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## Trade, value chain technology and prices: Evidence from dairy in East Africa

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## LICOS Discussion Paper Series

Discussion Paper 422/2021

### **Trade, Value Chain Technology and Prices: Evidence from Dairy in East Africa**

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# Trade, Value Chain Technology and Prices: Evidence from Dairy in East Africa

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## Abstract

Agricultural value chains, particularly in the developing world, have been going through drastic changes over the past decades. Differences in world market participation and access to value chain technologies might however have resulted in uneven experiences across countries. In this paper, we explore their impact on prices in the value chain, using the example of two East African countries, Ethiopia and Uganda. We develop a conceptual framework and then validate the model using unique primary price data collected at several levels in the dairy value chains in both countries. We find that prices are overall significantly lower in Uganda than Ethiopia, reflecting their respective net exporting and importing status. Moreover, despite shorter value chains, we find much more significant effects of distances from the capital (the major end destination) on milk prices in Ethiopia than in Uganda. This is seemingly linked to the widespread presence of milk chilling centers in Uganda. While it has been shown that such technology is important for milk quality, we find here that they also have the added benefit to reduce the impact of farmer's remoteness on prices and therefore allow for more geographically extended value chains.

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## 1. Introduction

Over the past few decades, rising incomes and increasing urbanization in many African countries have had a profound impact on food consumption patterns. More and more, people started demanding more nutritious food in locations that are often far from where production takes place. As a result, agrifood systems have been transforming at an equally rapid pace, especially in post-farmgate segments of the supply chains (Reardon et al., 2015). Animal source foods (ASF) in particular have been in high demand, as they are rich in a range of micronutrients that are critical in the growth and development of children. Furthermore, aspirational foods such as meat, eggs and milk have been found to have high income elasticity.

In this paper, we document transforming supply chains in the dairy sub-sector. This is done using case studies of the dairy value chain linking surplus producing areas to the capital cities of two countries in East Africa – Ethiopia and Uganda. While both countries have experienced a significant increase in both supply of raw milk and demand of (semi-processed) dairy products, the underlying value chain transformation process differs substantially. We provide a conceptual framework to rationalize this divergence, with key roles for integration in international markets and mid-stream value chain technology. We then use data, collected at various levels of the value chain, to validate this explanation.

This paper contributes to a growing literature on transforming agricultural value chains, using primary data collected at different nodes in milk value chains. Most existing studies on the role of value chain transformation in economic development look at complex international value chains, often involving tight standards, linking producers of high value commodities in the global south to producers in developed countries (eg. Minten et al., 2009; Wollni and Zeller, 2007; Colen et al., 2012). More recently, transformation of local value chains have started to receive some attention (eg. Minten et al., 2016a; Vandercaesteelen et al., 2018). However, most of these studies focus on fairly simple staple food value chains, involving little processing and only basic grading to assess quality (Minten et al., 2016b). Our paper considers a high value commodity with strict sanitation requirements in the context of a local value chain. While in global value chains, challenges related to quality preservation and tightening standards are accommodated through increased vertical integration (Maertens and Swinnen, 2009). In global value chains, multinational organizations often play an important role. These organizations have the resources and

expertise to develop modern supply chains.

In local value chains, this integration and coordination may be harder to achieve. We find that in Ethiopia, even in the absence of particularly severe infrastructural bottlenecks, development of dairy markets is limited (Hoddinott et al., 2015), with farmers owning one or two cows mainly for own milk consumption and significant production in semi-urban areas to cater for consumption in cities. In Uganda, however, we find a dairy value chain that is much more developed mid-stream, with milk cooling centers collecting and aggregating raw milk and an efficient cold chain linking producer areas to consumers and processors that are a significant distance apart. This leads to the important finding that, despite being more complex and longer, the dairy value chain is much more efficient in Uganda.

Most existing value chain studies also focus on case studies within a single country, like teff in Ethiopia (Minten et al., 2016a), dairy in India (Burkitbayeva et al., 2019; Janssen and Swinnen, 2019), Ethiopia (Francesconi et al., 2010) and Zambia (Neven et al., 2006), rice or the vegetable sector in Vietnam (Minot and Goletti, 2000; Mergenthaler et al., 2009). More recently, studies have also started to look at comparisons of value chains across different countries (eg. Barrett et al., 2012; Reardon et al., 2012; Vandeplas and Minten, 2015). Our comparison of the Ethiopian case to the Ugandan case allows us to shed light on how differences in competitiveness in the international market can lead to widely differing value chains, with implications for prices at all levels. In particular, low production costs in Uganda means that the world price of milk is the reference price for all actors. In Ethiopia, production and marketing costs seem higher, making import of milk profitable. A sizable import tariff means that the relevant price in Ethiopia is thus much higher than in Uganda.

The remainder of this paper is structured as follows. Section 2 provides information about the trade situation and the milk sector in Ethiopia and Uganda. Section 3 introduces the conceptual framework and the data collection process is described in Section 4. Section 5 examines the different structures of the value chain in each country, Section 6 then translates the conceptual framework to the collected data. Finally, Section 7 offers a discussion of the main results and concludes with some policy recommendations.

## 2. Setting

### 2.1. Dairy Overview

In this section, we document the evolution of the dairy sector over time in Uganda and Ethiopia. Figure 1 shows that production in Ethiopia has increased more drastically than Uganda since 2005.<sup>1</sup> The total consumption in each country, on the other hand, has run mostly parallel in the same time frame. It should be noted that during this time Ethiopia's population has been almost three times the size of Uganda which indicates that consumption per person is much higher in Uganda.<sup>2</sup> Further, it is important to note that Figure 1 shows that each country does produce enough for its own consumption. These data also mask a high degree of heterogeneity within the two countries, with urban demand for milk products increasing at a much faster pace than in rural areas (Bachewe et al., 2017; Van Campenhout et al., 2019). Consumption is projected to further accelerate in the coming years with some East African countries, for example, having begun to promote milk consumption with school programs (Makoni et al., 2014). Despite this growth, consumption levels in both countries remain well below the global average, which is around 100 liters per capita per year (FAO, 2014). In 2016, Ethiopia averaged 8.7 and Uganda averaged 25 liters per capita per year respectively (Minten et al., 2018; Van Campenhout et al., 2019). As these types of data are difficult to find and are not perfect, our goal is to present general trends from the dairy sector in these countries. Despite the apparent similarities in the evolution of both production and consumption in both countries, the dairy sector of each country has taken differing trajectories.

### 2.2. Domestic markets and milk value chains

The milk value chains in Ethiopia and Uganda are operating within different institutional environments. In particular, the Ugandan government started the transformation and liberalization of the dairy sector in 2006 with the privatization of the only nationally owned processing company. Further, the influx of foreign direct investment into the dairy sector in Uganda, facilitated by the authorities, has significantly increased production in the sector (Van Campenhout et al., 2019). This has contributed to the rise of milk collection

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<sup>1</sup>Production data is from FAOstat and is the reported amount of whole cow milk produced.

<sup>2</sup>The consumption data comes from Minten et al. (2018) and Van Campenhout et al. (2019) and is only available for 2005, 2009, 2011, 2012 and 2016, the years in between are extrapolated.

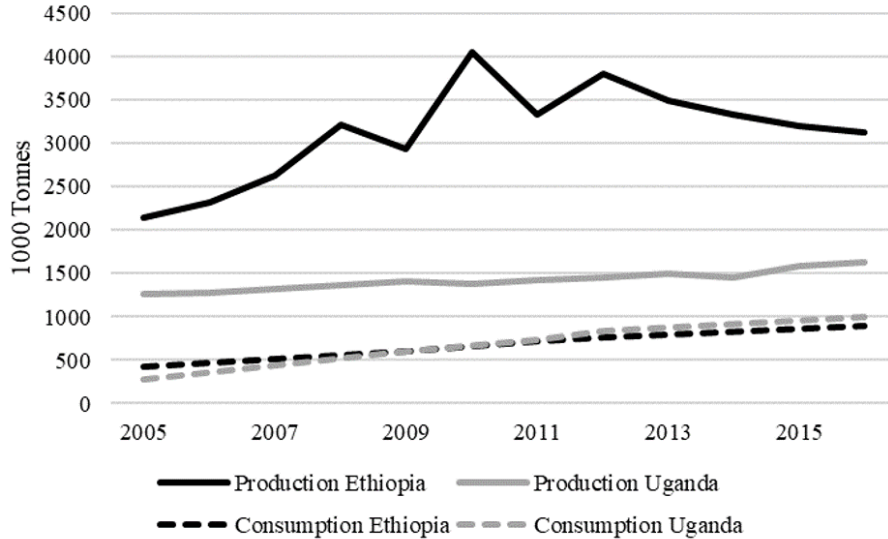


Figure 1: Milk production and consumption over time (Source: Production data: FAOstat; Consumption data: Minten et al. (2018); Van Campenhout et al. (2019))

centers (MCCs) in Uganda and to the widespread presence of cooling equipment across the different milk producing regions in the country.

The institutional changes in Uganda over the last 15 years have been an important driving force behind the drastic increase in milk production as well as milk exports. Alongside these changes, quality standards started to play a more important role in the sub-sector as well. Since the early 2000s, the government has started to provide training on milk handling and quality control (Mbowa and Shinyekwa, 2012). The rapid growth of this sub-sector does not mean that there are no challenges for dairy farmers in Uganda. The dairy sector faces high variation in seasonal production. This variation along with weak contract enforcement can translate in an uncertainty of supply upstream. Due to this, side selling is widespread (Shepherd, 2016). The natural resources of Uganda represent a key advantage for the milk sector. Because of the high availability of land, milk production costs are low especially when cows are exclusively grass-fed (Ndambi et al., 2008).

In Ethiopia, Minten et al. (2018) studied the changes in the dairy sector over the last decade. A particular characteristic of milk demand in Ethiopia is the common practice of Orthodox Christian fasting, periods during which animal products (including milk) cannot be consumed. For the most devoted Orthodox followers, fasting periods can total up to 180 days per year (D’Haene et al., 2020; Makoni et al., 2014), causing important disruptions in demand. However, D’Haene et al. (2020) found minimal price fluctuation

for raw milk in Ethiopia over various fasting periods. In addition, even though Ethiopia has the largest cattle population in Africa, productivity is low and costs of production are relatively high due to natural resource constraints (Bachewe and Tadesse, 2019; Makoni et al., 2014). Despite these factors, with the increase in demand for milk, more large processing companies have opened but the country is lagging far behind Uganda in terms of investment, particularly in the middle of the value chain.

The key difference in the operation of the value chains in the two countries is the presence of so-called milk collection centers (MCCs) in Uganda (Yilma et al., 2011). These are centers that manage the collection, storage, cooling and sales of milk in the middle of the value chain. MCCs have been present in Uganda since the 1960s with the number of them fluctuating with the dairy sector over the years. There has been a steady increase since the liberalization of the dairy sector (Mwebaze and Kjaer, 2013). The more recent growth of MCCs is due to help from the governments of Denmark and the Netherlands in funding milk coolers through Agricultural Business Initiative (aBi) grants. Some MCCs are privately owned, others are owned by a processor or by a farmer cooperative. The different types of ownership can lead to different services being offered by MCCs to their suppliers in the context of vertical coordination. The milk collection centers are open every day in the morning and the collected milk is stored in a milk cooler until it is transported. The bulked milk is transported using milk tankers to processors or other consumer outlets.

MCCs source their milk from mostly small producers who produce for home consumption and sell the excess production. Some farmers sell directly to consumers, others directly to collection centers, but most sell to middlemen. Traders and transporters who collect milk at the farm gate and transport it to MCCs. Most of these traders or transporters are small scale, usually using motorbikes (referred to locally as *bodas*) or even bicycles.

Cooling is generally absent in Ethiopian dairy value chains. If milk is not processed at the farm or consumed locally, it must be sold and transported quickly before spoilage. This has repercussions for the functioning of the entire value chain as there is a small window of time to get milk to a large processor or to the end consumer. Milk quality declines over time if the product is not either cooled to four degrees Celsius or heated and boiled (Ajmal et al., 2018; Soler et al., 1995; Bonfoh et al., 2003).<sup>3</sup> Farmers in Ethiopia

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<sup>3</sup>Ajmal et al. (2018) tested quality difference between samples that were cooled right away and those stored at approximately 35 degrees Celsius for two hours, then both samples were processed. The two hours led to shorter shelf life for the pasteurized milk and other chemical changes.



mostly produce for home consumption and then either sell their excess milk or process it into butter, cheese or yoghurt which in turn, is consumed or sold. Some sell directly to the consumer while others sell to traders. Traders in Ethiopia usually collect milk at fixed locations (either by the roadside or in the village) and the farmers bring their milk to the traders by foot or using a donkey. These traders generally use pick-up trucks with aluminum milk tanks. The traders then transport it to processing companies or directly to retail shops in the city. No cooling is involved.

### 2.3. International Trade

Both Ethiopia and Uganda are landlocked economies with trade policies that favor exports and deter imports. There is also evidence to suggest that even though Uganda is a member of a free trade area (the East African Community, EAC), the implementation and the enforcement of tariffs in particular is far from perfect. For our purposes, the crucial difference between the two countries when it comes to trade is that Ethiopia has long been a net importer of dairy products, while Ugandan dairy exports have started to grow exponentially in recent years, as shown in Figure 2.<sup>4</sup>

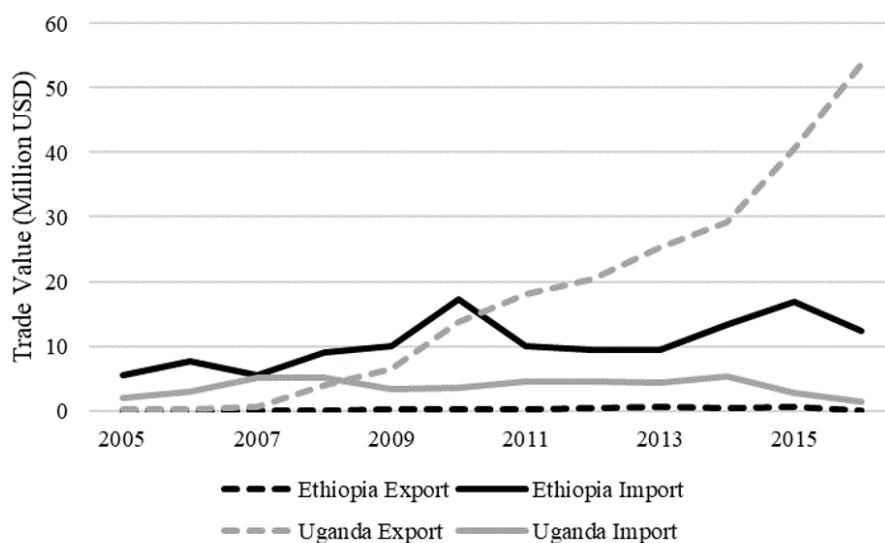


Figure 2: Import and export value (USD) of milk products over time (Source: Comtrade)

On top of that, we find that Ethiopian dairy imports are subjected to a tariff of 30 percent at the Ethiopian border and have to be imported through neighboring Djibouti,

<sup>4</sup>Comtrade recommends trade values be defined for Imports as a CIF-type value and values for Exports as a FOB-type value.

leading both to a higher tariff rate (an extra 13 percent) as well as higher transport costs. Even though Uganda (or more specifically the EAC) also imposes high tariffs on dairy imports (up to 60 percent), these are not binding for Uganda given that it is a net exporter. All in all, the evidence suggests that the differences in trade position might be an important part of the reason why milk prices at all levels of the dairy value chain are substantially higher in Ethiopia than in Uganda.

### 3. A Conceptual Framework

The previous section suggests two reasons for the diverging evolution of the dairy supply chains in Ethiopia and Uganda. Here, we bring these factors together in a conceptual framework.

The way in which trade policy is affecting price formation in the local dairy value chain is illustrated in Figure 3. As argued in Section 2.3, both Ethiopia and Uganda are small, open economies, each of them connected to the world milk market. However, while Ethiopia is a net importer of milk, Uganda is a net exporter. The price in both countries is to a large extent determined by the world price of milk ( $P_W$ ). The price paid by urban consumers in both countries though is also influenced by, on the one hand, the import tariff imposed on milk coming into the country and, on the other hand, the cost of transporting the imported milk from the point of entry to the urban center. The description of the dairy value chain in section 2.1 suggests that the combination of these costs is higher in Ethiopia than in Uganda. Therefore, the urban consumer prices in the former ( $P_E^{Ur}$ ) will be higher than urban consumer prices in the latter ( $P_U^{Ur}$ ). Consumption is at  $Q_E^D$  in Ethiopia and  $Q_U^D$  in Uganda. The domestic supply in Ethiopia is  $Q_E^S$ ; in Uganda,  $Q_U^S$ . Suppose, for now, that the supply functions of farmers ( $S_E^F$  and  $S_U^F$ ) run parallel with the urban supply functions (thus assuming that the marketing costs in the chain are constant and the same across countries). We then find that farmers in Ethiopia and Uganda will respectively receive prices  $P_E^F$  and  $P_U^F$ . Finally, imports in Ethiopia are  $Q_E^D - Q_E^S$  and exports in Uganda are  $Q_U^S - Q_U^D$ . Figure 3 thus demonstrates how differences in the trade situation (higher effective import tariffs and/or higher transport costs of imported goods) can result in large price differences for both consumers as well as farmers.

Figure 4 demonstrates the effect of (the lack of) cooling technology in light of the high perishability of milk and under the assumption of no transport costs. When there is cooling, the farm-level demand function ( $C$ ) and associated price levels decrease only

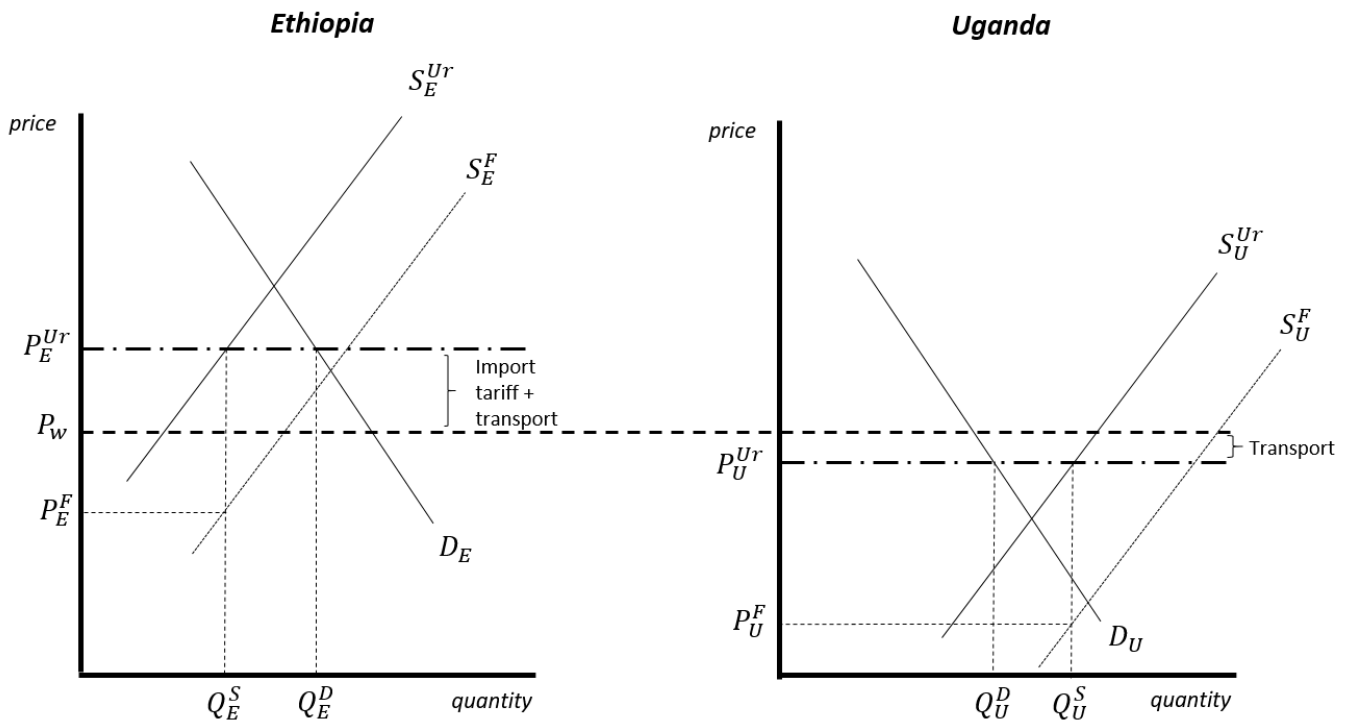


Figure 3: Conceptual framework of prices in countries with different trade and tariff policies

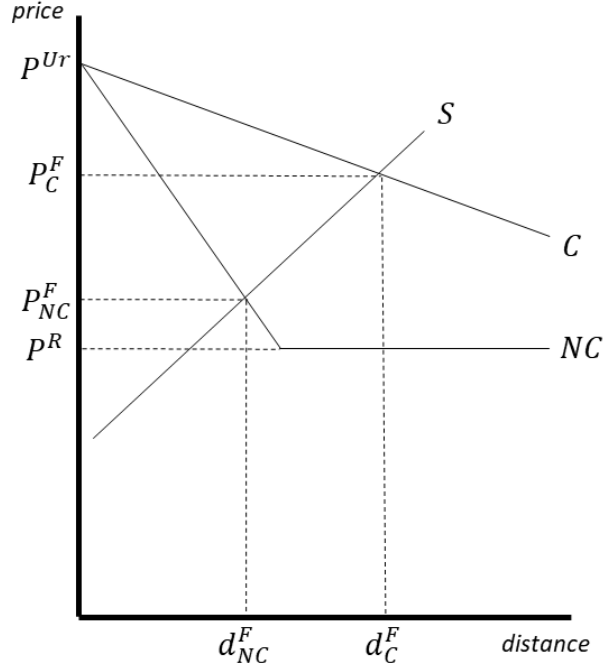


Figure 4: Stylized representation of price gradients (across distance) in function of (cooling) technology

moderately with distance. However, without cooling equipment, larger distances quickly become an issue resulting in a much steeper slope of the farm-level demand function ( $NC$ ). This continues until a ‘reservation price’ ( $P^R$ ) is reached, which refers to the local price at which milk can always be sold. Figures 3 and 4 thus demonstrate that a different institutional organization of the middle of the value chain can result in different price gradients across distance and, ultimately, in a different gap between consumer and producers prices in each country

Figure 5 then shows a stylized representation of the situation in both Ethiopia and Uganda, combining the two factors we have discussed so far, namely trade and technology. First, the large differences in trade and trade policy are depicted in Figure 3, causing the urban consumer price in Ethiopia ( $P_E^{Ur}$ ) to be considerably higher than in Uganda ( $P_U^{Ur}$ ). The lack of cooling in Ethiopia is represented by Figure 4, leading to a steeper price gradient. The trade situation explains the large differences in consumer and producer prices while technology can account for the larger gap between the two in Ethiopia.

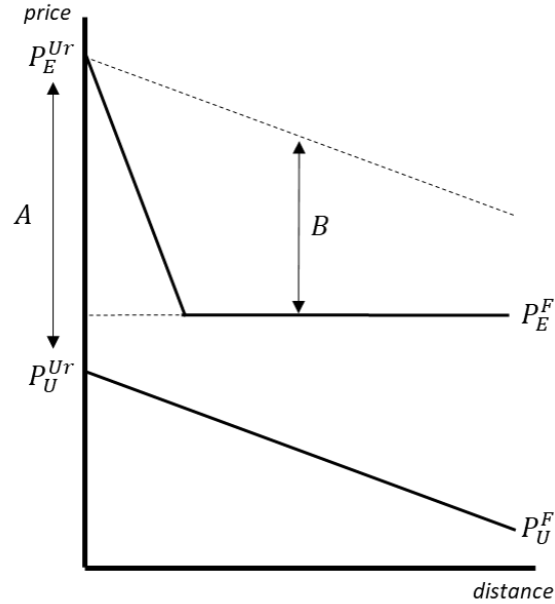


Figure 5: Combination of different explanatory factors for price differences: trade and cooling technology

#### 4. Data Collection

We use primary data on the domestic value chains supplying the capital cities of both Ethiopia and Uganda. In both countries, data was collected at different levels of the milk value chain using stacked surveys. In Ethiopia, data was collected in January and February 2018 in the dairy value chain that is supplying Addis Ababa, the Ethiopian capital city. In Uganda, data was collected in September 2018 in the central milk shed which mostly supplies the domestic milk value chain with most of the milk going to the Ugandan capital city, Kampala.

In both countries, a similar household survey was implemented among a large number of farmers in predominantly rural and sub-urban areas. In Uganda, 1,200 farmers were interviewed using a two stage random sampling strategy<sup>5</sup>. First, villages were selected with a probability proportional to village size. In each selected village, we then consulted village household lists and village leaders to randomly select dairy farmers. The number

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<sup>5</sup>These villages were randomly selected from districts and sub-counties that were stratified by distance in a somewhat ad hoc manner. For instance, some villages were chosen in Kiboga district close to the main road to Kampala, which could be considered a peri-urban setting. Other villages were chosen in areas in Masindi that were much harder to reach.

of dairy farmers selected within each village was again proportional to the total number of dairy farmers residing in the village. In Ethiopia, meanwhile, a sample of 870 dairy farmers was targeted. A three-step sampling procedure was followed whereby both woredas (comprising several villages) and villages themselves were selected to have sufficient variation in remoteness to Addis Ababa. Within the selected villages, farmers were chosen randomly from a census of all households with cows. In an effort to also include the bigger farms in the survey area, farms with more than 25 cows was targeted, resulting in an extra 13 observations.

The selected farmers in both countries were interviewed on a range of farm and household characteristics, from the household's food security to the feeding practices of their dairy animals. Several sections of the survey were dedicated to milk marketing, interactions with actors downstream in the value chain and, more generally, the management of the dairy business. This means we have extensive data on milk prices, amounts produced and sold, adoption of technology, quality of the milk and all of the important costs of production (like animal feed, medicines, and different animal breeds).

In a second step, we targeted traders who were buying dairy products from the surveyed farmers. In Uganda, 500 traders were sampled using a systematic sampling technique where enumerators interviewed the  $n$ -th trader that came to deliver milk at a given MCC, located in the different subcounties where farmers were surveyed.<sup>6</sup> In Ethiopia, 100 traders were surveyed, 50 of which were trading in milk, while the other 50 were trading in processed dairy products (like butter or cheese). To be able to compare the traders with their Ugandan counterparts, we restrict the sample to the 50 milk traders. To obtain this sample, enumerators were instructed to interview a random selection of 10 traders in those woredas selected for the farm surveys. Again, a similar survey instrument was implemented in both countries, with the bulk of the questions dealing with the trader's buying and selling practices.

Third, tracing the milk even further downstream, interviews have been conducted with MCCs (only in Uganda) and retailers (only in Ethiopia). In Uganda, we interviewed the managers of 50 milk collection centers. These were selected through simple random sampling from the list of all milk collection centers in each subcounty, obtained from the Dairy Development Authority. Shorter surveys were implemented, but crucial information

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<sup>6</sup>This most likely led to an oversampling of those traders who sell to milk collection centers, which should be kept in mind when interpreting the results.

was obtained on buying and selling of milk as well as on the type of services offered to buyers. In Ethiopia, urban retailers, operating in Addis Ababa, were selected at different administrative levels to arrive at a mix of around 250 different actors selling milk to consumers, including open market sellers, milk shops, supermarkets, mini markets and retail shops. All retailers were asked to provide details on recent dairy-related sales, we use the price of fresh milk.<sup>7</sup>

Table 1: Descriptive statistics

	Unit	<b>Farmers</b>		<b>Traders</b>		<b>MCCs</b>	<b>Retailers</b>
		Ethiopia	Uganda	Ethiopia	Uganda	Uganda	Ethiopia
Gender	% male	92	91	76	99	85	54
Age	Years	49 (14)	49 (14)	38 (10)	30 (9)		39 (20)
Schooling	Primary (0/1)	32	30	73	44	89	74
Experience	Years	11.6 (1.7)	10.6 (3.8)	7.1 (7.2)	3.1 (3.7)	3.6 (4.5)	5.9 (7.6)
Local Cows Owned	Number	1.7 (1.6)	8.6 (14.9)				
Improved Cows Owned	Number	1.1 (2.1)	6.2 (9.0)				
Milk produced	l/day	8 (15)	37 (78)				
Milk sales	%	36	100				
N		870	1,265	50	440	46	254

Source: Author's Calculations. Notes: Means are shown with standard deviations in parentheses.

Table 1 provides an overview of the different samples from the two countries as well as descriptive statistics on the agents in the value chains. We notice that, while the milk value chain is dominated by men in both countries, in Ethiopia, the proportion of women increases as milk moves downstream, with female retailers making up almost half of the sample. The average age of farmers is the same between the countries at 49 years. The traders in Ethiopia are older than their counterparts in Uganda, 38 years compared to 30 years. The average level of schooling within the chain also goes up the closer they are operating to the end consumer. In this respect, the difference in educational attainment between traders in Ethiopia and Uganda is especially striking: only 44 percent of milk traders in Uganda report having finished primary school, whereas this is the case for 73 percent of Ethiopian traders. The dairy value chain in Ethiopia seems to be more established, with years of experience in dairy being higher across the chain. On the other hand, we see that between the two countries, Ugandan households tend to own more cows

<sup>7</sup>We also have retail price data for fresh milk in Uganda for two markets near Kampala during the same time period the survey was done. Only price data was collected, therefore it is not included in Table 1.

than Ethiopian households, both local and improved. The difference in cattle ownership also means that average daily production is higher in Uganda (37 liter per day) compared to Ethiopia (only 8 liters per day). It should be noted, finally, that while the farmers in Uganda were purposefully sampled to be engaged in milk sales, this is only true for 36 percent of the Ethiopian sample. As we want to assess variables of farmers who are connected to the milk value chain, we will only focus on those 317 Ethiopian dairy farmers selling milk in the rest of the analysis.

## 5. Technology and the Value Chain

### 5.1. Descriptives

We start by documenting the characteristics of the actors in the middle of the chain and the technologies they use. In particular, we compare Ethiopian traders with traders in Uganda, as well as with Ugandan MCCs.

Table 2 shows that traders in Ethiopia are selling to a mix of consumers (26 percent), processing companies (46 percent), wholesalers (14 percent) and retailers (10 percent). In Uganda, traders almost exclusively sell to MCCs (91.8 percent). The sales pattern of MCCs in Uganda resembles that of traders in Ethiopia, with the majority of sales also going to dairy processing companies (58.3 percent). Other main buyers of MCCs include wholesalers (22.9 percent) and independent traders (18.8 percent). Table 2 further demonstrates that the differences in amounts traded between traders in both countries are high. Ethiopian traders are collecting well above 1,000 liters daily, their Ugandan counterparts are collecting just below 100 liter of milk per day. MCCs in Uganda, meanwhile, are handling daily amounts in the same order of magnitude of Ethiopian traders, around 1,800 liters. The above suggests that Ethiopian traders are more closely related to Ugandan MCCs, and Ugandan small traders are an additional link that is missing in the Ethiopian chain.

Table 2 further shows that transport costs vary. The average transport cost per liter per kilometer for traders in Ethiopia is 0.22 compared to 1.7 USD cents in Uganda. The MCCs' average transport cost is much lower than Ethiopian traders at 0.04 USD cents per liter per kilometer. The crucial difference between traders in both countries in terms of transport, however, relates to the mode of transport used. Traders in Ethiopia use trucks (62 percent) and have a high average carrying capacity (2,288 liters). In Uganda,



Table 2: Comparing actors in the middle of the chain

		Traders Ethiopia	Traders Uganda	MCCs Uganda
	Unit			
<b>Type of buyer</b>				
Consumers	%	26.0	1.2	
Retail	%	10.0	3.6	
Processing company	%	46.0	3.4	58.3
MCCs	%		91.8	
Coop Centers	%	4.0		
Wholesaler/Broker	%	14.0		22.9
Independent Trader	%			18.8
<b>Transport</b>				
Milk traded	'00 l/day	11.0 (16.3)	0.93 (0.62)	18.3 (19.8)
Transport cost	USD/l/km	0.002 (0.03)	0.017 (0.04)	0.0004 (0.01)
Mode of transport:				
Truck	%	62.0		62.0
Motorcycle	%		53.0	35.4
Bicycle	%		74.2	
Transport capacity	l	2288 (5240)	167 (86)	5598 (5485)
<hr/>				
N		50	440	46

Source: Author's Calculations. Notes. Means are shown with standard deviations in parentheses.

traders use motorbikes (53 percent) and/or bicycles (74 percent) with an average carrying capacity of around 167 liters. MCCs in Uganda are similar to the traders in Ethiopia in terms of transport practices, with trucks being used to the same extent (62.0 percent) and with considerably higher transport capacities (5,598 liters).

Figure 6 visualizes the variation in the daily amounts of milk being traded, as well as the transaction costs. We include here an important measure, the implicit transport cost faced by Ethiopian farmers. These farmers must walk their milk to the fixed location where the dairy trader purchases milk.<sup>8</sup> The average cost of transport faced by Ethiopian

<sup>8</sup>Within our sample, the farmers report their average time to walk to this fixed point and how long they usually wait there to sell their milk. The round trip and waiting time take, on average, 55 minutes. This timing can help us calculate a rough estimate of distance. Using the time it takes to walk to the trading location and a speed of walking of 4.5 kilometer per hour (as used in Vandercasteelen et al. (2019)), we then have an approximate distance. The cost of the farmer's time can be calculated using a conservative wage of 10 birr per hour. All of this information plus the amount of milk sold allows us to calculate the transport cost faced by the farmers in terms of \$ per liter per kilometer. This transport cost is a rough calculation and will not be used in the regression analysis. It is however an important point to keep in

farmers is 0.035 \$ per liter per kilometer which is the highest of all of the levels. We do not report a transport cost for Ugandan farmers because most farmers do not pay for transporting their milk.<sup>9</sup> The wide use of bodas and bicycles allow the traders to pick up milk at the farm gate. Therefore Ugandan farmers do not need to spend time selling their milk and we assume their implicit transport cost to sell milk is zero.

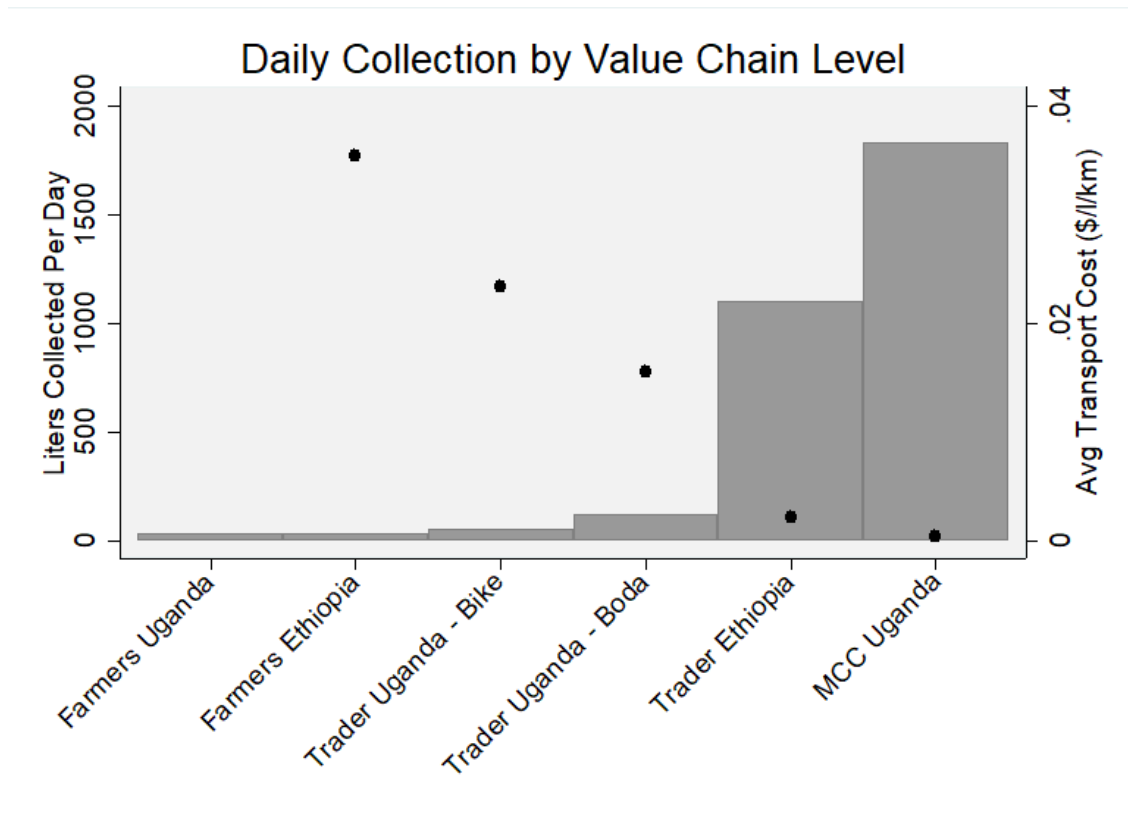


Figure 6: Milk Traded per Day by Value Chain Level

Source: Author's Calculations. Note the bars represent the liters collected in the dry season and refer to the primary y-axis and the dots represent the transportation cost and refer to the secondary y-axis.

In Figure 6, traders in Uganda barely exceed the levels sold by farmers; apparently they merely act as a link between the producers and the bulking (and cooling) stage of the value chain, with little aggregation happening at this level. The costs faced by Ugandan traders are lower than Ethiopian farmers at 0.023 \$ and 0.017 \$ per liter per kilometer for bicycles and motorbikes, respectively. Traders in Ethiopia, on the other hand, seem to bulk the milk obtained from various primary producers, and deliver it to the actors further

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mind that the price farmers receive does not take into account this cost.

<sup>9</sup>For the few farmers that do report paying a transport cost, we do not know the distance traveled.

downstream. Figure 6 also shows that Ethiopian traders have much lower transportation costs (0.002 \$ per liter per km) and Ugandan MCCs have the lowest transport cost (0.0004 \$ per liter per km). This difference is likely related to scale economies. The technological advances in Uganda, the use of bodas/bicycles and the use of coolers, which allows for more remote farmers to be included in the value chain and quality to be preserved over longer distances.

### *5.2. Structure of the value chain and technology*

As has already been argued, the structure of the milk value chain in Uganda and Ethiopia differs substantially. A notable difference is the existence of a cold chain in Uganda, but not in Ethiopia. In this section, we look at the length and structures of the dairy value chains more closely, mapping milk flows from producers to consumers. First, using farmer level data, we calculate what share of total amounts sold went to which sales outlet. In Uganda, farmers report having four possible sales outlets: consumers (Direct), retailers (R), MCCs (M) and traders/transporters (T). In Ethiopia, farmers are selling to five different possible actors: consumers (Direct), retail (R), processing companies (P), cooperatives (C) and trader/transporters (T). Second, we use trader data to assess their sales channels. In Uganda, traders are selling milk to four different outlets: consumers, retail, processing companies or MCCs. Ethiopian traders sell to the same type of buyers apart from MCCs. Finally, we also know who MCCs are selling to in Uganda and we have information on the procurement practices of retailers in Ethiopia, with distributors (D) sometimes doing the transport between processing companies and retailers.

Figure 7 shows the value chain structure for Uganda and Ethiopia separately. The difference in structure between the two countries is immediately evident. Where the average number of transactions between farmer and consumer is about four in Uganda, the value chain in Ethiopia is considerably shorter with 70 percent of the dairy products changing hands at most twice. Direct sales are substantial in both countries: around 20 percent and 15 percent of milk in Uganda and Ethiopia respectively is sold by the dairy producer to the end consumer. In Uganda, a liter of milk is most likely (about 50 percent) to be sold by the farmer to a trader, who then sells it to a MCC before being delivered to a processing company and finally ending up with a (most likely, urban) retailer. The second most prevalent situation in Uganda (apart from direct sales) is when milk does not pass through a trader, but is directly sold by the farmer to a MCC. In Ethiopia,

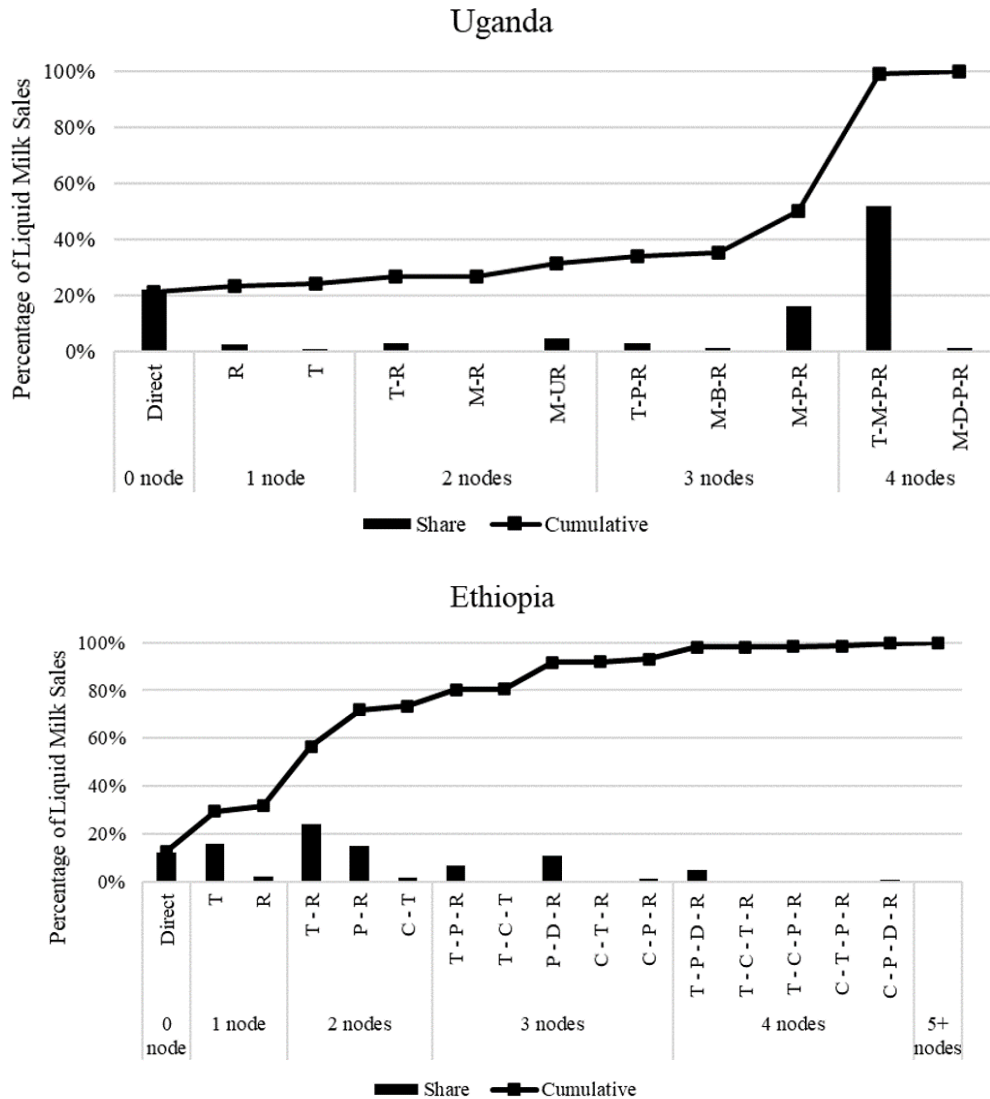


Figure 7: Value Chain Structure by Country

(Source: Author's Calculations. Direct refers to sales directly to consumers. The other abbreviations represent the following: R: Retailer; T: Trader; M: MCC; P: Processor; D: Distributor; C: Cooperative)

more combinations are possible. The most common situation (25 percent and 15 percent respectively) is when farmers are selling milk to traders or to processing companies, who deliver it to retailers directly, and then further on to consumers. The other likely scenarios are traders transporting milk between the farmer and the processing company (10 percent) or processing companies (buying directly from farmers or from traders) making use of an extra distributor to bridge the gap to the urban retailers (around 20 percent in total).

The presence of cooling technology has thus allowed Uganda to develop a long cold chain for milk, whereas in Ethiopia the value chain is much shorter and unrefrigerated.

After all, as there are more opportunities for cooling the milk along the value chain, a role performed by MCCs in Uganda, the perishability of milk becomes less of an issue. Conversely, when there is no (or limited) cooling, even short distances quickly become insurmountable, resulting in the steep price gradients in Ethiopia, something we turn to in the next section.

## 6. Price and Distance

### 6.1. Descriptives

Now that we have a sense of the value chain structure in both countries, we explore differences in the price gradients across distance – a second important feature of our conceptual framework developed in Section 3. To calculate the price gradients, defined as the change in price as distance to consumer markets (Kampala and Addis Ababa) changes, we use travel time (using road network data in both countries) for the different actors in the value chain.<sup>10</sup> Distance to large consumption hubs have been shown to be driving factors for many agricultural outcomes (Vandercasteelen et al., 2018; Stifel and Minten, 2008).

Table 3: Price and Distance

	Unit	Farmers		Traders		MCCs	Retailers	
		Ethiopia	Uganda	Ethiopia	Uganda	Uganda	Ethiopia	Uganda
Price	(\$/PPP)	1.40 (0.32)	0.69 (0.16)	1.53 (0.43)	0.85 (0.14)	0.88 (0.10)	2.45 (0.30)	1.37 (0.14)
Distance City	hrs	2.2 (1.3)	2.8 (0.74)	1.2 (0.51)	2.4 (0.53)	2.8 (0.49)		
Distance MCC	hrs		0.40 (0.31)					
N		256	882	50	440	46	56	60

Source: Author's Calculations. Standard deviations are in parentheses.

Table 3 presents the descriptive statistics for price and distance for the actors in our value chains. The mean price that farmers in Ethiopia received for a liter of fresh milk was \$1.40, while for the farmers in Uganda this was \$0.69. The surveyed farmers in Ethiopia

<sup>10</sup>The travel time is travel by car under usual road conditions. It was calculated using the Stata command *georoute* developed by Weber and Péclat (2017). This command utilizes mapping data to calculate the route distance between two locations instead of calculating a straight line which is often used. We used the GPS coordinates of the respondent and a central location in the city. Some farmers did not have GPS coordinates which explains the small drop in the number of observations for farmers in both countries.

live, on average, just over two hours from the city and farmers in Uganda live almost three hours away. However, farmers in Uganda live less than 30 minutes from a MCC. Traders in Ethiopia sell milk for an average of \$1.53 per liter, while those in Uganda only sell a liter for \$0.85, seemingly indicating slightly higher margins in Uganda for these traders. Traders in Ethiopia were interviewed in locations that were on average 1.2 hours from the city and this was double for those in Uganda. The MCCs in Uganda sell milk, on average, for \$0.88 per liter and are 2.8 hours away from Kampala. The price of milk from retailers in the cities averages \$2.45 in Ethiopia and \$1.37 in Uganda. From our sample, we see that prices are higher across all value chain levels in Ethiopia but these traders are also working closer to the city. We will analyze this relationship in the next sections with price gradients.

## *6.2. Non-Parametric Regressions*

We start by looking at producers upstream in the value chain. Figure 8 shows that the farm-level demand functions in both Ethiopia and Uganda are consistent with the conceptual framework.<sup>11</sup> Focusing first on the comparison between Ethiopia and Uganda, price gradients start from a higher level and are considerably steeper in Ethiopia compared to Uganda. As one moves further away from the Kampala market in Uganda, prices do not really change, resulting in a (mostly) flat price gradient. Conversely, in Ethiopia, there is a large drop in prices as soon as you are located beyond one hour of travel time from Addis Ababa.

One may argue that the difference between Uganda and Ethiopia is due to the fact that, in Uganda, there are no farmers located closer than one hour travel time to Kampala. Perhaps, in Uganda, the absence of a steep gradient is due to missing data. For this reason, we include Figure 9, which uses distance to the nearest MCC for Ugandan farmers. This now compares price and distance for the non-cooled value chain in Ethiopia with the non-cooled segment of the value chain in Uganda. We find that also in this distance radius, the price gradient remains flat in Uganda. The fact that we see different price gradients in a section of the value chain that is characterized by the absence of cooling in both countries, is interesting. It suggests that there is little risk for quality deterioration once

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<sup>11</sup>Farmers who reported neighbors as their main buyer of fresh milk are not included in this figure. 22 percent of farmers in Ethiopia and 29 percent of farmers in Uganda report their neighbors as the main buyers of their milk.

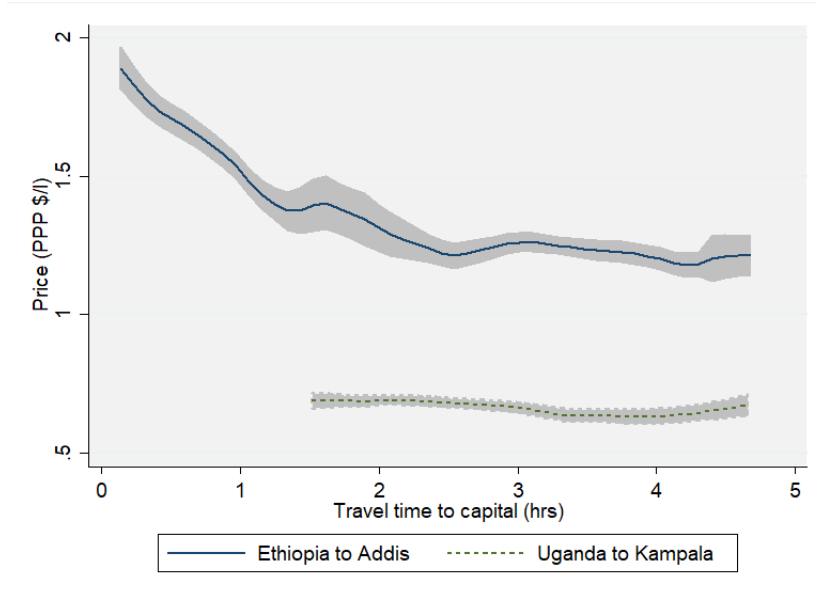


Figure 8: Price gradient (across distance to city) for farmers in Ethiopian and Ugandan milk value chains (95 percent confidence intervals are shown) Source: Author’s Calculations.

the milk has been chilled within a certain period of time. Most likely, in Uganda, there is also selection going on, with milk that requires transport times in excess of 1 hour being rejected. It also suggests that, in Ethiopia, most of the quality risk premia are passed on to the most remote farmers.

### 6.3. Price Regressions

While Figures 8 and 9 suggest that distance plays an important role, we also want to account for potential confounding factors with a regression analysis. We implement a regression model, where the price of the product is considered to be a function of different embedded characteristics of that product.<sup>12</sup> Similar types of analyses have been conducted in the context of value chain research in developing countries, for example in studies on retailing in India (Minten et al., 2010) and Thailand (Schipmann and Qaim, 2011), but also in studies that cover the whole value chain, like teff in Ethiopia (Minten et al., 2016a).

In our methodology, the retail price per liter of liquid milk is regressed on variables for the type of retail outlet, whether the product was sold directly to the consumer, and distance. We use distance to the city for both countries and also explore distance to the nearest MCC in Uganda as it is here the milk is refrigerated and the quality maintained.

<sup>12</sup>See Lancaster (1966) for more details.

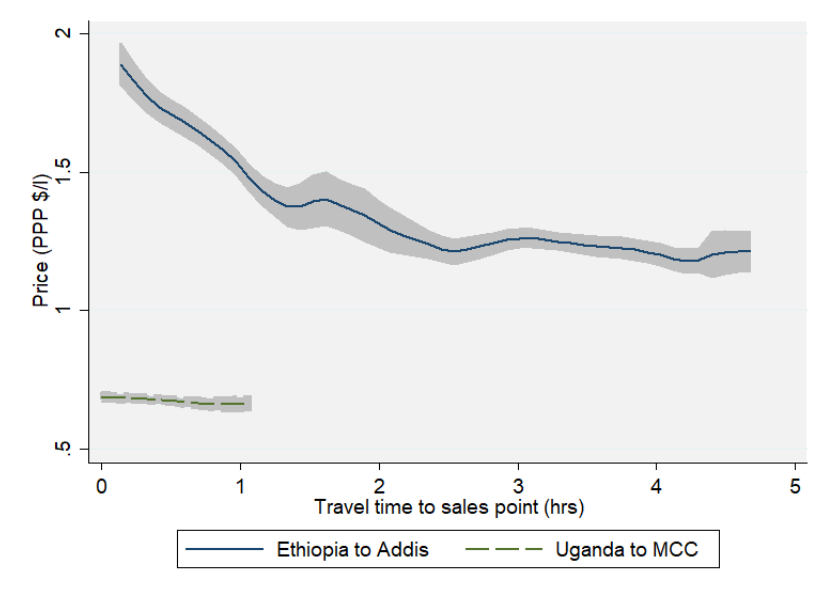


Figure 9: Price gradients (across distance to city or MCC) for farmers in Ethiopian and Ugandan milk value chains (95 percent confidence intervals are shown) Source: Author's Calculations.

In particular, regressions of the following form are run:

$$p_h = \sum \beta_{hk} X_h^k + \epsilon, \quad (1)$$

where the price of milk (in PPP terms) at different levels of the chain,  $p_h$ , is regressed on a series of attributes  $k$  of product  $h$ ,  $X_h^k$ .  $\beta_{hk}$  is the implicit price and  $\epsilon$  is the error term, clustered at the village level in Ethiopia and at the subcounty level in Uganda. The attributes included are the level of the value chain (retail, MCCs, traders and farmers), distance, selling directly to consumers and a dummy variable for the country.<sup>13</sup> The results are shown in Table 4.

The results of Table 4 are consistent with the price gradients observed in Figures 8 and 9. The dependent variable in Models 1 and 2 is the absolute price price of milk per liter and the dependent variable in Models 3 and 4 is the log transformation of the price of milk, therefore providing the relative price changes. Models 1 and 3 present the results which include the variables for the value change level, distance and whether or not the respondent

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<sup>13</sup>In an ideal data set, we would also have quality variables for the product at each level. However, our aim is not to describe what defines the milk price as this would need a great deal more of data, our aim is to further understand the price differences at each level in relation to distance from the city. We are not claiming causality, only studying the correlations.



sold directly to a consumer. We find, with the retail price as the reference category the average price per liter of milk in Uganda is \$1.082 lower than it is in Ethiopia. As Ethiopia is the reference group, the next variable ‘Sell Direct Consumer’ refers to the situation in Ethiopia. This result indicates that when the respondent (except for retailers because they always sell to the consumer) sell directly to a consumer in Ethiopia, they earn \$0.324 per liter more than their counterparts within their country who do not. Next, ‘Uganda x Sell Direct Consumer’ presents the results for Uganda. The coefficient must be interpreted together with the Ethiopian result for the difference of selling to directly to the consumer between countries, meaning Ugandans earn only \$0.056 more per liter if they sell directly to consumers, compared to Ethiopians. The ‘Uganda’ coefficient must also be included when calculating the overall price effect for Uganda. The overall results suggest that direct sales to consumers are rewarded possibly because of the transaction costs involved (because of the small size) or because consumers are willing to pay a premium to be able to buy from a trusted source.

With regard to the value chain levels, before we consider distance, we see that the Ethiopian coefficients for farmers and traders are significant and negative (which is expected given the reference price is retail and should be the highest).<sup>14</sup> The interactions with Uganda will inform us if Uganda has any further differences with Ethiopia aside from the \$1.082 country difference in price. For farmers there is a minimally significant positive effect and for traders we find no significant effect. This indicates that farmers in Uganda have a smaller margin of price difference between the retail price compared to those in Ethiopia. However, traders in Uganda do not have a statistically significant difference in their margins when compared to traders in Ethiopia. The MCCs are also significant and negative as expected.

We next include distance to the city measured as driving hours in typical conditions. We see the results for Ethiopian farmers and traders are negative and significant and the results for Uganda are positive and significant. This indicates that distance results in a greater absolute loss in price of milk in Ethiopia than Uganda.<sup>15</sup> An interesting result is

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<sup>14</sup>We want to note that the estimate for Ethiopian farmers does not take into account their implicit transportation cost incurred from walking their milk to the traders that was discussed earlier. Therefore this estimate is a lower bound and the total price difference between the price received by farmers and the retail price is slightly higher. We do not think this additional cost would change our results drastically.

<sup>15</sup>Models 3 to 4 will study the relative changes and see if this holds.

that traders in Uganda seem to earn more per liter the farther away they are. Once both coefficients are combined, these traders earn \$0.015 more per hour of distance compared to the Ethiopian traders. This could be a result of the technology as there may be more or larger MCCs further from the city and once the milk is cooled, the distance will not affect the price as much. We also have a much larger sample of traders from Uganda than Ethiopia.

The next specification, Model 2, includes the square of the distance to the city. The square of the distance to the city is included because our conceptual model suggests a non-linear relationship between price and distance, and this non-linearity is also reflected in the non-parametric regressions in Figures 8 and 9. The results have a couple main differences from the first specification. Farmers in Uganda no longer have a further price difference from their counterparts in Ethiopia aside from the country difference which is still \$1.082 per liter.

Traders in Ethiopia no longer have a significant price difference between the retail price. This lack of significance could however be due to our small sample size. We also now find traders in Uganda do earn less than traders in Ethiopia. With respect to distance, we again see that distance does seem to affect the Ethiopian price more than the Ugandan price with the Ugandan coefficients almost offsetting the Ethiopian ones. With regard to distance we see that the reduction in price per hour is even higher for Ethiopia than in Model 1, but the positive coefficient estimate for the interaction with distance squared indicates that the reduction is less the larger the distance. The Ugandan coefficient for distance squared is negative and has a slightly higher absolute value which means that the prices the more remote farmers receive are more affected by distance than the less remote farmers, however the magnitude of this is very small. The same is also true of the traders in both countries. We will see if this result holds in the relative price differences.

In Model 3, we find that the price of milk in Uganda is 58% less than in Ethiopia. We again find that selling directly to the consumer earns a higher price, although this premium is a higher share in Ethiopia than Uganda. We again find that each level in the value chain earns less than the retail price with minimal differences in this amount between the two countries. When we study the distance variables, we start to see different results than the absolute price differences. The distance that farmers are from the city is correlated to a significant and negative coefficient which suggests that in Ethiopia, more remote farmers earn less per liter. There is no significant finding on the Uganda coefficient

for this variable which means those farmers face about the same price difference when it comes to distance. Traders in Ethiopia have a larger margin of price difference when it comes to distance, earning 23.4% less for each additional hour of travel. In Uganda, traders actually earn 1.1% more per additional hour of travel suggesting that distance does not negatively affect their price. This is likely a result of cooling technology because those remote traders probably do not transport milk to the city due to spoilage. They sell to MCCs that are able to cool it and maintain quality. MCCs again have no significant findings with respect to distance.

Model 4 includes the distance variables squared. One main difference we find between the variables that we have already studied is that now MCCs no longer have a price difference compared to the retail prices. Also, the coefficient for Ethiopian farmers and their distance is now much higher. With regard to distance squared we again see a positive coefficient estimate for the interaction with distance squared which indicates that the reduction is less the larger the distance. However, the Ugandan coefficient is no longer significant which means those farmers face the same price changes as Ethiopian farmers with regard to measures of distance. We find the same pattern for traders in Ethiopia that we did for farmers. Traders who operate further from the capital earn less per liter but the reduction in price due to distance is less for more remote farmers. Ugandan traders tend to earn more the further away they are from the capital.

## 7. Conclusion

This paper offers insights into milk value chains in two East African countries: Ethiopia and Uganda. While both countries have seen similar trends in both production and consumption of milk and are facing similar challenges in further transforming their respective dairy sectors, we find two crucial differences in pricing: both consumer and producer prices as well as the gap between the two are higher in Ethiopia than in Uganda. We present a conceptual framework that allows us to explain these differences. Differences in prices between countries at all levels can be explained by trade policy and trade position, while differences in price margins can be explained by differences in the organization of the value chains, including the use of modern cooling technology.

Using primary data collected among different actors of the value chain, we show that there are important differences in terms of the structure and technology used in the milk value chain in both countries. In particular, in Uganda, we find that producers are con-

nected to processors and/or consumers through small traders who collect milk at the farm gate and bulk it in milk collection centers, where the milk is chilled for further transport. In Ethiopia, assembly traders seem to be absent, and farmers have to carry their milk to traders that collect milk at fixed points in villages at particular points in time. These traders are thus bigger than the assembly traders in Uganda. In fact, they rival milk collection centers in capacity. However, these traders do not cool the milk they collect, exposing them to greater risk related to milk quality. The efficiency of the Ugandan value chain helps in making Ugandan milk competitive in the world market; in Ethiopia, there is a milk deficit, and import tax means that the reference price for the sector is relatively high, providing little incentive for the value chain upgrading.

Our research illustrates how outcomes upstream in the value chain are linked to the structural and technological differences in the middle of the value chain. For instance, it shows that shorter value chains, with fewer links, are not necessarily more efficient than value chains with many different actors. In Uganda, small traders with only a bicycle or motorbike and a few milk cans specialize in collecting milk from dozens of farmers on a daily basis at very competitive fees. While many studies have stressed the importance of this type of traders, policy makers and NGO's often still believe that cutting out the middlemen is bound to benefit smallholder farmers (Sitko and Jayne, 2014). Furthermore, it also shows how investing in technology in the middle of the value chain can improve outcomes for actors further upstream. In Uganda, we see that technology that increases shelf life increase the price that farmers in remote locations get relative to Ethiopia, where traders seem to pass risk premia down to the farmers.

Table 4: Hedonic Price Regressions: \$PPP/liter

	Absolute Price		Relative Price	
	(1)	(2)	(3)	(4)
Uganda	-1.082*** (0.045)	-1.082*** (0.045)	-0.580*** (0.026)	-0.580*** (0.026)
Sell Direct Consumer=1	0.324*** (0.057)	0.276*** (0.052)	0.190*** (0.034)	0.160*** (0.031)
Uganda × Sell Direct Consumer=1	-0.268*** (0.060)	-0.220*** (0.055)	-0.105** (0.044)	-0.075* (0.043)
Farmer=1	-0.853*** (0.117)	-0.634*** (0.157)	-0.434*** (0.069)	-0.294*** (0.091)
Uganda × Farmer=1	0.247* (0.128)	0.003 (0.229)	-0.163 (0.098)	-0.320 (0.274)
Trader=1	-0.533** (0.205)	0.378 (0.245)	-0.269** (0.124)	0.286* (0.143)
Uganda × Trader=1	-0.018 (0.218)	-1.126*** (0.354)	-0.262* (0.156)	-1.079*** (0.371)
MCC=1	-0.420*** (0.066)	-0.231 (0.301)	-0.364*** (0.067)	-0.132 (0.335)
Farmer Distance (City)	-0.121*** (0.035)	-0.398*** (0.129)	-0.082*** (0.021)	-0.259*** (0.079)
Uganda × Farmer Distance (City)	0.087** (0.037)	0.383** (0.179)	0.029 (0.028)	0.219 (0.212)
Trader Distance (City)	-0.397** (0.153)	-2.199*** (0.377)	-0.234** (0.095)	-1.330*** (0.236)
Uganda × Trader Distance (City)	0.412*** (0.156)	2.374*** (0.420)	0.255** (0.101)	1.564*** (0.340)
MCC Distance (City)	-0.023 (0.023)	-0.156 (0.208)	-0.026 (0.024)	-0.191 (0.233)
Farmer Distance (City) Squared		0.060** (0.024)		0.039** (0.015)
Uganda × Farmer Distance (City) Squared		-0.064* (0.032)		-0.041 (0.038)
Trader Distance (City) Squared		0.744*** (0.150)		0.452*** (0.098)
Uganda × Trader Distance (City) Squared		-0.775*** (0.154)		-0.494*** (0.107)
MCC Distance (City) Squared		0.023 (0.035)		0.028 (0.039)
Constant	2.452*** (0.035)	2.452*** (0.035)	0.889*** (0.014)	0.889*** (0.014)
$R^2$	0.843	0.853	0.718	0.723

Notes. N = 1790. Dependent variables are prices in PPP dollar terms (Models 1-2) and log prices in PPP dollar terms (Models 3-4). The reference group for the value chain levels is retail. Cluster robust standard errors are shown in parentheses. \*\*\*, \*\*, \* indicate two-sided significance levels at 1, 5, and 10 %, respectively.

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# Appendix

## A. Price Distribution

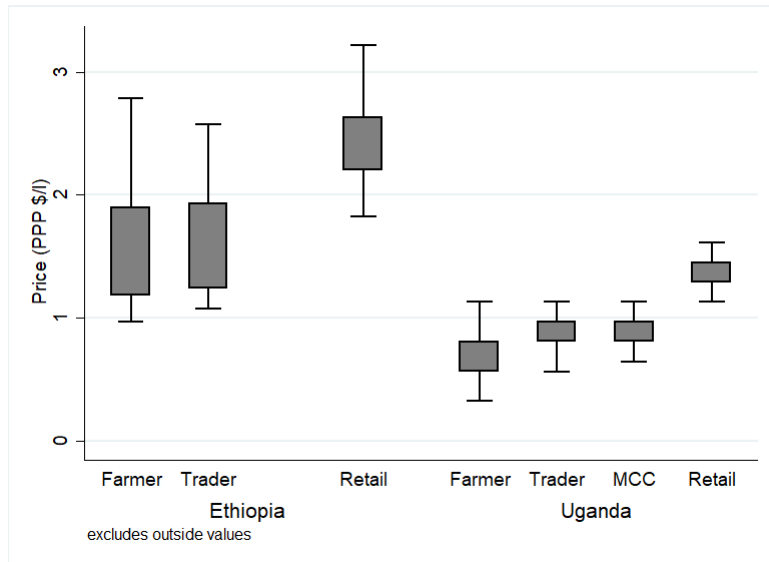
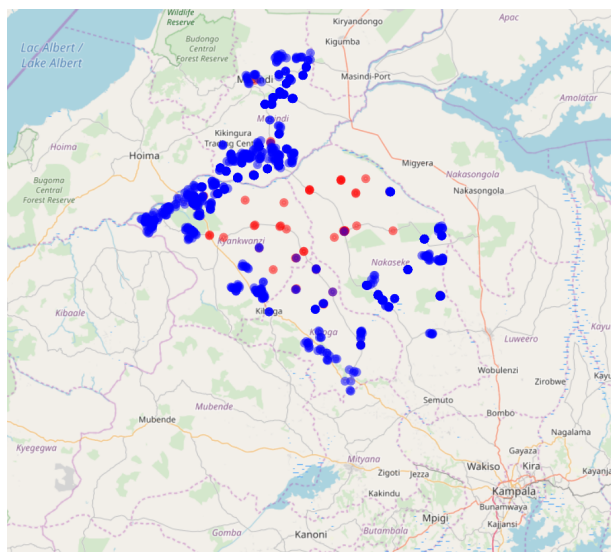


Figure A.1: Price Distribution by Value Chain Level

## B. Maps



Ethiopian Farmers (blue)

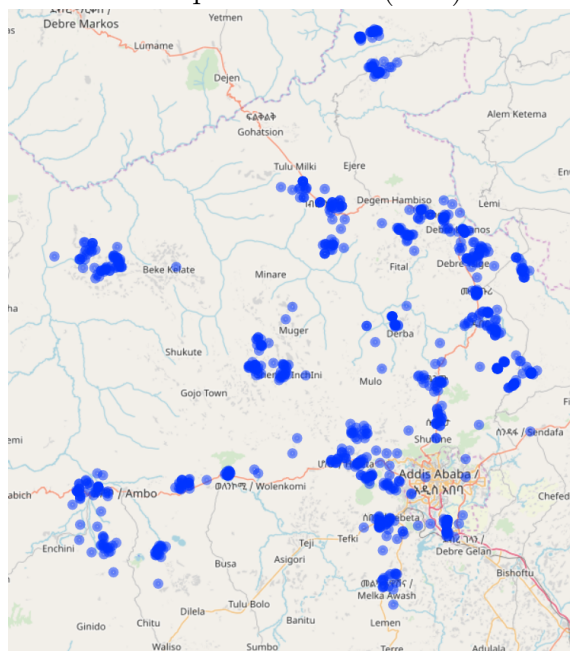


Figure B.1: Ugandan Farmers (blue) and MCCs (red)

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