctly Classified Observations	77.55%	
N. of observations	98	

Standard error in parentheses (), *denotes significance at 10% level, **denotes significance at 5% level

[Tab. 1] Note that in order to improve predictions, the probit regression presented in Table 4 (and consequently also correlations in Tables 2 and 3, and instrumental regressions in Tables 6 and 7) are intentionally over-parametrised, using as many variables and quadratic terms as possible. Note also that besides observable and unobservable characteristics, all regressions and correlations include a dummy indicating the year in which households were surveyed (equal to zero for 2003 and one for 2006). This dummy allows to control for eventual inconsistencies between the two surveys.

from 100 to 91 (see Table 3).[7] Statistical robustness of PSM is further supported by the use of two matching techniques (Kernel and Stratification method).[8]

The second step for the IVREG method involves instead an additional regression analysis in which performance indicators are expressed as a function of the predicted probability of cooperative membership and observable characteristics. Unobservable characteristics, captured by military affiliation and rural location, are excluded from this second step since they explain the decision to participate in the cooperative, but do not influence performance, given membership (i.e. they are instrumental variables). While military affiliation has a positive and significant (10 percent level) impact on cooperative membership (Table 2), the correlation between military affiliation and performance indicators is not significant, given cooperative membership (Tables 4 and 5). Similarly, rural location has a negative and significant (5 percent level) effect on membership (Table 2), but no clear correlation with any performance indicators (Tables 4 and 5). This statistical evidence goes in support of the theoretical argument presented above in order to justify the validity of these two instrumental variables.

Table 3: Blocks of propensity scores, Debre Zeit, 2003/06

Propensity Scores' Blocks	Individual	Cooperative	Total
0.045	15	1	16
0.2	7	5	12
0.4	11	12	23
0.6	7	10	17
0.8	2	21	23
Total	42	49	91

Table 4: Correlation between performance and instruments, Debre Zeit, 2003/06

	Production	Productivity
Cooperative Membership	9.56(1.02)**	5.09(0.84)**
Dummy for survey year	0.86(0.97)	0.87(0.59)
Observable Characteristics:		
Farmer Education	0.32(0.25)	-0.12(0.15)
Squared term of Farmer Education	-0.02(0.01)	0.01(0.01)
Farmer Age	-0.10(0.14)	-0.05(0.13)
Squared term of Farmer Age	0.00(0.00)	0.00(0.00)
Household Size	0.44(0.55)	0.05(0.27)
Squared term of Household Size	-0.04(0.04)	-0.01(0.01)
% of Children	1.32(2.11)	0.67(1.13)
% of Women	0.48(3.08)	-1.06(1.88)
Instruments:		
Dummy for Military Affiliation	-1.53(1.18)	-0.30(0.73)
Dummy for Rural Location	-1.64(0.99)	-0.41(0.77)
R-squared	0.6618	0.5309
N. of observations	89	92

Standard error in parentheses (), *denotes significance at 10% level, **denotes significance at 5% level

[7] Note that STATA reports that balancing property is satisfied across the block identifiers of the propensity scores estimated.

[8] Nearest Neighbour and Radius matching methods were not used since they would have discarded observations from an already small sample (Becker and Ichino 2001).

Table 5: Correlation between performance and instruments, Debre Zeit, 2003/06[Tab1]

	Dependent Variables		
	Fat content	Protein content	TBC
Cooperative Membership	-1.59(0.31)**	-0.47(0.10)**	-1.34e+07(7.06e+06)*
Dummy for Survey Year	-0.32(0.24)	-0.12(0.09)	-6.45e+07(7.29e+06)**
Observable Characteristics:			
Farmer Education	-0.01(0.06)	-0.00(0.02)	1.61e+06(2.41e+06)
Squared term of Farmer Education	0.00(0.00)	0.00(0.00)	-1.95e+06(1.39e+05)
Farmer Age	0.06(0.04)	0.02(0.01)	-1.33e+06(1.66e+06)
Squared term of Farmer Age	-0.00(0.00)	-0.00(0.00)	1.15e+04(1.57e+04)
Household Size	0.02(0.08)	-0.01(0.03)	3.21e+06(3.51e+06)
Squared term of Household Size	0.00(0.00)	0.00(0.00)	-1.56e+05(1.54e+05)
% of Children	-1.17(0.65)*	-0.22(0.22)	-5.62e+06(1.71e+07)
% of Women	-2.27(0.72)**	-0.18(0.35)	1.35e+07(2.63e+07)
Instruments:			
Dummy for Military Affiliation	0.17(0.27)	0.02(0.09)	2.07e+06(7.20e+06)
Dummy for Rural Location	0.29(0.30)	0.04(0.11)	-9.44+06(7.82e+06)
R-squared	0.4261	0.2866	0.5583
N. of observations	94	97	98

Standard error in parentheses (), *denotes significance at 10% level, **denotes significance at 5% level

In order to support the robustness of the resulting IVREG model (see Tables 6 and 7) we also performed tests of over-identifying restrictions. In this case, the test has a chi-square distribution with one degree of freedom, since the model includes two instruments and one instrumented variable. Since the test statistics

Table 6: The impact of cooperative membership (IVREG), Debre Zeit, 2003/06

Explanatory Variables	Production	Productivity
Dummy for survey year	0.81(1.00)	0.90(0.57)
Instrumented Variable:		
Cooperative Membership	11.50(1.90)**	5.69(1.21)**
Observable Characteristics:		
Farmer Education	0.19(0.27)	-0.17(0.17)
Squared term of Farmer Education	-0.01(0.01)	0.01(0.01)
Farmer Age	-0.13(0.16)	-0.07(0.15)
Squared term of Farmer Age	0.00(0.00)	0.00(0.00)
Household Size	0.35(0.64)	-0.01(0.26)
Squared term of Household Size	-0.04(0.04)	-0.01(0.01)
% of Children	1.84(2.37)	0.83(1.22)
% of Women	0.49(3.29)	-0.96(1.86)
Instruments:		
Dummy for Military Affiliation	/	/
Dummy for Rural Location	/	/
R-squared	0.64	0.52
N. of observations	89	92
Test of over-identifying restrictions:		
Chi-square (1)	1.84	0.33
p-value	0.18	0.56

Standard error in parentheses (), *denotes significance at 10% level, **denotes significance at 5% level

Table 7: The impact of cooperative membership (IVREG), Debre Zeit, 2003/06

Explanatory Variables	Fat content	Protein content	TBC
Dummy for survey year	-0.32(0.25)	-0.13(0.09)	-6.35e+07(7.67e+06)**
Instrumented Variable:			
Cooperative Membership	-2.00(0.66)**	-0.54(0.24)**	8.95e+06(1.72e+07)
Observable Characteristics:			
Farmer Education	-0.01(0.07)	0.00(0.00)	7.78e+06(2.65e+06)
Squared term of Farmer Education	0.00(0.00)	0.00(0.00)	7.04e+03(1.41e+05)
Farmer Age	0.08(0.05)*	0.02(0.02)	-2.08e+06(1.67e+06)
Squared term of Farmer Age	-0.00(0.00)*	-0.00(0.00)	1.83e+04(1.56e+04)
Household Size	0.03(0.09)	-0.01(0.00)	2.39e+06(3.41e+06)
Squared term of Household Size	0.00(0.00)	0.00(0.00)	-1.28e+05(1.45e+05)
% of Children	-1.28(0.67)*	-0.23(0.23)	7.44e+05(1.94e+07)
% of Women	-2.35(0.75)*	-0.20(0.34)	1.82e+07(2.53e+07)
Instruments:			
Dummy for Military Affiliation	/	/	/
Dummy for Rural Location	/	/	/
R-squared	0.40	0.28	0.51
N. of observations	94	97	98
Test of over-identifying restrictions:			
Chi-square(1)	1.34	0.17	0.13
p-value	0.25	0.68	0.72

Standard error in parentheses (), *denotes significance at 10% level, **denotes significance at 5% level

are consistently smaller than the Chi-square for one degree of freedom at the 5 percent significance level (3.84), we cannot reject the possibility that over-identifying restrictions are zero and therefore that the model is well specified. Finally, it is important to note that we excluded a few influential observations (outliers) from the model; we made sure that all residuals estimated were normally distributed, and we applied robust standard errors to control for heteroskedasticity (detected in all regressions).

5. Results

Cooperative impacts estimated with IVREG and PSM methods are summarized in Table 8 together with the description and naïve comparisons (based on simple t-tests) of production and quality performance of cooperative and individual farmers.

Table 8 shows that the average cooperative farmer produces almost 17 litres of milk per day, with a productivity of eight litres per cow per day. Cooperative milk is characterised by an average 3.6 percent of fat content, 3.0 percent of protein content, and 25 million cfu/ml. On the other hand, the average individual farmer produces 3.5 litres, with a productivity of 2.5 litres, 5.2 percent of fat content, 3.5 percent of protein content, and 31 million cfu/ml.

Table 8 shows also that naïve estimates (based on t-tests estimating the statistical difference of performance indicators between the two groups) do not differ much from the results obtained with PSM and IVREG methods, suggesting that cooperative membership is almost randomly distributed within the sample. Nonetheless, if we exclude the IVREG result for milk production, naïve differences appear slightly but consistently smaller than the differences computed with IVREG and PSM methods. Consistent underestimation, even if small, by naïve analyses suggests that selection bias might indeed be present in the sample. Considering also that none of the estimation methods allow for control for diffusion (or spill-over) bias (a potential source of additional underestimation), the most realistic impact estimates are expected to be the largest ones (in bold in Table 8).

Table 8: The impact of cooperative membership (t-test, PSM, IVREG), Debre Zeit, 2003/06 [Tab.2]

Performance	Cooperative farmers	Individual farmers	Naive (t-test)	ATT Kernel	ATT Stratification	IVREG
Production (lt/farm/day)	16.8(11.1)	3.5(3.3)	13.3[1.7]**	**13.7[1.8]** **	13.6[1.7]**	11.5[1.9]**
Productivity (lt/cow)	8.0(6.1)	2.5(2.5)	5.5[1.0]**	**5.8[1.0]** **	**5.8[1.0]** **	5.7[1.2]**
Fat (%)	3.6(0.6)	5.2(1.8)	-1.5[0.3]**	**-2.0[0.7]** **	-1.8[0.6]**	**-2.0[0.7]** **
Protein (%)	3.0(0.3)	3.5(0.6)	-0.5[0.1]**	-0.5[0.2]**	**-0.6[0.2]** **	-0.5[0.2]**
TBC (cfu/ml)	2.5e+07(4e+07)	3.1e+07(4.4e+07)	-5.4e+06[8.4e+06]	8e+05[8e+06]	2.1e+06[1e+07]	8.9e+06[1.7e+07]

Standard deviation in (), Standard error in []
*denotes significance at 10% level, **denotes significance at 5% level

[Tab. 2] ATT is equal to the outcome of cooperative farmers minus the outcome of individual farmers after Propensity Score Matching. Since analytical standard errors are not computable for the Kernel and Stratification methods, we compute robust standard errors using 100 bootstrap replications.

Regardless of the estimation method used, Table 8 clearly suggests that the cooperative has a positive impact on milk production and productivity, a negative impact on milk nutritional value (fat and protein content) and an insignificant impact on milk hygiene (total bacteria count). It is interesting to note that although milk hygiene does not vary significantly between the two groups, Table 7 reports a significant increase in overall milk hygiene between 2003 and 2006. Milk hygiene apart, results in Table 8 confirm the two hypotheses presented in the introduction. In other words, they prove the formation of dairy cooperatives can indeed induce an increase in milk production and productivity, as well as substantial modifications of milk quality. In particular, our findings show that as milk production and productivity increase, milk quality decreases.

Likely explanations for these findings can be found in the different incentives faced by farmers inside and outside the cooperative. As discussed above, a key difference is associated with the fact that this cooperative, like most Ethiopian dairy cooperatives, provides smallholder farmers with access to subsidized inputs from the government. State subsidies are mainly directed to facilitate the procurement of artificial insemination services and live exotic cows. As a result, cooperative herds are dominated by high yielding crossbred cows, as opposed to the zebus typically found in the herds of non-cooperative farmers.

While indigenous zebus are characterised by the production of small volumes of milk (2-3 lt/day) with high density of nutrients, crossbred cows produce larger volumes with lower fat and protein content (Taneja and Aiumlamai 1999; Walstra et al. 2006). Hence, a great deal of the estimated impact can be referred to technological innovation triggered by the introduction of exotic genes in cooperatives herds. Such an explanation finds large support in the development literature where institutional change induced by collective action is often described as a pre-condition to technological innovation (see Dulfner 1974; Hayami and Otsuka 1992; Munckner 1998).

However, innovation in herds' genotype does not provide an exhaustive explanation for the drastic reduction in nutrient density observed in the cooperative's milk. According to dairy literature, the average nutritional values estimated in this study for cooperative milk fall largely below most common international standards for fat and protein content, even for exotic cows.[9] Therefore, the negative impact on milk quality must involve additional explanations. In particular, we observe that cooperative farmers feed their cross-bred cows mainly with dried forages and crop residues, suggesting that the lack of more nutritious, concentrated feed could be a reason for the excessive dilution of nutrients in cooperative milk.[10] Cooperative farmers argue in fact that concentrate feed is scarce and far too expensive, and cooperative managers are constantly in search of affordable feed to redistribute to their members. Moreover cross-bred cows are kept almost constantly inside the barn, indicating that the lack of grazing could also be part of nutritional shortfalls. On-barn husbandry is a consequence of the fact that most cooperative farms are located within the urban area, as well as by the farmers' fear that something may happen to their expensive cross-bred herds while grazing out of sight.

Last but not least, the poor nutritional value of milk produced by cooperative farmers reflects inadequate incentives for on-farm quality management. In particular, we observe that the cooperative makes use of alcohol and specific gravity tests to screen milk quality and safety at the farm gate. There is a widespread perception among cooperative managers, extension agents and policy-makers that these tests are simple, cheap and very useful. However, modern management theory (Weaver and Kim 2001) demonstrates that quality control techniques of the type adopted by these cooperatives are often useless.

In support to management theory we observe that specific gravity tests are usually conducted without accounting for differences in the temperature of milk supplies, which is critical to provide a reliable estimation of milk density. Second, quality control by Ethiopian dairy cooperatives is neither monitored nor certified. This allows for frauds against buyers and consumers, meaning that milk supplies that do not comply with quality standards are nonetheless accepted and commercialised by the cooperative. Or even for frauds against farmers (good supplies are rejected), especially against those cooperative members that are disliked by others or simply by the technician that carries out the quality control.

Third, alcohol and specific gravity tests are not attribute specific, in the sense that they do not provide cooperative members with precise information about the cause of eventual quality alteration. Finally, these two tests measure milk quality as good or bad, and not on a continuum, hindering the possibility to upgrade milk quality above the standards set by the two tests. As a result, milk price does not reflect milk quality in Addis Ababa, but only production scale and productivity. The uselessness of these tests is further confirmed by the negligible share of milk supplies that are rejected by the cooperative, suggesting that the quality standards set by these tests lie below the actual (and very poor) quality and safety of milk supplies.

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9 Taneja and Aiumlamai (1999) and Walstra et al. (2006) report average values of 4.8 fat content and 3.2 protein content for zebu cattle and 3.9 fat content and 3.5 protein content for Frisian cows.

10 These arguments are supported by standard dairy literature (see Balasini, 2000; and Belavadi and Niyogi, 1999).

6. Conclusions and Implications

This study evaluates the impact of a prominent dairy marketing cooperative on the performance of smallholder farmers in the surroundings of Addis Ababa. To do so it compares a sample of cooperative farmers and a group of otherwise similar (individual) farmers on the basis of their milk production and quality. The conclusions emerging from this study are that, in the peri-ruban areas of Addis Ababa, cooperative membership has a positive impact on milk production and productivity, a negative effect on milk quality and an insignificant impact on milk hygiene.

The robustness of these findings is demonstrated by the fact that two analytical approaches, based on instrumental variable regressions and propensity scores matching, yield consistent results. Furthermore, estimated impacts on milk production and productivity appear in line with previous studies on dairy marketing cooperatives in Ethiopia (Holloway et al. 2000; Ahmed et al. 2003; D'Haese et al. 2006). On the other hand, the estimated effects of cooperative membership on milk quality and safety add new insights and raise important concerns to the ongoing and heated debate on the role of agricultural cooperatives in Ethiopia.

Possible explanations for these contrasting impacts can be referred to a misalignment in the external incentives faced by the cooperative. The demand pressure for cheap milk coming from Addis Ababa is expected to be extremely high. As a result, the cooperative may face significant incentives to expand production and productivity, which inevitably come at the detriment of quality incentives. Due to the inverse relation between milk productivity and quality, we argue that it is important for national policy-makers to improve the alignment of incentives. In particular, a first step could be to invest in and improve the capacity of Ethiopia's Quality and Standard Authority (EQSA). More needs to be done by this state institution in order to reach out to dairy producers and ensure that they adopt state of the art grades and standards for quality management and control. Alternatively, quality upgrading could also be achieved through private, third-party certification schemes (Bio, Fair Trade, UTZ, etc.) However, further research will be necessary to better understand the underlying quality-productivity trade-offs faced by dairy cooperatives and to indentify adequate strategies to improve the overall performance of milk farms in Ethiopia.

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