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THE FEDERAL DEMOCRATIC REPUBLIC OF ETHIOPIA
POLICY STUDIES INSTITUTE

STRATEGY SUPPORT PROGRAM | WORKING PAPER 146 JUNE 2020

Food safety, modernization, and food prices

Evidence from milk in Ethiopia

Bart Minten, Yetimwork Habte, Kaleab Baye, and Seneshaw Tamru

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ABSTRACT

Modern marketing arrangements are increasingly being implemented to assure improved food quality and safety. However, it is not well known how these modern marketing arrangements perform in early stages of roll-out. We study this issue in the case of rural-urban milk value chains in Ethiopia, where modern processing companies – selling branded pasteurized milk – and modern retail have expanded rapidly in recent years. We find overall that the adoption levels of hygienic practices and practices leading to safer milk by dairy producers in Ethiopia are low and that there are no significant differences between traditional and modern milk value chains. While suppliers to modern processing companies are associated with more formal milk testing, they do not obtain price premiums for the adoption of improved practices nor do they obtain higher prices overall. Rewards to suppliers by modern processing companies are mostly done through non-price mechanisms. At the urban retail level, we surprisingly find that there are no price differences between branded pasteurized and raw milk and that modern retailers sell pasteurized milk at lower prices, ceteris paribus. Modern value chains to better reward hygiene and food safety in these settings are therefore called for.

1. INTRODUCTION

There is increased attention for the delivery of quality and safe food in value chains of developing countries overall and of Africa in particular (Jaffee et al. 2018). This is for a number of reasons. First, it has been shown that a large majority of consumers in developing countries rely on markets, and therefore value chains, to obtain their food (Haddad 2019). Second, given urbanization, population growth, and urban income growth, we see rapid expansion of value chains, especially so in Africa. Haggblade (2011) estimates that rural-urban value chains in particular expanded between 600 and 800 percent over the past three decades, while Dolislager et al. (2015) estimate that almost half of agricultural produce sold in Eastern and Southern Africa now goes to cities. Third, there is increasing awareness of the importance of food-borne diseases in these environments (Jaffee et al. 2018) and addressing those through improved value chains is considered important. Fourth, as average incomes have been rapidly increasing in Africa (Beegle et al. 2016), there is better ability and willingness to pay for safe food in these environments.

Modern marketing arrangements are increasingly being put in place to ensure the delivery of high-quality and safe food through these value chains. These arrangements are aimed at improving the information consumers are provided on both visible and unobservable characteristics of a commodity within a value chain (Fafchamps et al. 2008). This is illustrated by the increasing spread of vertical integration mechanisms where quality and safety standards are strictly managed within a firm (Swinnen 2007) or the increasing use of certification and contractual arrangements guaranteeing traceability to ensure required standards in value chains (Otsuka et al. 2016). We further see modern processing methods taking off, the increased branding of products to signal safety and quality to consumers, and the emergence of modern retailing, often with their own stringent standards (Reardon et al. 2003). However, overall there is a lack of evidence on how such modern arrangements perform in their early roll-out in Africa.

We focus on the dairy sector where food safety is a major concern. Given the presence of harmful bacteria that possibly can cause foodborne illnesses, the need of a functional cold chain and incentives for adulteration (given relatively high prices of milk), enhanced coordination between value chain agents is required and effective public and/or private interventions and regulations are often needed. For example, it has been shown that improved public regulations in this sector can lead to important health effects (e.g. Komisarow 2017). Alternatively, private standards imposed by modern players – often through foreign direct investment – have also contributed to improved quality and safety outcomes (Dries and Swinnen 2004; Dries et al. 2009). Modern players can therefore become important catalysts for the widespread adoption of appropriate quality standards in dairy value chains.

In the case of liquid milk, pasteurization is a process that kills off harmful bacteria and that allows for a longer shelf life. Raw milk that is not pasteurized and is not stored under refrigeration – as is often the case in rural areas in developing countries – is associated with quick growth of bacteria and other pathogens and is therefore considered an unsafe food (USFDA 2001). However, despite this knowledge, the consumption of pasteurized milk is still relatively rare in in Africa, because of the costs associated with the production of pasteurized milk – which is done in modern processing plants – leading to higher retail prices for pasteurized compared to raw milk or because of the preference of local consumers for raw high-fat milk (Omore et al. 2001).

We study this issue in the case of Ethiopia where dairy value development and modernization is still in early stages. We contribute to three major questions.

- First, we assess to what extent modern processing companies are linked to improved hygienic practices at the farm level – presumably leading to safer milk. While this is often

assumed to be the case (Dries and Swinnen 2004), Janssen and Swinnen (2019) did not find any relation between modernization and improved hygienic practices in cow management and milk handling in a case study in India.

- Second, we research how rewards for such improved practices are reflected in prices. If such improved practices are not valued, producers have no incentive to adopt them, given the costs involved. While Hoffmann and Moser (2017) argue that you get what you pay for, others show that unobservable characteristics are often not valued in these developing value chains (Minten et al. 2014, Fafchamps et al. 2008). On top of producers, we also look at the rewards for food safety and quality downstream for both pasteurized and raw milk.
- Third, we assess the role of modern retail. It has been found that in its early roll-out, quality and safety is better guaranteed in modern retail. Modern retail shops typically charge higher prices (Minten and Reardon 2008, Minten et al. 2010, 2013, Assefa et al. 2016), but also provide better rewards to producers (Rao et al. 2020). However, few authors have studied this issue for urban retail markets for milk.

We rely on unique primary data from a large-scale survey of the value chain supplying milk and other dairy products from rural areas to Addis Ababa, the capital and biggest city in Ethiopia. In producing areas, we find overall that the adoption by dairy producers of hygienic practices and other practices leading to safer milk is low. However, producers involved in liquid milk value chains perform better compared to other dairy farmers. We see however few differences in the adoption of these practices between producers involved in the traditional and the modern liquid milk value chains, respectively, except for the level of testing on acidity (as a measure of sourness of milk) and lactose content. We further find no higher prices paid to milk suppliers for modern value chains, ceteris paribus. Rather, we note that buyers in the modern value chain rely more on non-price mechanisms to bind clients to them, such as advice on cow management and milk handling, access to veterinarians and medicines, and the provision of improved cans. At the urban retail level, we performed chemical tests for a number of quality and safety measures for pasteurized and raw milk. We find that pasteurized milk is not sold at significantly higher prices than raw milk ceteris paribus and that there are rewards to some measures of quality, but not for others. Finally, we find that modern retail – which focuses exclusively on the sale of pasteurized milk – sells that milk at significantly lower prices than traditional retail, ceteris paribus. This likely is because of shorter procurement channels for modern retail compared to traditional retail, since processing firms mostly deliver directly to them, whereas traditional retail mostly relies on middlemen.

Our findings have a number of implications.

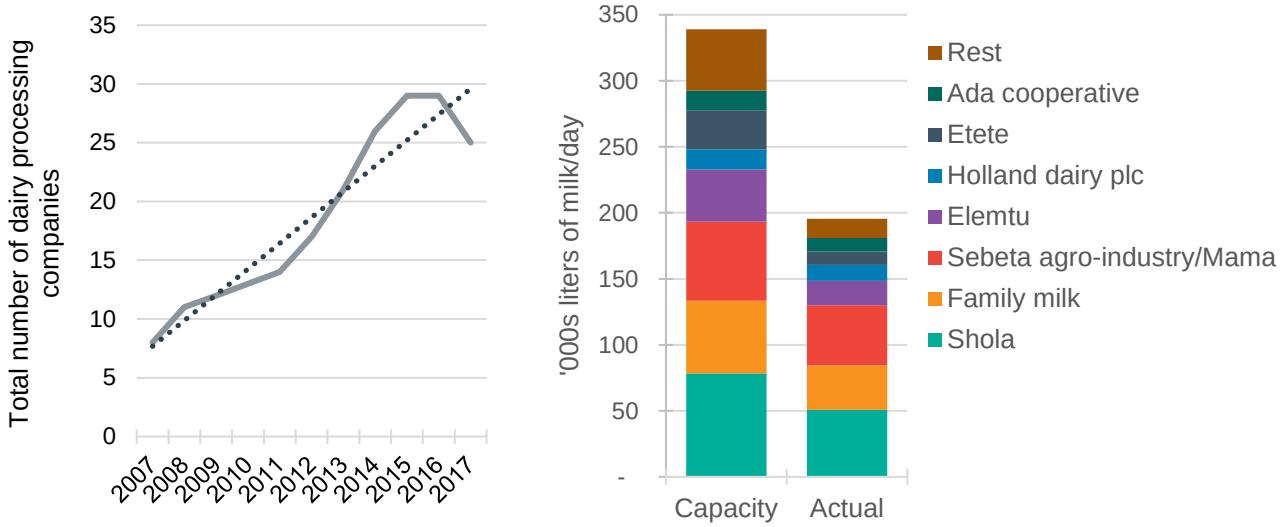
- First, food safety is mostly not rewarded in these fresh milk value chains. This indicates the need to promote either improved branding, certification, and traceability mechanisms within layers of the value chain or vertical integration of activities to improve adoption and better transmission of information on the adoption of safe practices.
- Second, as consumers seemingly perceive that prices paid for pasteurized milk do not reflect desired quality and safety, they are willing to pay increasingly higher prices for raw milk, driving down price differences between modern and traditional channels. In doing so, they are reducing the incentives to invest in needed modern marketing arrangements. This also indicates the need for training on improved milk handling processes in the traditional raw milk value chain (Omore et al. 2001).
- Third, modern retailing is able to deliver food at cheaper prices, ceteris paribus. Its further spread – possibly through foreign direct investment and links with international processors – should be encouraged. This might improve affordability of safer milk and allow for further improvements of safe hygienic practices in the dairy value chain (Dries and Swinnen 2004).

2. BACKGROUND ON MILK CONSUMPTION AND PROCESSING IN ADDIS ABABA

Expenditures on milk consumption have increased quickly in Addis Ababa as shown by data of the nationally representative Household Consumption and Expenditures Survey (HCES). While overall dairy consumption in Addis Ababa is low – at 10.2 kg of total dairy products and 8.5 liters of liquid milk per adult equivalent annually, compared to average annual global milk consumption estimated at 111 liters per capita (IDF 2016) – the annual quantities consumed per adult equivalent increased by 31 percent between 2005 and 2016 (Minten et al. 2020). The growth in income in the country as a whole and particularly in Addis Ababa over the past 20 years partly explains the growing consumption, given positive income elasticities for dairy products (Abegaz et al. 2018).

With growth in expenditures on dairy products in Addis Ababa, we also see increasing formalization and modernization of dairy markets. At the national level, there were eight dairy processing companies active in 2007. By 2017, this number had more than tripled to 25 (Figure 1, left).[1] Thus, there were large investments in the last decade, and more are planned. We obtained data on processing and the processing capacity of the dairy processing companies in Addis Ababa and surrounding areas. In the period 2016/17, daily processing was almost 200,000 liters of milk per day (Figure 1, right). There is significant concentration, with the four largest dairy processing firms, supplying three-quarters of all the pasteurized dairy products in the market. The graph also illustrates the significant overcapacity in the sector – over 40 percent of the dairy processing capacity is not being used. It is to be noted that, in contrast to a number of other countries, such as India, processing by dairy cooperatives is relatively less important. The largest cooperative active in the areas around Addis Ababa is the Ada'a cooperative with a market share of about 5 percent.

Figure 1: Number of processing firms nationally (left) and dairy processing capacity and use in 2016/17 of dairy firms in Addis Ababa and surrounding areas (right)



Source: Ethiopian Meat and Dairy Industry Development Institute

3. DATA AND DESCRIPTIVE STATISTICS

A survey of 955 dairy producers was fielded in January and February 2018 in two major rural dairy production zones around Addis Ababa, the zones of North and West Shewa; in suburban zones; and in the city of Addis Ababa. 97 dairy farming households were interviewed in Addis Ababa, 256 in suburban areas in the Oromia Special Zone surrounding Addis Ababa, and 602 in rural areas.

[1] Miniwagaw (2019) indicates that the number of dairy processing companies increased even further to 40 in 2019.

As part of the survey, we also interviewed 13 large commercial farms, defined as those with more than 25 cows. In rural areas, we ranked all woredas by remoteness to Addis Ababa. We then divided them in quartiles and selected farms randomly from each stratum proportional to the number of cows and woredas. Three kebeles were selected per woreda. In each selected kebele, we did a census of all households with cows in milk. We randomly selected ten households from those households that had three or more cows in milk and ten from those households that had one or two cows in milk. When averages are calculated, the relative weight of each strata is taken into consideration. After the selection of the sample household, a comprehensive survey was fielded that collected information on household characteristics, income generating activities, assets, and details on cows and dairy activities.

To make the distinction between modern and traditional marketing channels, we asked the farmers to whom they normally sold their liquid milk. Those that reported that they normally sold to agents or traders of processing firms were put in the modern channel, while all others – selling to traditional traders or directly to consumers, institutions, or the service sector – were put in the traditional channel. Those that did not sell milk, were categorized as 'Other dairy producers'. Table 1 shows descriptive statistics for the dairy farmers in these different channels, as well as for the sample as a whole. About 39 percent of our sample sells liquid milk while the rest does not sell at all or sells only processed products, such as cheese and butter. Liquid milk sellers have slightly different characteristics from other dairy farmers. In particular, they are located closer to Addis Ababa, have higher education levels, and own more cows (see also Vandercasteelen et al. 2019). On the other hand, there are few differences between traditional and modern liquid milk sellers.

Table 1: Farm survey – descriptive statistics

		Other dairy producers		Liquid milk sellers					
				Traditional		Modern		Total	
	Unit	Mean	Std. Dev.	Mean	Std. Dev.	Mean	Std. Dev.	Mean	Std. Dev.
Small farms (1-2 cows)	share, %	49.7		28.5		35.3		40.0	
Medium dairy farm (3-24 cows)	share, %	50.3		65.4		61.2		57.3	
Transport cost, kebele to Addis Ababa	Birr	62.8	41.4	20.4	24.1	33.7	21.9	48.1	40.0
Male household head	share, %	91.9		92.0		89.8		91.5	
Age of household head	years	49.7	14.1	48.1	12.7	48.6	13.0	49.1	13.6
Education of household head	years	2.6	3.5	6.4	5.3	4.8	5.1	3.9	4.6
Household size	number	6.1	2.1	5.9	2.2	5.8	2.1	6.0	2.1
Dependency ratio	%	101.7	78.6	73.6	62.2	74.0	63.9	89.6	73.5
Land owned, total	hectare	2.6	2.3	1.6	2.0	1.9	2.1	2.3	2.2
Observations		568		228		139		935	

Source: Authors' calculations

In parallel, a survey of retail shops was conducted In Addis Ababa. Five sub-cities from a total of 10 in the city were randomly selected. In each sub-city, four woredas were also selected randomly. Based on different retail outlet categories, samples were drawn for these different administrative levels of the city. 208 outlets were visited in total. Table 2 shows the distribution over the different retail outlets. 54 percent of all the outlets (n=113) visited were minimarkets and regular shops, 13 percent were supermarkets, and the rest were dairy shops. This survey was done at the same time as the producer survey in January and February 2018.

Table 2: Survey of Addis Ababa retail shops selling milk – descriptive statistics

	Unit	Observations	Mean	Standard deviation
Retail survey				
Observations	number	208		
Open market dairy shop	share of total obs., %	4	1.9	
Modern retailer	share of total obs., %	28	13.5	
Minimarket and regular shop	share of total obs., %	113	54.3	
Dairy shop, not open market	share of total obs., %	63	30.3	
Raw milk price observations	number	59		
Pasteurized milk price observations	number	289		
Lab analysis of milk samples from shops				
Observations	number	103		
Moisture	%	100	88.7	1.8
Fat	%	92	3.3	0.7
Solid non-fat	%	99	8.3	2.1
Lactose	%	92	4.3	0.8
Added water	share yes (%)	103	61.2	
pH	value	98	6.1	0.2
Total plate count (microbial quality)	number (million)	103	19.8	48.9
Regular shop	share of total obs., %	42	40.8	
Modern retailer	share of total obs., %	11	10.7	
Dairy shop	share of total obs., %	50	48.5	

Source: Authors' calculations

From the full sample of outlets, 103 retailers were randomly selected and re-visited. Milk samples from each were bought and analyzed in the lab. Samples of fresh raw milk (n=50) and pasteurized milk (n=53) were collected using aseptic techniques in a pre-cooled ice box. The samples were then immediately analyzed for proximate composition, pH, microbial quality, and addition of water. Ten to 12 samples for each brand of pasteurized milk were collected at different time periods to ensure collection of different batches. Three types of laboratory analyses were done:

- Proximate composition. Moisture and total solid (100-moisture) were measured immediately. Moisture was analyzed in duplicate by oven drying at 105 degree Celsius to constant weight. Protein was analyzed using the Kjeldahl method (AOAC International 2006). Fat was analyzed using the modified Gerber method (AOAC International 2006). Ash was measured by the gravimetric method using a muffle furnace.
- Adulterants. Added water was determined using the Lactoscan.
- Lactose. Lactose was measured using Lactoscan.

The lower panel in Table 2 shows the different results of these tests. The moisture, protein, and fat contents were in the range considered normal for full fat milk. The pH content of the milk was slightly acidic (pH$\leqslant$6.3). More than half (61.2 percent) of the samples had added water, and the total bacterial count was high and highly variable, suggesting reduced shelf-life.

4. MODERNIZATION, HYGIENE, AND FOOD SAFETY

Table 3 gives an overview of some of the hygienic and milk handling practices that the surveyed farmers adhered to. We see that the majority of cows are milked inside for those producers involved in liquid milk value chains. This is in contrast to other dairy producers – those selling

Table 3: Hygienic and safe practices, testing and milk handling, modern versus traditional channel milk suppliers – descriptive statistics

	Unit	Other dairy producers	Liquid milk sellers		Total
			Traditional	Modern	
Place of milking					
In stall/shed	%	26.8	82.5	81.3	48.5
Outside	%	68.8	16.7	16.6	48.3
Both	%	4.4	0.9	2.2	3.2
Udder and teats are cleaned before milking	% yes	15.0	88.1	74.8	41.7
Mode of washing of udder and teats before milking					
Cold water only	%	42.9	39.5	26.0	36.6
Lukewarm water only	%	56.0	59.0	73.1	62.1
Water and disinfectant	%	0.0	1.0	1.0	0.8
Other	%	1.2	0.5	0.0	0.5
Method of drying the udder and teats before milking					
None	%	60.0	25.6	23.1	32.4
Clothes	%	29.4	70.4	73.1	62.2
clean towel	%	0.0	1.0	0.0	0.5
Other	%	10.6	3.0	3.9	4.9
Milk storage area is free from the sun, heat and animals	% yes	82.2	86.8	92.8	84.9
The stored milk kept in a fridge	% yes	1.8	23.7	20.9	10.0
The milk storage pot covered with a lid?	% yes	91.3	90.4	81.3	89.6
Times that cows are milked per day	mean	1.9	2.0	2.0	1.9
once	%	8.0	2.3	1.5	5.7
twice	%	92.0	97.2	98.5	94.2
three times	%	0.0	0.5	0.0	0.1
For those milking 2 or more times per day					
The morning and afternoon/ evening milk are put together in the same container	% yes	92.7	39.1	58.5	74.3
If sold as liquid milk, what is typical time span between afternoon/evening milking and the time of sales, hours	mean	4.4	10.3	12.3	10.6
The most common method of milk preservation used by the farmer before sale					
Not treated	%	80.3	62.4	35.6	56.9
Boiling	%	2.6	2.2	2.3	2.3
Refrigerated	%	0.0	8.6	9.1	7.1
Cold water bath	%	10.5	23.7	51.5	30.5
Other additives	%	1.3	0.5	0.8	0.8
Other methods	%	5.3	2.7	0.8	2.5
Different use of milk when cows are sick	% yes	15.0	39.5	41.4	24.4
Use of milk when cows are sick					
Sell it	%	0.0	6.3	18.2	6.9
Own consumption	%	8.2	5.1	9.1	7.3
Give it to calves	%	71.8	43.0	45.5	54.8
Process it into butter/cheese	%	15.3	1.3	1.8	6.9
Spoiled	%	4.7	39.2	21.8	21.5
Other	%	0.0	5.1	3.6	2.7
Milk handling and testing					
When the farmers sell milk, its quality is checked					
… through a lactometer	% yes		57.5	91.3	71.8
… through an alcohol test	% yes		53.5	89.8	68.8
The farmer owns stainless steel/aluminum buckets/cans	% yes	21.2	37.8	22.3	26.1
The buyer uses stainless steel/aluminum buckets/cans	% yes		31.1	60.2	38.3

Source: Authors' calculations

processed products or only auto-consuming milk – who carry out milking outside. Eighty-eight and 75 percent of traditional and modern channel milk suppliers, respectively, report that they clean milk udders and teats before milking. This is an important practice, as not washing the udder can lead to contaminants from the soil, urine, dung, or feed polluting the milk (Yilma 2012). This relatively high number contrasts sharply with dairy producers not involved in the liquid milk value chains where only 15 percent reports to do this. Twelve percent of dairy producers keep milk in a refrigerator. While milk sellers do this more (24 percent for the traditional and 21 percent for modern suppliers), the number is still worryingly low, likely because the majority of these producers do not own a fridge and, even if they did own one, they might still lack reliable electricity.

We also asked if milk from the evening and the morning milkings – cows are typically milked twice per day – were put together. Given that the milk is often not preserved in fridges, doing so could create important hygienic and milk safety issues. Fifty-eight and 39 percent of the modern channel and traditional channel sellers, respectively, reported that they did this. However, a number of these farmers also indicated that they preserve the milk in cold water baths in an attempt to reduce these hazards. Finally, we asked farmers if they used milk obtained from cows that were sick for other purposes. About 40 percent of the liquid milk sellers indicated that they used such milk in a different way, but 60 percent reported no changes in how they use the milk in case of a cow being sick. For farmers that used such milk differently, they reported giving it to calves or discarded it.

While we see differences between dairy farmers that are not connected to liquid milk value chains and those that are connected, we see few differences between modern and traditional milk value chains. However, we test this through formal statistical methods. We look in particular at four measures of hygienic and safe practices, i.e. the cleaning of udder and teats, the storing of milk in a refrigerator, the mixing of evening and morning milk, and the use of milk when cows are sick. We present results of a simple proportion test and results of a probit model where we control for other confounding factors (Table 4). In the latter specification, robust standard errors are adjusted for sample clustering at the kebele level. We find mostly no significant indications that hold up in both tests that modern channel sellers use better practices than those selling through traditional channels.

Table 4: Tests of hygienic and safe practices, testing, and milk handling – modern versus traditional channel milk suppliers

	Proportion test			Probit regression – Marginal effects of traditional versus modern			
	Observa-tions	z-value	Pr (diff≠0)	Observa-tions	Coeff.	Std. error	P>|z|
Hygienic and safe practices							
Udder and teats are cleaned before milking	366	-3.29	0.001	246	0.08	0.05	0.111
Stored milk kept in refrigerator	367	-0.63	0.531	246	-0.00	0.05	0.931
Morning and afternoon/evening milk are put together in the same container	345	3.54	0.000	241	0.01	0.06	0.932
Different use of milk when cows are sick	333	0.34	0.736	246	-0.03	0.06	0.579
Milk handling and testing							
When farmers sell milk, its quality is checked							
… through a lactometer	337	7.04	0.000	243	-0.27***	0.08	0.001
… through an alcohol test	337	7.13	0.000	243	-0.24***	0.07	0.001
Farmer owns stainless steel or aluminum buckets or cans	367	-4.02	0.000	246	0.10	0.07	0.149
Buyer uses stainless steel or aluminum buckets or cans	356	3.74	0.000	236	-0.16**	0.08	0.047

Source: Authors' calculations. *** p<0.01, ** p<0.05, * p<0.10.

We further look at the quality of milk that is put on the market and assess if there are differences between modern and traditional channels. While we have no data on effective adulteration or sourness of milk, we have data on the use of milk tests by buyers in traditional and modern channels to assess these two common problems. Two milk tests are commonly used in Ethiopia – an alcohol and a lactose test. An alcohol test is able to detect "sour" milk, i.e. milk with an elevated level of acidity as a result of lactic acid formation by bacteria. Such sour milk is prevalent in cases when refrigeration is lacking or in cases of long transport of milk in ambient temperatures. A lactometer is used to test the density of the milk to detect possible adulteration of milk with water. We see in Table 3 that such tests are done by about 90 percent of the buyers involved in modern channels. This is a high number, but it also indicates that all modern buyers do not do these tests. We further see that such tests are also done to a certain extent in traditional channels, if less so than in modern channels. When we test this association with a proportion test and a probit model, we find that this difference between the traditional and modern channel is highly significant (Table 4).

We further look at milk handling. The use of stainless steel or aluminum buckets and milk cans is a recommended practice to contribute to milk safety. Other containers are difficult to clean, their surfaces are easily scratched, and they often more easily heat up in the sun, all accelerating bacterial growth. Table 3 shows that the ownerships of such buckets and cans is low. Only 26 percent of farmers reported owning improved containers. While farmers involved in liquid milk value chains are more likely to own such improved containers compared to other dairy farmers, there is no evidence that modern value chain suppliers are more likely to own them than traditional ones – Table 4 shows that these differences are not significant. We also asked questions on the use of such cans by the buyers of these different channels. Only 38 percent of farmers overall reported that their milk buyers used them. While the share of buyers that use them is higher in the modern versus the traditional channel, it is still noteworthy that 40 percent of the supplying farmers of the modern channel indicate that they are not being used by their buyers. We do find, however, that there is a significant difference between modern and traditional buyers and that the probability of modern buyers to use these improved milk cans is 16 percent higher than for traditional buyers (Table 4).

The data on hygiene practices and milk handling indicate that hygienic practices overall are not more commonly practiced by modern suppliers than by traditional ones. However, we note that milk supplied to modern channels is significantly more likely to be tested. Unfortunately, we have no data on how stringent these tests are, so we do not know what the real quality differences might be. However, because of the significantly more widely used testing in modern channels, these results suggest that this might lead to higher quality and safety, at least for the characteristics tested. We also find that modern buyers are more likely to use improved milk cans themselves, although their suppliers may not. To make sure that hygienic and safe practices are adopted, farmers need to receive incentives for these practices. We look at this issue in the next section.

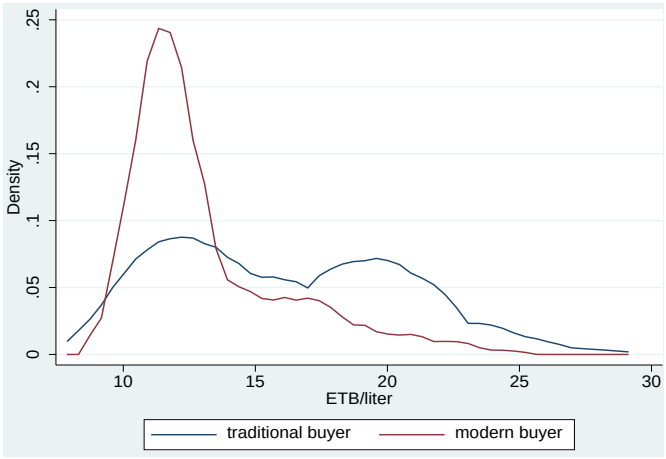
5. MODERNIZATON AND REWARDS FOR HYGIENE AND FOOD SAFETY

5.1 Producer level

To assess how rewards differ between modern and traditional channel suppliers, we look at milk prices by channel. Average milk prices over the 30 days before the survey was administered were asked in a detailed sales module. Figure 2 plots the density of reported prices by type of channel. We see that prices paid to modern channel suppliers are overall lower than in traditional ones. However, these prices might differ because of other reasons, e.g., those that supply traditional raw

milk value chains are often located close to town or even in the city itself (Minten et al. 2020). We therefore need to use regression analysis to control for possible confounding factors.

Figure 2: Density function of producer prices for suppliers of modern versus traditional value chain



Source: Authors' calculations

Table 5: Assessment of factors associated with producer prices of milk

		log (price (Birr/l))					
		(1)		(2)		(3)	
	unit	Coeff.	Std. error	Coeff.	Std. error	Coeff.	Std. error
Independent variables							
Type of seller (default: Modern milk channel)							
Traditional milk channel	yes=1	0.05**	0.02	0.04*	0.02	0.14***	0.05
Transport cost from kebele to Addis in Birr	ln(Birr+1)	-0.13***	0.01	-0.11***	0.01	-0.09***	0.01
Udder and teats cleaned before milking	yes=1			0.01	0.03	0.03	0.02
Stored milk is kept in a fridge	yes=1			0.06	0.04	0.11*	0.06
Type of milk typically sold to this buyer (default: both mixed)							
Only morning milk or only evening milk	yes=1			0.11**	0.04	0.03	0.03
Both morning and evening milk separately	yes=1			0.05***	0.02	0.01	0.02
Farmer possesses improved milk container	yes=1			0.04*	0.02	0.05	0.03
Interacted with traditional milk channel dummy							
Transport cost from kebele to Addis in Birr	ln(Birr+1)					-0.03**	0.01
Udder and teats cleaned before milking	yes=1					-0.03	0.04
Stored milk is kept in a fridge	yes=1					-0.08	0.07
Type of milk typically sold to this buyer (default: both mixed)							
Only morning milk or only evening milk	yes=1					0.12**	0.05
Both morning and evening milk separately	yes=1					0.05	0.03
Farmer possesses improved milk container	yes=1					-0.02	0.04
Intercept		2.93***	0.02	2.84***	0.03	2.76***	0.04
R-squared		0.70		0.73		0.75	
Observations		357		356		356	

Source: Authors' calculations. *** p<0.01, ** p<0.05, * p<0.10.

Table 5 presents the results of a regression where we assess the correlation of a number of factors – collected in the sales module – that might possibly influence milk prices following a hedonic pricing framework (Lancaster 1966). We first present a simple parsimonious regression where milk prices are regressed on the type of supplier (modern versus traditional channel) and travel costs to Addis. We find in this simple regression that prices are slightly (5 percent) higher in

the traditional than the modern channel. In price formation, travel costs to Addis matter significantly: When travel cost double, prices are significantly reduced by 13 percent. We then add a number of other possible controls in a second specification, reflecting hygienic and milk handling practices. Controlling for these factors, we still find a significant difference between traditional and modern channel suppliers, with the latter receiving a lower price. While we find no association of cleaning of udders or keeping milk in a refrigerator, we find a positive effect with prices of not mixing morning and evening milk and of ownership of improved containers. When we interact these hygienic and handling practices with a dummy for the traditional channel producers to determine if there are less or additional premiums for these producers compared to modern channel suppliers, we note that, except for storage of milk in a refrigerator (significant at the 10-percent level), none of the other variables are significant. These results indicate overall that hygienic practices and milk handling are not rewarded by the current modernization process in liquid milk value chains supplying Addis Ababa.

A number of qualitative questions further indicate that quality considerations in milk purchases are not very important, as only a small share of farmers indicate that they received a premium for higher quality (Table 6). However, it is noteworthy that the share of farmers reporting this is higher for modern channels suppliers. The farmers further reported that if the buyer finds signs of adulteration, milk will likely be rejected in the case of the modern channel, as indicated by 78 percent of the farmers. However, that is much less the case for traditional channels in which only 39 percent of farmers reported that their milk will likely be rejected.

Table 6: Services, modern versus traditional – descriptive statistics

		Liquid milk sellers		
	Unit	Traditional	Modern	Total
The farmer obtains a premium for higher quality	% yes	3.2	12.0	5.3
The normal penalty for adulteration:				
Rejection of supply	%	39.3	78.3	48.8
Price reduction	%	3.5	4.4	3.7
Termination	%	3.9	2.2	3.5
Temporary suspension	%	8.8	7.6	8.5
None	%	42.8	7.6	34.2
Other	%	1.8	0.0	1.3
The most important buyer…				
… provides training/advice on improved milk production	% yes	25.9	53.9	33.4
… provides training/advice on hygienic milk handling	% yes	26.7	58.2	35.2
… provides training/advice on health risks inflicted as a result of adulteration	% yes	23.5	52.8	31.4
… keeps buying milk during fasting periods	% yes	50.2	64.8	54.1
… provides veterinary medicines/veterinary services/ artificial insemination services	% yes	13.0	17.6	14.2
… supplies milk storage cans	% yes	10.1	22.0	13.3
… supplies feed	% yes	8.1	14.3	9.8
… provides credit/loans	% yes	4.5	6.6	5.0

Source: Authors' calculations

It might be that other mechanisms than prices are used to bind producers to buyers, as noted in other countries (Dries and Swinnen 2004; Van Campenhout et al. 2019). To assess these relationships, we asked a number of additional questions in the sales module (Tables 6 and 7). One-third of farmers selling milk indicate that they receive advice from their buyers on improved milk production, hygienic milk handling, and health risks inflicted because of adulteration (Table 6). However, suppliers to modern channels reported that they receive significantly more advice on such practices (Table 7).

Table 7: Tests of service provision, modern versus traditional

	Proportion test			Probit ME regression Effect of traditional versus modern			
	Observa-tions	z-value	Pr (diff≠0)	Observa-tions	coeff.	std. error	P>|z|
The most important buyer…							
… provides training/advice on improved milk production	318	5.03	0.000	224	-0.19**	0.08	0.014
… provides training/advice on hygienic milk handling	318	5.22	0.000	224	-0.17**	0.07	0.017
… provides training/advice on health risks inflicted as a result of adulteration	318	5.41	0.000	224	-0.21***	0.05	0.000
… keeps buying milk during fasting periods	318	2.96	0.003	224	-0.08	0.08	0.325
… provides veterinary medicines/veterinary services/artificial insemination services	318	4.16	0.000	224	-0.18***	0.04	0.000
… supplies milk storage cans	318	2.83	0.005	224	-0.09**	0.04	0.037
… supplies feed	318	1.22	0.222	224	-0.02	0.04	0.637
… provides credit/loans	318	0.87	0.384	224	-0.03	0.03	0.405

Source: Authors' calculations. *** p<0.01, ** p<0.05, * p<0.10.

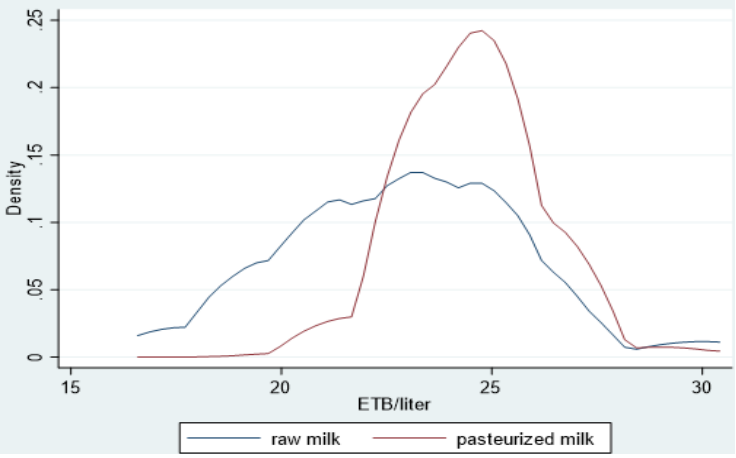
Intermittent demand is an important issue in the Ethiopian dairy value chain as it is estimated that the average annual number of fasting days that adult Orthodox Christians – the major religious group in the country – adhere to is 140 (D'Haene et al. 2020). During these fasting days, they refrain from the consumption of dairy foods, having possibly important effects on sales by these dairy farmers. Fifty-four percent of farmers indicate that their most important buyer continues buying their milk during the fasting period, but buyers in the modern value chain are more likely to do so. While that difference is significant in a proportion test, it is not for the probit regression.

Modern buyers are also 9 percent more likely to provide storage cans. We see similar significant associations with modern buyers providing more veterinary medicines, veterinaries, and access to artificial insemination services. However, the overall share of buyers doing this is still low (18 percent). We further see low numbers of milk buyers that provide loans and credit. Moreover, the differences in the provision of most of these services is not significantly different between modern and traditional channel suppliers (Table 7).

5.2 Retail level

To test the rewards at the urban retail level for branded pasteurized milk compared to raw milk, we first look at price density functions for both types of milk (Figure 3). Surprisingly, in contrast with other countries and previous periods, we note no large price differences at the time of the survey. We further test with a simple hedonic price regression set-up if there is a difference in prices when we control for a number of possible explanatory factors, i.e. the type of outlet, a fasting period dummy, and location. We find in a simple regression where we do not control for any other factors (specification 1) that the price of pasteurized milk is 6 percent significantly higher. However, the price difference disappears once we include other explanatory variables (Table 8).

Figure 3: Price density functions pasteurized versus raw milk in retail markets in Addis Ababa



Source: Authors' calculations

Table 8: Assessment of factors associated with retail prices of milk in Addis Ababa

		log (price (Birr/l))					
		(1)		(2)		(3)	
	unit	Coeff.	Std. error	Coeff.	Std. error	Coeff.	Std. error
Independent variables							
Milk is pasteurized	yes=1	0.07***	0.02	0.06***	0.02	0.03	0.02
Shop type: (default - minimarket & regular shop)							
Modern retailer	yes=1			-0.03***	0.01	-0.03***	0.01
Dairy shops	yes=1			-0.02	0.02	-0.06***	0.02
Survey time: Easter fasting season	yes=1			0.01	0.01	-0.01	0.02
Sub-cities dummies included		no		no		yes	
Intercept		3.12***	0.02	3.14***	0.02	3.19***	0.02
R-squared		0.128		0.160		0.206	
Observations		347		347		347	

Source: Authors' calculations. *** p<0.01, ** p<0.05, * p<0.10.

Given that we have unique data on quality differences within pasteurized versus raw milk channels, we further test the extent that quality differences are reflected in prices of milk (see Gulseven and Wohlgenant (2014) for a similar exercise in US markets). We run two different specification, one for pasteurized milk and another for raw milk (Table 9). We see in the case of raw milk that added water is associated with a lower price and that higher counts of microbial loads lead to significantly lower prices, indicating that at least some measures of safety are reflected in prices. However, we also note that lactose content has an unexpected negative sign. As we have a limited number of observations and there are some correlation issues between right-hand variables, we also rely on a Principal Component Analysis (PCA) of these different quality measures and create an overall indicator for quality and safety. When we regress that variable on milk prices, we find no significant association (Table 9, columns (2) and (4)). In the case of pasteurized milk, we note that there are even fewer associations of price with quality measures. The only exception is the pH level, where a higher level is associated with a lower price. We also note in the case of pasteurized milk that there is no association of the overall quality and safety indicator with milk prices.

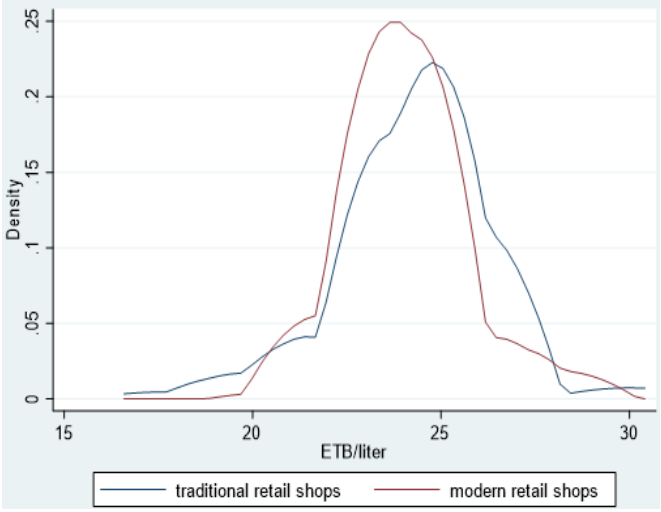
Table 9: Assessment of factors associated with retail prices of raw milk and pasteurized milk

		log (price (Birr/l))							
		Raw milk				Pasteurized milk			
		(1)		(2)		(3)		(4)	
Independent variables	Unit	Coeff.	Std. error	Coeff.	Std. error	Coeff.	Std. error	Coeff.	Std. error
Moisture	%	-0.01	0.01			0.00	0.01		
Fat	%	-0.02	0.04			0.01	0.02		
Lactose	%	-0.10*	0.05			-0.03	0.02		
Added water	yes=1	-0.20**	0.08			0.00	0.03		
pH	number	0.14	0.08			-0.12**	0.05		
Microbial load, total count	millions	-0.00**	0.00			0.00	0.00		
Overall quality/safety indicator	number			0.01	0.82			0.00	0.17
Shop type: (default - regular shop)									
Modern retailer	yes=1					-0.02	0.02	-0.02	-0.95
Intercept		3.70***	0.80	3.30***	157.11	3.86***	0.56	3.32***	294.48
R-squared		0.32		0.01		0.28		0.02	
Observations		45		45		44		44	

Source: Authors' calculations. *** p<0.01, ** p<0.05, * p<0.10.

Finally, we look at price differences of milk between modern and traditional retail (Figure 4). We note that price distributions over the period of the survey were not significantly higher for modern compared to traditional outlets. If anything, we note slightly lower prices. This is confirmed in regression analysis where modern retailers are estimated to sell milk at a price that is 3 percent lower than in traditional shops (Table 8). Modern retail in this stage of roll-out typically sells products at significantly higher prices, as they are mostly focused on the wealthier middle class (Assefa et al. 2016; Minten and Reardon 2008). However, the latter authors show in a cross-country review that especially processed products are often found cheaper in modern retail, even in early roll-outs. This is also found in this case study of milk in Ethiopia. Seemingly because of economies of scale, differential procurement mechanisms – 96 percent of modern retailers obtain milk directly from dairy processing companies, while this is only 24 percent in the case of regular shops, which rely more on middlemen – and their lower losses often due to better milk storage (Minten et al. 2020), modern retail is able to offer milk at lower prices.

Figure 4: Price density functions modern versus traditional retail markets in Addis Ababa



Source: Authors' calculations

6. CONCLUSION

Assuring food safety is an important challenge that is receiving increased attention in a number of developing countries. This is an important consideration for liquid milk value chains given its perishability as well as incentives for adulteration (given relatively high prices for milk – compared to cereals – and the difficulty and costs of assessing adulteration). Modern processing and marketing mechanisms are increasingly appearing to address this issue. However, there is lack of evidence on how these modern marketing systems perform in early stages of roll-out. We study this issue with unique primary data from the milk value chain in Ethiopia.

We find that the adoption levels of hygienic practices and practices leading to safer milk by dairy producers in Ethiopia are low overall. While producers involved in liquid milk value chains perform better compared to others, we find few differences between traditional and modern milk value chains. At the producer level, we find that few monetary rewards are paid by modern buyers to farmers adopting hygienic and safe practices. However, we note that modern buyers do more testing. To reward farmers for practices that might lead to improved quality, we find that modern buyers rely more on non-price mechanisms, such as advice, the provision of improved cans, and access to veterinarians and veterinary medicines. However, the incidence of these practices is generally still low. Such interlinkage of extension and other inputs with output markets has been noted in other settings as well (Dries and Swinnen 2004). We also note that branded pasteurized milk is sold at similar prices to raw milk, ceteris paribus, with little, if any, rewards for quality and safety measures. Finally, modern retail that is increasing being rolled out in developing countries is shown to be able to sell milk at slightly lower prices than traditional retail.

Our results point to a number of areas where further research would be welcome. First, our analysis is limited to observational data. Methodological improvements should be pursued to better understand the incentives for farmers to take up hygienic practices when they are sure to be rewarded for it. Second, there is still little known on consumers' preferences on dairy products in general in these settings and, in particular, on raw versus pasteurized milk demand. More research in this area would be useful. Third, some countries in Africa and Asia have been much more successful in rolling out cold chains and chilling centers, often linked to successful cooperatives (e.g. Van Campenhout et al. 2019, Cunningham 2009). Better understanding of constraints to these interventions and investments in Ethiopia would be helpful.

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ABOUT THE AUTHORS

Bart Minten is Program Leader of the Ethiopia Strategy Support Program (ESSP) and a Senior Research Fellow in the Development Strategy and Governance Division (DSGD) of the International Food Policy Research Institute (IFPRI), based in Addis Ababa, Ethiopia. **Yetimwork Habte** is a Research Officer in the Ethiopia Strategy Support Program (ESSP) under Policy Studies Institute (PSI), based in Addis Ababa, Ethiopia. **Kaleab Baye** is an Associate Professor in the Center for Food Science and Nutrition, Addis Ababa University, based in Addis Ababa, Ethiopia. **Seneshaw Tamru** is a Country Economist in the International Growth Center (IGC), based in Addis Ababa, Ethiopia.

INTERNATIONAL FOOD POLICY RESEARCH INSTITUTE
1201 Eye St, NW
Washington, DC 20005 USA
T. +1-202-862-5600 | F. +1-202-862-5606
Email: ifpri@cgiar.org
www.ifpri.org | www.ifpri.info

IFPRI–ESSP ADDIS ABABA
P.O. Box 5689, Addis Ababa, Ethiopia
T. +251-11-617-2000 | F. +251-11-667-6923
Email: ifpri-essp@cgiar.org
http://essp.ifpri.info

POLICY STUDIES INSTITUTE
P.O. Box 2479, Addis Ababa, Ethiopia
T. +251.11-550-6066; +251-11-553-8633
F. +251-11-550-5588
http://psi.gov.et/

The Ethiopia Strategy Support Program (ESSP) is managed by the International Food Policy Research Institute (IFPRI); is jointly implemented with the Policy Studies Institute (PSI); and is financially supported by the United States Agency for International Development (USAID), the Department for International Development (DFID) of the government of the United Kingdom, and the European Union (EU). The research presented here was conducted as part of the CGIAR Research Program on Policies, Institutions, and Markets (PIM), which is led by IFPRI.

This study was made possible by the generous support of the American people through USAID under the Feed the Future Innovation Lab for Livestock Systems (LSIL), which is implemented by the Institute of Food and Agricultural Sciences of the University of Florida in partnership with the International Livestock Research Institute (ILRI). LSIL is funded by the United States Agency for International Development (USAID) through a five-year Leader with Associates Cooperative Agreement Award No. AID-OAA-L-15-00003.

This publication has been prepared as an output of ESSP and has not been independently peer reviewed. Any opinions expressed here belong to the author(s) and are not necessarily representative of or endorsed by IFPRI, PSI, USAID, DFID, EU, University of Florida, ILRI, PIM, or CGIAR.