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 milk 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 likely 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 farmers remoteness on prices and therefore allow for more geographically extended value chains.

1. Introduction

Over the past few decades, African economies have been going through expansion and urbanization, leading to drastic increases in the demand for agricultural products, particularly those with high income elasticities like dairy (Colen et al., 2018; Delgado, 2003).

The development of dairy sectors comes with large opportunities for economic growth and agricultural transformation, especially for poor producers (Gulati et al., 2007; Ngigi, 2004; Cunningham, 2009). In the case of milk, the benefits are increased through milk's benefits for health and child nutrition outcomes (Hoddinott et al., 2015; Headey et al., 2018). Ethiopia and Uganda, two East African countries, are good illustrations of this trend: both have seen the demand for and production of dairy products rising in recent years and within the region they are considered to have the highest growth potential for milk (Makoni et al., 2014). However, due to different types of trade, domestic policies, and adoption of technology, the transformation of the dairy value chain in the two countries has taken different paths, making a detailed comparison between the two markets interesting.

This paper contributes to the growing literature on the analysis of agricultural value chains by using unique primary data on different actors in milk value chains collected through a method of stacked surveys. Many studies focus on a single commodity in a single country like teff in Ethiopia (Minten et al., 2016), dairy in India (Janssen and Swinnen, 2019) and Ethiopia (Francesconi et al., 2010) or the vegetable sector in Senegal (Maertens and Swinnen, 2009) and Madagascar (Minten et al., 2009). However, several have also started to look at comparisons of value chains across different countries, on issues like quality (Vandeplas and Minten, 2015), the inclusion of smallholders into the value chain (Barrett et al., 2011), or value chain coordination (van Berkum, 2007). Particular attention in this paper will be paid to the middle of the value chain (between producers and consumers) which is often poorly understood and considered to be populated by a large number of small traders, characterized as 'evil' actors or even 'parasites' (Sitko and Jayne, 2014). However, the middle is often treated as a black box with little attention being paid to the actual marketing behavior of the people populating it (Reardon, 2015). By analyzing how the actors in the middle might vary across different countries, we add to the growing literature on traders and other middlemen in developing countries (see, among others, Fafchamps et al., 2005 and Liverpool-Tasie et al., 2017).

We aim to detail and explain different value chain dynamics in otherwise similar countries. We find that the differences between both countries can best be explained using a conceptual framework that combines two factors: world market participation on the one hand and a value chain related factor on the other, namely technology. The former explains the differences in

consumer and producer milk prices, while the latter results in steeper price gradients across distance from the city in Ethiopia and thus explain the larger gap in prices. We show that the main difference in the functioning of the value chain between the countries is the presence of milk collection centers (MCCs) leading simultaneously to a higher coverage of refrigeration in the chain (technology). Another factor, competition or a difference in market power between the two countries, could be argued to influence the price difference, however this, as explained later, is probably not the case and therefore we will not include this in the analysis.

The rest 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

Ethiopia and Uganda, the two study settings in this paper, have seen changes in consumption over the recent decades. Two main drivers of this shift are income growth and urbanization. Table 1 presents the 2018 GDP per capita and urbanization rate for each country. These two indicators are similar for each county and have taken similar paths over time, yet this growth has not translated into the dairy sector.

Table 1: Country Indicators

	Ethiopia	Uganda
GDP per capita (PPP $)	2,033	2,019
Urban Population (%)	20.8	23.8

Source: World Bank Development Indicators 2018

2.1. Dairy

In regard to the dairy sector we explore transformations overtime within each country. Figure 1 shows that production in Ethiopia has quadrupled while production in Uganda has tripled since 2000. Average consumption, on the other hand, has risen faster in Uganda compared to Ethiopia since 2005. These averages 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 rise even more sharply in the coming years with some East African countries, for example, having begun to promote

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milk consumption with school programs (Makoni et al., 2014). Levels of consumption in both countries remain well below the global average though, which is around 100 liters per capita per year (FAO, 2014). In spite of the apparent similarities in the evolution of both production and consumption in the two countries, the dairy sector of each country has taken diverging paths. The countries have different policy approaches to their domestic markets as well as their difference in participation in the world market. Below, we describe each of them in turn.
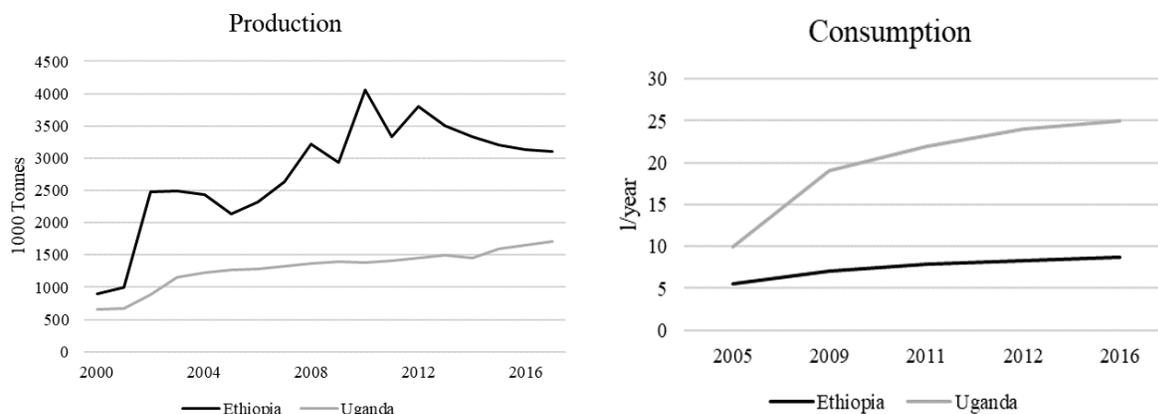

Figure 1: Milk production and consumption over time (Source: FAOstat, Uganda National Panel Survey, Ethiopia Central Statistics Agency)

2.1.1. Domestic markets and milk value chains

The milk value chains supplying the capital cities of Ethiopia and Uganda are operating within different policy 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. A similar process was announced in Ethiopia in 2015 with the government's Livestock Master Plan (Shapiro et al., 2015), however this plan has yet to come to fruition. Further, the influx of foreign direct investment into the dairy sector in Uganda, facilitated by the authorities, has only increased production in the sector. It has partly contributed to the rise of MCCs in Uganda and to the widespread presence of cooling equipment across the different milksheds in the country. More processors have opened in Ethiopia in recent years, but the country has not received the same level of investment as Uganda.

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 more important roles in the sector as well. Since the early 2000s, the government has started giving training on milk handling and quality control (Mbowa and Shinyekwa, 2012). The rapid growth of this sector does not mean that there are

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no challenges for dairy farmers in Uganda. The dairy sector faces low prices and high variation in seasonal production. This variation along with weak contract enforcement can translate in an uncertainty of supply downstream. Due to this uncertainty, side selling is widespread as farmers will sell to whomever offers the best price, not to the party with which they have a contract (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 (Makoni et al., 2014), causing important disruptions in demand. In addition, even though Ethiopia has the largest cattle population in Africa, productivity is low and costs of production are higher due to natural resource constraints (Makoni et al., 2014). Despite these factors, with the increase in demand for milk, more large processing companies have opened. However, Ethiopia lags behind Uganda in terms of the adoption of advanced technologies, most notably cooling (Yilma et al., 2011).

The key institutional difference in the operation of the value chains in the two countries is the presence of so-called milk collection centers (MCCs) in Uganda. 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. There are different types of MCCs, some 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. For example, processor-owned centers want to ensure quality and therefore may pay premiums or provide more training to be able to meet stringent hygienic standards. Upstream in Uganda, farmers are mostly small producers who produce for home consumption and sell the excess production. Some sell directly to consumers, others directly to collection centers but most sell to middlemen. The midstream of the value chain is populated by (in addition to MCCs) a large number of traders and transporters who pick up the milk at the farm gate usually using motorbikes (referred to locally as *bodas*) or even bicycles. These intermediaries then transport the milk either to an MCC, a retailer or directly to consumers. 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 to processors or other consumer outlets.

A weakness of the dairy sector in Ethiopia is thus the lack of cooling facilities within the value chain. 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).[1] Farmers in Ethiopia 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. After which the traders transport it to processing companies or directly to retail shops in the city. In some cases, trucks are used for transporting the milk cans to overcome the lack of cooling equipment.

2.1.2. International Trade

Now that we have explained the domestic dairy market and value chain in each country, we study each country's participation in the world market to help understand the difference in milk prices between Ethiopia and Uganda.

Both Ethiopia and Uganda are relatively open, but 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. 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, leading both to a higher tariff rate (an extra 13 percent) as well as higher transport costs. Uganda, or more specifically, the EAC, also imposes high tariffs on dairy imports (up to 60 percent), but these are not binding for Uganda given that it is a net exporter. All in all, the evidence suggests that the differences in trade might be an important part of the reason why consumer (and producer) prices of milk differ substantially between Ethiopia and Uganda. Interestingly though, they cannot account for the larger gaps between consumer and producer

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[1] 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.
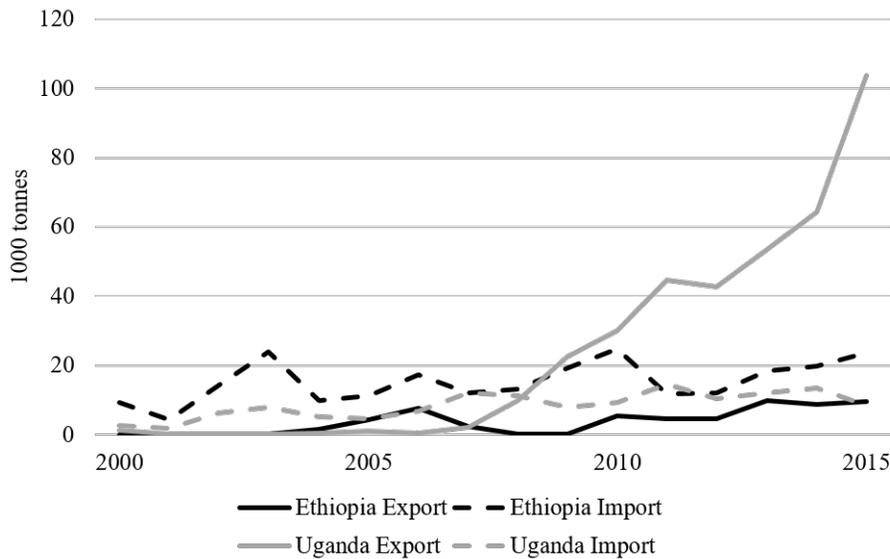
prices in Ethiopia compared to Uganda.

Figure 2: Imports and exports of milk products over time (Source: FAOstat)

3. A Conceptual Framework

The overview in the previous section suggests at least two potential factors that could each explain part of the difference in the price of milk between Ethiopia and Uganda: trade and technology (cooling). Here, we aim to bring these factors together using a conceptual framework.

The trade impact is illustrated in Figure 3. As argued in Section 2.1.2, both Ethiopia and Uganda are small, open economies, each of them connected to the world milk market (which is dealing mostly in powdered milk). Ethiopia is a net importer of milk and Uganda is a net exporter. We can then say that the price in both countries is to a large extent determined by the world price of milk (P_W). The price paid by the 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. We have seen that the combination of those 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 and Q_U^D. The domestic supply is Q_E^S and Q_U^S respectively. Supposing (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 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
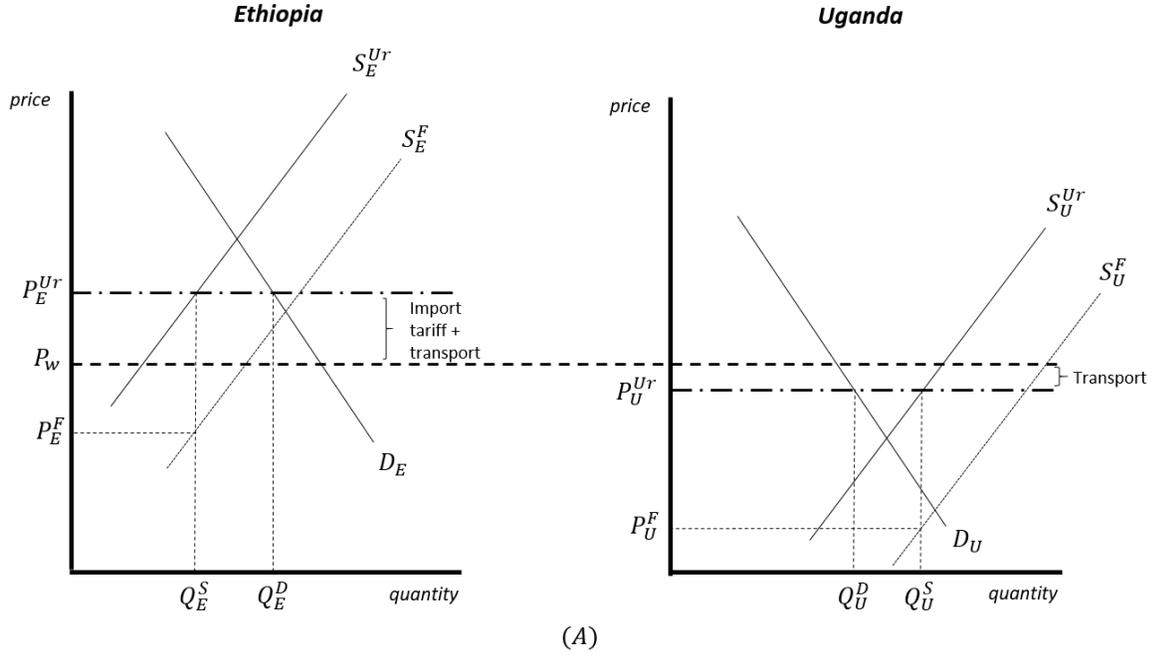
Ethiopia

Uganda

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

effective import tariffs and/or higher transport costs of imported goods) 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 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 will result in different price gradients across distance and, ultimately, in a different gap between consumer and producers prices.

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 as A, 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 B, 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. In the rest of the paper, our objective is to validate this conceptual framework using the data we have collected.
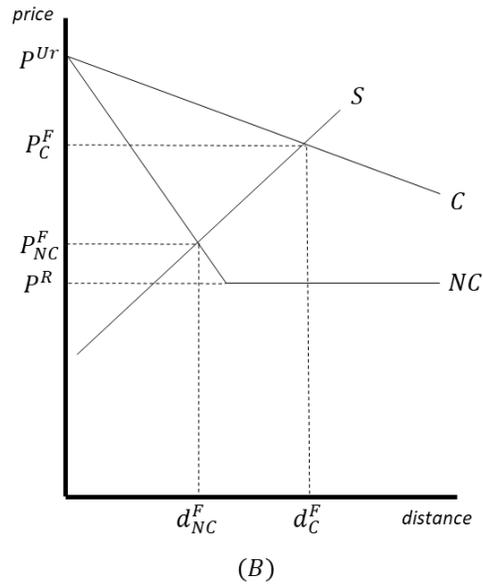
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Figure 4: Stylized representation of price gradients (across distance) in function of (cooling) technology
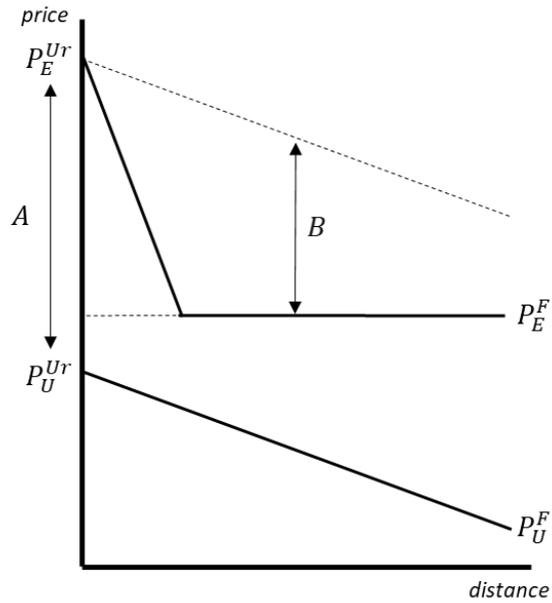

Figure 5: Combination of different explanatory factors for price differences: trade (A) and cooling technology (B)

4. Data Collection

We use unique primary data on the domestic value chains supplying the capital cities of both Ethiopia and Uganda. In both countries, data was collected at different stages of the milk value chain using a method of stacked surveys. This method provides us with a wealth of unique primary data which allows us to say something meaningful about different actors across the value chain. 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, representative number of farmers in predominantly rural and sub-urban areas. In Uganda, 1,200 farmers were interviewed using a two stage random sampling strategy. First, villages were selected with a probability proportional to village size. In each selected village, we then consulted village household lists to randomly select farmers. The number of households selected within each village was again proportional to the total number of households 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 host of farm and household characteristics, ranging from the household's food security to the feeding practices of their dairy animals. Crucially for our purposes though, several sections of the survey were dedicated to the marketing of the milk, 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 feed, medicines and, of course, the cows themselves).

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 nth trader that came to deliver milk at a given MCC, located in the different subcounties where farmers were surveyed.[2] In Ethiopia, 100 traders were surveyed, 50 of which were trading in milk while the other 50 were trading in processed dairy products

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[2]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.

(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 the administrative centers of 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 manager or employee 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 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.[3]

Table 2: Descriptive statistics

| | | Farmers | | Traders | | MCCs | Retailers |
	Unit	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	1,264	50	541	55	254

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

Table 2 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

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[3]We also have retail price data for milk in Uganda for a couple of markets near Kampala. Only price data was collected therefore it is not included in Table 2.

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 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

Here, we focus more explicitly on the technology and characteristics of the actors in the middle of the chain in both countries. In particular, we compare Ethiopian traders with their counterparts in Uganda as well as with Ugandan MCCs. The results of this comparison are shown in Table 3.

First, we have information on the direct buyers of different actors across the chain. Whenever any of these actors sell to two or more buyers, we select the biggest buyer (in value terms) as the main buyer. Table 3 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) whereas sales from traders in Uganda are almost exclusively going to MCCs (91.8 percent). The sales pattern of MCCs in Uganda mirrors closely 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 3 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.

Table 3: Comparing actors in the middle of the chain

	Unit	Traders Ethiopia	Traders Uganda	MCCs Uganda
Type of buyer				
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
Transport				
Milk traded	'00 l/day	11.0 (16.3)	0.93 (0.62)	18.3 (19.8)
Transport cost	USD/l/km	0.0022 (0.03)	0.0233 (0.01)	0.0004 (0.01)
Mode of transport:				
Truck	%	62.0		61.5
Motorcycle	%		53.0	35.4
Bicycle	%		74.2	
Transport capacity	l	2288 (5240)	167 (86)	5598 (5485)
Vertical coordination				
Services to Suppliers				
Advance payments	%	16		
Training/advice	%	54		77
Credit	%	24		69
Equipment/feed	%	26		49
Continue buying during fasting	%	90		
Pick-up in truck	%	48		
Assistance of any kind*	%		14	
Other				
Workers	#	5.3 (7.3)	1 (0)	3.5 (2.5)
Assets:				
Warehouse	%	36.0		69.1
Mobile	%	94.0	89.5	85.5
N		50	440	48

Source: Author's Calculations. Notes. Means are shown with standard deviations in parentheses. * These reported by farmers.

Table 3 further shows that the transport costs vary. The average transport cost per liter per kilometer for traders in Ethiopia is 0.0022 compared to 0.0233 USD in Uganda. The MCCs' average transport cost is even lower than Ethiopian traders at 0.0004 USD per liter per kilometer. The crucial difference between traders in both countries in terms of transport, however, relates to the mode of transport used. Where traders in Ethiopia use trucks (62 percent) and have a high average carrying capacity (2,288 liters) compared to traders in Uganda who 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 (61.5 percent) and with considerably higher transport capacities (5,598 liters). Once the average capacities of these different actors in the value chain are considered, the transport costs seem logical as they decrease as capacity increases.

Another important role of the middle of the value chain is to provide services to primary producers who do not otherwise have access to those services (for example, if no formal institutions providing them exist). Also in this respect, we notice similarities between traders in Ethiopia

and MCCs in Uganda (no such data was collected for traders in Uganda). Table 3 shows that majorities within both groups of actors provide their suppliers with training or advice while the provision of credit or equipment and feed is more ubiquitous among MCCs in Uganda than among traders in Ethiopia. It is clear that the middle in both countries is filling institutional voids but that this practice is more established in Uganda than in Ethiopia, possibly due to the superior scale advantages of the MCCs.

A similar picture emerges when considering the number of workers at and the assets owned by traders and MCCs. In terms of the number of workers being employed per actor, we see that traders in Ethiopia employ on average 5.3 people (albeit with high variation) while all traders in Uganda report working by themselves. MCCs in Uganda provide employment for an average of 3.5 people. The traders in Ethiopia appear to have more developed businesses. This indicates both types of operations exceed the simple transportation model, which is often used to characterize traders in developing countries. In terms of assets, just over a third of traders in Ethiopia have a warehouse and almost all have a mobile phone. In Uganda, no trader has a warehouse as they only operate on their bike or boda but 89.5 percent have a mobile phone. Of the MCCs, 85.5 percent have a mobile and 69.1 percent have a warehouse.

Figure 6 presents a nice visual that demonstrates the enormous variation in the daily amounts of milk being traded and the transport costs faced when comparing traders in Uganda with traders in Ethiopia. Traders in Uganda barely exceed the levels traded daily by farmers, which means they merely act as an extra step between the producers and the bulking (and cooling) stage of the value chain, the MCCs. Traders in Ethiopia, on the other hand, are responsible for bulking the milk coming from a multitude of primary producers and delivering it to the actors further downstream. Also, in Figure 6, are the average transportation costs for traders and MCCs. We see that Ugandan traders face the highest costs (0.030 USD and 0.021 USD per liter per km for bikes and bodas), which makes sense given their lack of cooling and small capacity limit. Comparatively, Ethiopian traders have a much lower transportation cost (0.002 USD per liter per km) and Ugandan MCCs have the lowest transport cost (0.0004 USD per liter per km). We see the clear difference in the costs related to the capacity of each value chain player, comparing the bicycle and boda transport to the truck transport. The difference in cost between the Ethiopian traders and Ugandan MCCs may be due to the cooling difference. The results show that Ethiopian farmers' main buyers are able to bulk larger amounts of milk on a daily basis, thus being able to dictate terms more than their counterparts in Uganda who can only source limited amounts of milk (from a limited number of farmers).

These results demonstrate that the characterization of the middle, i.e., the people who are responsible for getting the agricultural produce from the producer to the consumer, is vastly
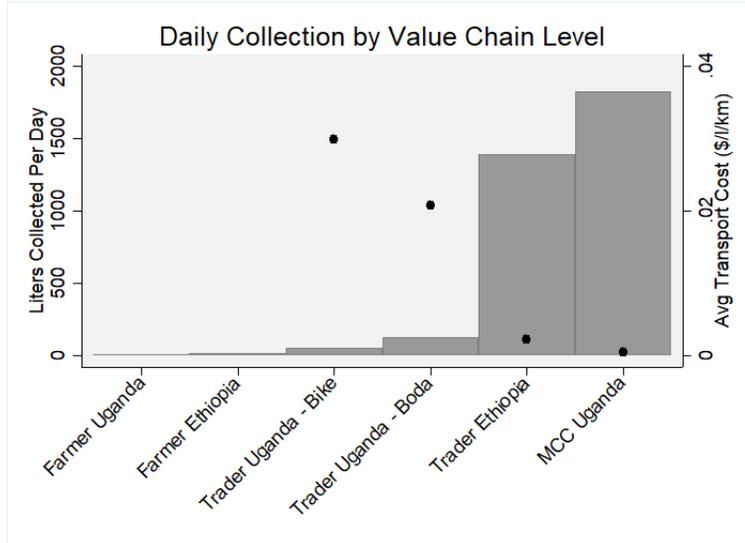
Figure 6: Milk Traded per Day by Value Chain Level

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.

different in Ethiopia and Uganda. In particular, we find that where (a section of) the midstream of the milk value chain is divided into traders and MCCs in Uganda, both roles are being fulfilled by only one type of actor in Ethiopia, namely the traders. This means that traders in Ethiopia wield considerably more market power than their counterparts in Uganda and arguably MCCs as well.

5.2. Structure of the value chain and technology

As has already been argued, the institutional set-up of the milk value chain in Uganda and Ethiopia differs substantially, which can, in broad terms, be reduced to the existence of MCCs in Uganda and their absence in Ethiopia. We formalize the distinction between both value chains by studying their structures more closely. In particular, the wealth of data at our disposal at different stages allows us to map milk flows as they move from producers to consumers. First, using farmer level data, we calculate what share of the amounts recently 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), cooperative (C) and trader/transporter (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.
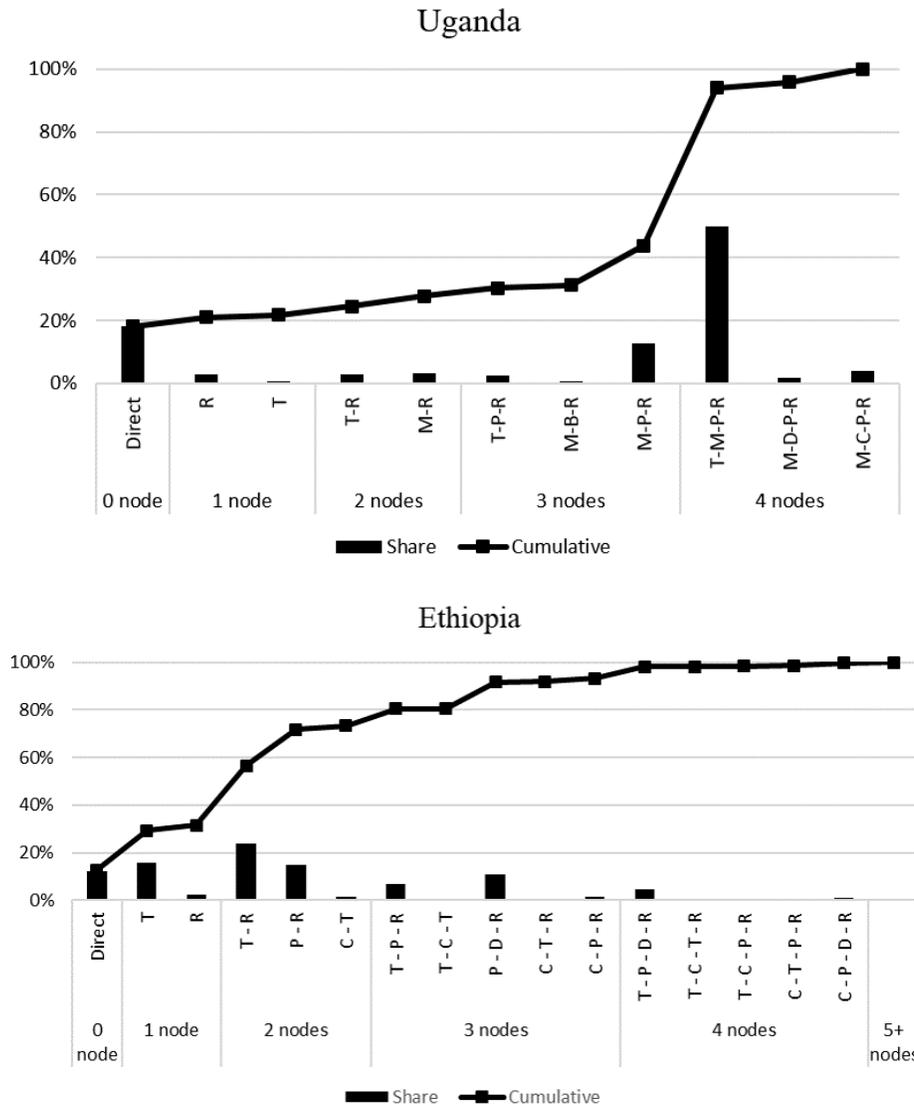

Figure 7: Value Chain Structure by Country
(Source: Author's Calculations.)

Figure 7 shows the value chain structure for Uganda and Ethiopia separately. The differences in structures between the two countries are 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 not negligible in either country: 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 an 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 by a trader, but is directly sold by the farmer to an MCC. The dairy value chain landscape in Ethiopia is considerably more dispersed. The most common pathways (25 percent and 15 percent respectively) occur when farmers are selling milk to traders or to processing companies, who deliver it to retailers directly, where it is then sold 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).
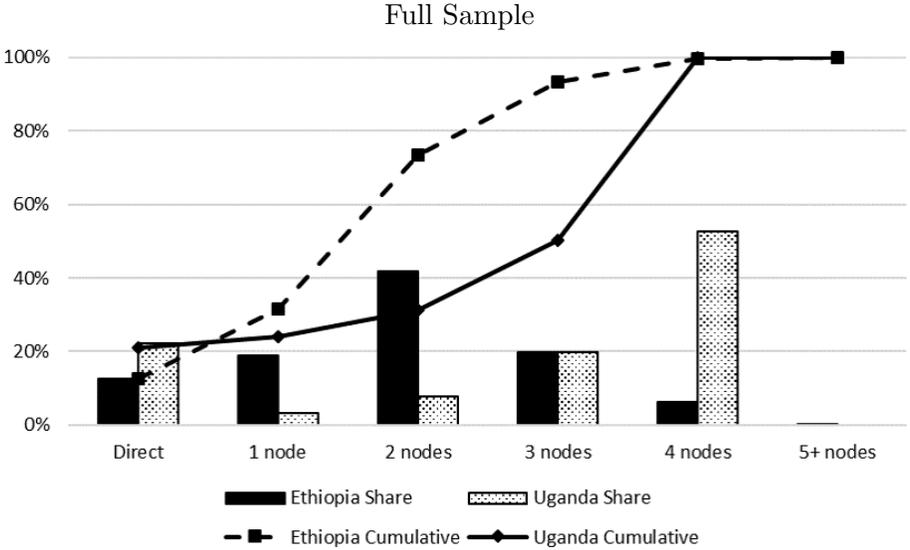

Figure 8: Value Chain Structure
(Source: Author's Calculations.)

Figure 8 combines the previous findings and shows the value chain structures by the number of transactions between the farmer and consumer. It emphasizes once again that the center of gravity in the Ugandan milk value chain lies considerably further downstream than in the case of the Ethiopian chain. Where more than 80 percent of milk in Ethiopia is going from milk producer to consumer in fewer than three steps, this is only the case for about 40 percent of milk in Uganda. It also shows that the differences in structure cannot be completely reduced to the presence of MCCs (and refrigeration) in Uganda. After all, this would only increase the average number of nodes by one, while in reality, the average number of nodes in Uganda exceeds that of Ethiopia by about two.

The presence of cooling technology has thus allowed Uganda to develop a long, cold chain for milk whereas the Ethiopian dairy sector can be characterized as short and unrefrigerated. This affirms the role of technology as outlined in the conceptual framework. 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 gradients in Ethiopia (as observed in Figures 9 and 10).

6. Price and Distance

Now that we have a clear picture of the value chain structure in each country, we try to validate the conceptual framework developed in Section 3 by showing the price gradients across distance for the respondents in our data. In other words, we examine whether or not reality resembles the stylized representation in Figure 5. Distances of the different actors in the value chain are captured in the form of travel time (using road network data in both countries) between their respective locations and the relevant market (Addis Ababa in Ethiopia and Kampala in Uganda). Distance to large consumption hubs have been shown to be driving factors for many agricultural outcomes (Vandercasteelen et al., 2018). Table 4 presents the descriptive statistics for price and distance for the actors in our value chains. The average price per liter in Ethiopia is much higher than Uganda in each level.

Table 4: Price, Quality and Distance

		Farmers		Traders		MCCs	Retailers	
	Unit	Ethiopia	Uganda	Ethiopia	Uganda	Uganda	Ethiopia	Uganda
Price	($/PPP)	1.50	0.69	1.53	0.85	0.88	2.45	1.37
Distance MCC	hrs		0.40					
Distance City	hrs	0.93	2.8	1.2	2.4		2.8	
N		317	994	50	440	49	56	

Source: Author's Calculations.

6.1. Upstream

We begin this analysis with the producers upstream in the value chain. Figure 9 indeed shows that the farm-level demand functions in both Ethiopia and Uganda closely match the predictions from the conceptual framework.[4] 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 you move 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. Of course, we only have a partial view of the situation in Uganda as there are no farmers located closer

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[4]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.
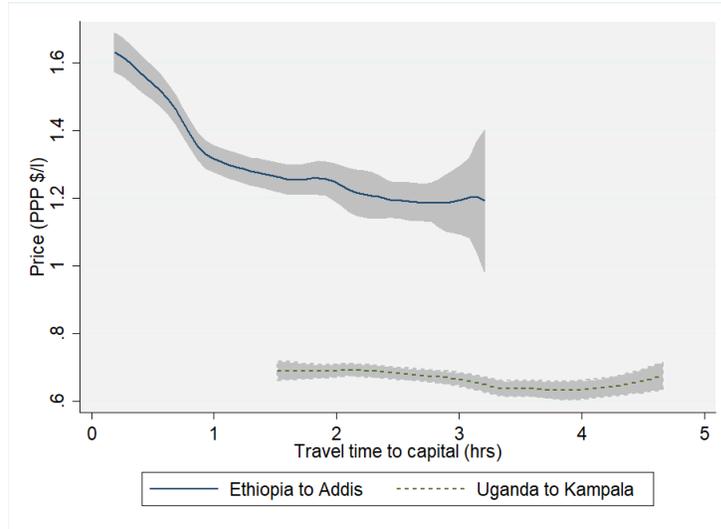
Figure 9: Price gradient (across distance) for farmers in Ethiopian and Ugandan milk value chains (95 percent confidence intervals are shown) Source: Author's Calculations.
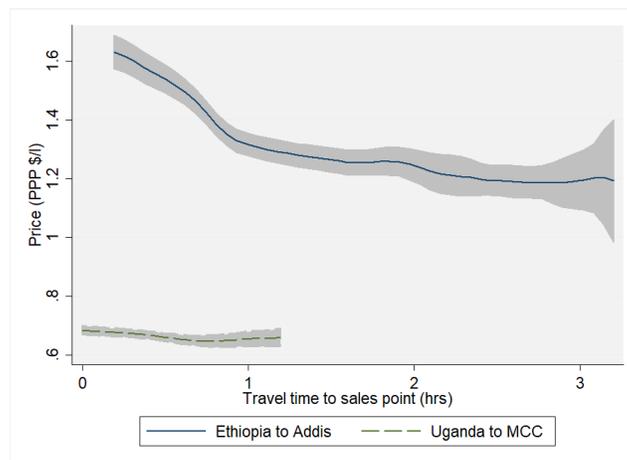

Figure 10: Price gradients (across distance) for farmers in Ethiopian and Ugandan milk value chains (95 percent confidence intervals are shown) Source: Author's Calculations.

than one hour travel time to Kampala.

For that reason, we include Figure 10 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 cold chain in Uganda. Most Ugandan farmers sell either directly to MCCs or to a trader who sells to the MCC. Here the milk is refrigerated and therefore able to better maintain quality. Therefore instead of looking at distance to Kampala for the farmers in Uganda, we use their distance to the nearest MCC. In Ethiopia, even when the farmer sells to a trader, the milk is not refrigerated until it reaches the processor in Addis Ababa and we still use the measure of distance to the city. We see a similar pattern as in Figure 9 with a steep decline in prices in Ethiopia within the first hour's distance from Addis Ababa and a mostly flat gradient in Uganda.
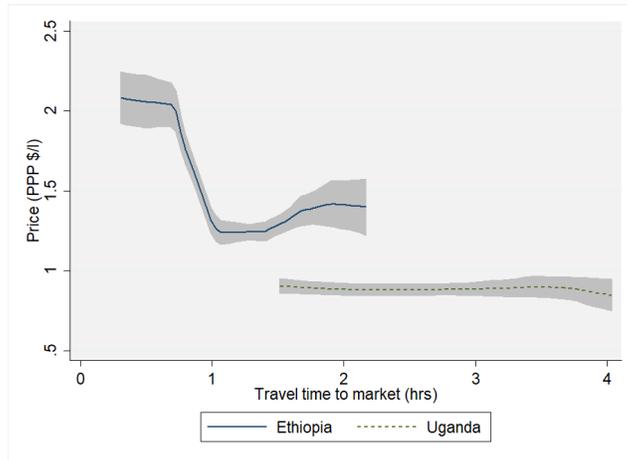
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Figure 11: Price gradients (across distance) for farmers in Ethiopian and Ugandan milk value chains (95 percent confidence intervals are shown) Source: Author's Calculations.

We thus find that the milk value chains in Ethiopia and Uganda mirror our conceptual framework quite closely. These results warrant a further investigation of the middle of the value chain in both countries.

6.2. Midstream

Figure 11 further explores the price gradients in both the Ethiopian and the Ugandan milk value chains, now including the actors in the midstream. For Ethiopia, we use price data reported from the traders and for Uganda, we use price data reported from the MCCs.[5]

The price drop that we observed for the Ethiopian farmers in Figure 9, is even more outspoken for the Ethiopian traders in our sample. Likewise, price gradients are as flat for MCCs in Uganda as they are for farmers. However, once again we are missing those nearest to Kampala.

6.3. Price Regressions

While Figures 9 to 11 suggest that distance plays an important role, we also want to account for potential confounding factors with a regression analysis. We implement a hedonic price model (Lancaster, 1966), where the price of the product is considered to be a function of different embedded characteristics of that product. 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., 2016). In particular, regressions of the following form are run:

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[5]We interviewed traders in Uganda and their point of delivery and therefore do not have information on their distances traveled.

$$p_h = \Sigma \beta_{hk} X_h^k + \epsilon, \tag{1}$$

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. β_{hk} is the implicit price and ϵ 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 and selling directly to consumers. The results are shown in Table 5.

Table 5: Hedonic Price Regressions: $PPP/liter

	Ethiopia		Uganda			
	(1)	(2)	(3)	(4)	(5)	(6)
Farmer (0/1)	-0.374**	-0.244	-0.550***	-0.575***	-0.537***	-0.537***
	(0.161)	(0.165)	(0.047)	(0.170)	(0.054)	(0.054)
Trader (0/1)	-0.188	0.614***	-0.495***	-0.691***	-0.490***	-0.686***
	(0.179)	(0.214)	(0.073)	(0.251)	(0.074)	(0.251)
MCC (0/1)			-0.363***	-0.175	-0.358***	-0.170
			(0.068)	(0.300)	(0.067)	(0.300)
Sell Direct Consumer	0.405***	0.342***	0.057***	0.056***	0.061***	0.061***
	(0.059)	(0.053)	(0.019)	(0.019)	(0.017)	(0.017)
Farm x Distance (City)	-0.279***	-0.666***	-0.034***	-0.015		
	(0.090)	(0.177)	(0.012)	(0.125)		
Farm x Distance (City) Squared		0.147***		-0.003		
		(0.049)		(0.022)		
Trader x Distance (City)	-0.365**	-2.055***	0.015	0.175	0.047**	0.208
	(0.142)	(0.354)	(0.028)	(0.184)	(0.023)	(0.175)
Trader x Distance (City) Sqaured		0.695***		-0.031		-0.031
		(0.141)		(0.032)		(0.032)
MCC x Distance (City)			-0.023	-0.156	0.010	-0.124
			(0.023)	(0.209)	(0.024)	(0.205)
MCC x Distance (City) Squared				0.023		0.023
				(0.035)		(0.035)
Distance to City (hrs)					-0.033**	-0.033**
					(0.013)	(0.013)
Farm x Distance (MCC)					-0.035	-0.035
					(0.031)	(0.031)
Constant	2.047***	2.109***	1.313***	1.314***	1.309***	1.309***
	(0.069)	(0.064)	(0.034)	(0.034)	(0.032)	(0.033)
R^2	0.686	0.725	0.500	0.502	0.502	0.503
Observations	423	423	1428	1428	1428	1428

Notes. Dependent variables are prices in PPP dollar terms. 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.

The results of Table 5 confirm the price gradients observed in Figures 9 and 10. Models 1 and 2 present the results for Ethiopia with Model 2 including the square of the distance to the city. In Model 1, with the retail price as the reference category, we find that farmers in Ethiopia receive, on average, 0.374 USD per liter less than the retailer, however in Model 2 there is no longer a statistically significant difference. The price traders receive in Model 1 is not statistically different than the retail price but in Model 2 the traders seem to earn 0.614 USD more than the

retailer which is an unusual result but needs to be considered with the interaction terms. Those actors who sold directly to the consumer earned about 0.40- 0.342 USD more per liter. When we interact with distance only (Model 1), the farmers report about 0.279 USD less per liter for each hour away from the city they live and traders report about 0.365 USD less per liter for each hour away from the city they work. When we include the square of the distance (Model 2), we see those farmers and traders who are farther from the city report higher prices per liter, 0.147 USD and 0.695 USD respectively. These results suggest distance is significantly associated with price levels in Ethiopia as we saw in the price gradient graphs. However, we have also shown that these prices do not change linearly.

Models 3 through 6 present the results for Uganda. We include the distance to the city (Model 1), the squared distance to the city (Model 2), the distance from farm to MCC (Model 5) and the distance from farm to MCC plus distance to city squared (Model 6). We include these different measures of distance for the same reason we used distance to the nearest MCC in Figure 10, the use of technology will maintain the quality of the milk and therefore the distance from the farmer to the city may not matter as much as the distance from the farmer to the MCC. The main results out of these four specifications include a consistent price difference between the different actors in the value chain. Farmers receive the largest difference in the price per liter as compared to the retailers and this difference shrinks with each level of the value chain.[6] As seen in Ethiopia, those who sell directly to consumers earn more in Uganda, about 0.05-0.06 USD more per liter. Overall, for the different distance variables explored for Uganda, distance appears to be far less significant as compared to Ethiopia. Farmers who are farther from the city earn 0.034 USD less per liter per hour's distance from Kampala (Model 3), while traders who are working in remote areas may earn 0.047 USD more per liter per hour's distance from Kampala (Model 5) but any value chain participant also may earn 0.033 USD less per liter per hour's distance from Kampala (Models 5 and 6). In sum, our hedonic price analysis does confirm the price gradient trends we found in earlier sections.

7. Conclusion

This paper offers more insight into the operation of the milk value chains in two East African countries: Ethiopia and Uganda. While both countries have seen similar increases 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 price behavior: both consumer and producer prices as well as the gap between the two are higher in Ethiopia than in Uganda. We

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[6]In Models 4 and 6, the traders seem to earn less than the farmers, however after performing a Wald test, these coefficients are not statistically different from each other.

argue that these differences can be best explained using a conceptual framework. Consumer and producer price divergences can be attributed to differences in trade and world market participation while the origin of the larger spread between urban and farm prices can be found in the operation of the value chain. More specifically, we assert that the Ugandan milk value chain is characterized by a higher coverage of cooling technology and a higher degree of competition, resulting in steeper price gradients across distance for the Ethiopian case. This higher coverage in Uganda also allows for more geographically extended value chains.

Using primary data collected among different actors of the value chain, we are then able to provide evidence for these assertions, showing that there are important differences in both the structure as well as the middle of the milk value chain in both countries. We find a inefficiencies in supply (a lack of cooling equipment) in Ethiopia. In particular, we argue that traders in Ethiopia are performing dual roles (both transport and bulking) whereas there is a separation of both tasks in Uganda (between traders and MCCs).

A striking corollary of this finding is the much wider variety in the concept of traders between the two countries than what has previously been considered. In particular, we find that traders in Ethiopia display more similarities with MCCs in Uganda than with traders in Uganda. They have a high level of sophistication (higher ownership of trucks and other assets and more employees) and they trade higher volumes on a daily basis. These differences in what constitutes a trader matter for policy-making and the design of value chain interventions. In particular, we argue traders cannot simply be dismissed as unproductive actors, having demonstrated that there are some groups of traders who provide services crucial to the operation of the value chain. At a more general level, a much deeper understanding of the middle of the value chain and its constraints continues to be indispensable for policy-making and the design of interventions and arguably remains a frontier in research on agricultural economics in developing countries.

The implications of our results for policy-making confirm the importance of investment in technology in order to help continue the agricultural transformation that is currently happening in sub-Saharan Africa. The Ugandan milk sector can be hailed as an example to be copied by other countries, especially in terms of cooling and processing capabilities. The far-reaching privatization and liberalization of the dairy sector have clearly benefited urban consumers in Uganda. While they have not resulted in higher prices for dairy producers, the demand for dairy is still growing within the country with multiple processors expanding their services for farmers and the number of MCCs. So, whether the Ethiopian dairy value chain should and can become as export-oriented as the Ugandan one remains an open question, but our comparison has shown that investment in more advanced capabilities (particularly cooling at the local level) is indispensable in the development of the dairy sector.

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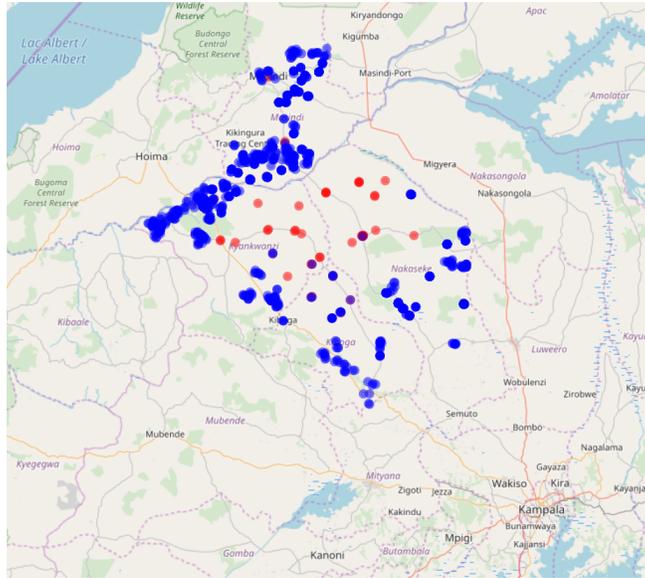
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A. Maps

Ugandan Farmers (blue) and MCCs (red)

Ethiopian Farmers (blue)