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Post-harvest losses in rural-urban value chains:

Evidence from Ethiopia

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ABSTRACT

We study post-harvest losses (PHL) in important and rapidly growing rural-urban value chains in Ethiopia. We analyze self-reported PHL from different value chain agents – farmers, wholesale traders, processors, and retailers – based on unique large-scale data sets for two major commercial commodities, the storable staple teff and the perishable liquid milk. PHL in the most prevalent value chain pathways for teff and milk amount to between 2.2 and 3.3 percent and 2.1 and 4.3 percent of total produced quantities, respectively. We complement these findings with primary data from urban food retailers for more than 4,000 commodities. Estimates of PHL from this research overall are found to be significantly lower than is commonly assumed. We further find that the emerging modern retail sector in Ethiopia is characterized by half the level of PHL than are observed in the traditional retail sector. This is likely due to more stringent quality requirements at procurement, sales of more packaged – and therefore better protected – commodities, and better refrigeration, storage, and sales facilities. The further expected expansion of modern retail in these settings should likely lead to a lowering of PHL in food value chains, at least at the retail level.

1. INTRODUCTION

The magnitude of post-harvest losses (PHL) in food value chains are increasingly being debated among food system analysts and policy makers, along with the design of policies to try to reduce these losses (World Bank 2011; FAO 2011, 2012). These issues are receiving increasing attention for two reasons. First, it is believed that by reducing PHL, food security will improve as lower PHL would ensure the availability of more food at lower prices (FAO 2011). Second, using resources for producing food that is ultimately wasted raises important environmental issues due to the misuse of water, land, and fertilizer. Reducing food wastage would therefore alleviate these environmental concerns (Kummu et al. 2012). To address PHL, different strategies are required for developed versus developing countries. Developed countries typically have different PHL levels than developing countries, with more losses near the consumer in value chains in developed countries as opposed to near the farm in developing countries (Hodges et al. 2011; FAO 2011).

Despite the presumed importance of PHL, their estimates have come under criticism. Critics have suggested that: (1) the methods used are based on experts' hypotheses rather than on detailed field survey estimates; (2) they are biased toward perishables and thus far over-state PHL; and (3) they are not focused on the products that make up the bulk of calories consumed, like potatoes, grains, tubers, or pulses (e.g., Sheahan and Barrett 2015). Recently several authors analyzed primary data from multiple countries or synthesized literature in this area (e.g., Affognon et al. 2015; Schuster et al. 2018; World Bank 2011; Sheahan and Barrett 2015; Kaminski and Christiaensen 2014; Parfitt et al. 2010). These studies show that there is limited information on the level of PHL at different stages of food value chains and that what estimates there are vary widely, especially so for developing countries.

We contribute to this literature by focusing on two major research questions. First, we assess the magnitude of PHL losses in rural-urban value chains. These value chains are important and are rapidly growing in Africa. For example, Dolislager et al. (2015) estimate that almost half of agricultural produce sold now goes to cities in Eastern and Southern Africa. Driven by population growth, increasing urbanization, and urban income growth, Haggblade (2011) evaluates the growth in rural-urban food value chains in Africa at between 600 and 800 percent over the past three decades. However, despite the growing importance of these value chains in Africa, there have been few attempts to quantify PHL in them.

We use new evidence from Ethiopia, the second most populous country in Africa, to analyze the level of PHL in the case of two major commercial commodities, the storable staple teff and the perishable liquid milk. We implement an innovative method where large-scale surveys were fielded at each level of the rural-urban value chain. These datasets allow us to analyze the structure of the value chains; to measure important variation between value chain agents; to capture PHL at each level; and thereby to evaluate PHL over the most prevalent segments of the value chains, except for consumption. We look in particular at the size of PHL in the value chains that supply these products to Addis Ababa, the capital and primary city of Ethiopia, from major production areas.

Second, we assess PHL in urban retail markets. We rely on a large food retail survey in Addis Ababa where PHL data were collected for more than 4,000 food products. We further assess the link of modern retail with PHL. Agri-food systems are rapidly changing worldwide, driven by urbanization, income growth, policy reforms, infrastructure investments, and globalization (Reardon et al. 2014). The modern retail sector is quickly emerging as one of the most important components of food distribution in major urban centers in almost all developing countries. Reardon et al. (2003) documents its roll-out over different waves in different continents and settings. This increasing importance of modern retail has important implications on the functioning of agricultural value chains that is not yet well understood. While there is a literature on supermarkets being linked to different prices and qualities (e.g., Minten and Reardon 2008), however, there are to our knowledge no studies that illustrate the extent to which modern retail might impact PHL. We fill that gap in this study.

We estimate PHL between rural producers and urban consumers in the teff value chain at between 2.2 and 3.3 percent of the quantity of grain produced, depending on the storage facilities used (or not) and on the level of losses occurring during transport by farmers. We estimate PHL for the raw milk value chain at 2.1 percent, almost exclusively because of PHL at the retail level. The PHL level is low for raw milk given the short value chain in place for Addis Ababa – the majority of raw milk retailers procure directly from farmers located close to or often even in the city. For pasteurized milk, despite lower losses at the retail level, overall losses are higher at 4.3 percent. Pasteurized milk has a longer value chain than does raw milk, with the most common value chain pathway involving three nodes between farmers and retailers – farmers typically sell to traders, who sell to companies, who sell to distributors, who then deliver to retailers. Given longer value chains, PHL for pasteurized milk are relatively higher than for raw milk, but still relatively low.

The results indicate that value chains endogenously adjust in the face of possible high PHL, i.e., systems respond to commodity characteristics to reduce PHL if they are expected to be severe. At the retail level, we find the highest level of PHL for perishable fruits and vegetables (between 2.6 and 11.8 percent), followed by cereals (between 0.5 and 2.0 percent), and then processed foods (between 0.1 and 0.5 percent). We also find that modern retailers are characterized by relatively lower PHL compared to the traditional retail sector, likely due to their more stringent quality requirements at procurement, more packed and better protected products, and better refrigeration, storage and sales facilities.

Overall, the estimated PHL from this research – except for fruits and vegetables – are significantly lower than is commonly assumed (FAO 2011) and point to the need to gather further evidence on PHL in these settings to ensure appropriate policies and investments. The results also highlight the importance of carefully assessing the structure of rural-urban value chains to evaluate overall PHL in them. Such structural assessments are not commonly done when measuring PHL. Finally, the results on modern retail suggest that the further expected expansion of modern retail in these settings might lead to a lowering of PHL in food value chains, at least at the retail level. The expansion of the modern retail sector should therefore be encouraged, at least for that performance dimension of food value chains.

2. DATA

2.1. The teff value chain

Based on a number of indicators, teff is evaluated as the most important crop in Ethiopia's agricultural economy.[1] We rely on information collected from major teff producing areas and follow the teff value chain from these areas to Addis Ababa. Questionnaires were designed for each level in the value chain and then fielded in November and December 2012.

- Upstream in the value chain, we selected 1,200 teff farmers through a multi-step process.[2]
- For the midstream value chain investigations, the following sample selection strategy was followed. First, 40 rural wholesalers were interviewed in the five zones with the highest commercial surplus of teff in the country. In the four *woreda*s selected for the survey in each of these zones, the major trading town or temporary wholesale market used by farmers in that *woreda* was selected. A census of all traders in that market/town was then made. Second, in Addis Ababa, 75 wholesale traders and brokers were interviewed in total.
- Downstream in the value chain, we relied on a stratified sampling scheme to select a representative sample of teff retail shops in Addis Ababa. In total, 282 retail outlets in Addis Ababa were interviewed.

Table 2.1 gives an overview of the characteristics of agents interviewed at each level in the teff value chain. We note significant differences between the agents. The level of education among farmers is lowest with, on average, 5 years of education. This compares to about 8 years for the other value chain agents mid- and downstream. Few women are directly involved in the value chain post-farm: 5, 0, and 15 percent of the rural wholesalers, urban wholesalers, and urban retailers, respectively, are women. At the farm level, only 5 percent of the households are headed by women. Value chain agents have significant experience in handling teff, between 8 and 10 years on average.

[1] In 2016/17, it was estimated by the Central Statistical Agency (CSA) that teff made up 21 percent of all the area cultivated by smallholders in the main *Meher* cropping season, covering about 3 million hectares and grown by 7 million farmers. Minten et al. (2018) estimate teff to be the most important cash crop in the country. The value of this commercial surplus (the part of production that is sold) for teff was estimated to be 850 million USD in 2016/17, making up half of the value of the total commercial surplus of the cereal sector.

[2] First, the five zones with the highest commercial surplus of teff in the country were identified and chosen. These five zones combined represented 38 percent and 42 percent in 2011/12 of the national teff area and commercial surplus, respectively. Second, within each production zone, *woredas* (districts) were ranked from the smallest to the largest producer (in terms of area cultivated). We then divided the *woredas* in two, the less productive and the more productive *woredas* (each group of woredas cultivating altogether 50 percent of the area). Two *woredas* were randomly selected from each group. Third, a list of all the *kebeles* of the selected *woredas* was then obtained. Two *kebeles* were randomly chosen from the top producing 50 percent *kebeles* and one from the bottom producing 50 percent *kebeles*. Fourth, a list of all teff producers in the selected *kebeles* was then compiled. They were ranked from small to large teff producers (based on the area cultivated). We then divided the farmers in two groups, small production and large production farmers, each group of farmers cultivating altogether 50 percent of the area. A total of 20 farmers were then selected: ten from the group of small production farmers and ten from the large production farmers. In total, 240 farmers were interviewed per zone.

Table 2.1: Descriptive statistics on respondents to teff value-chain surveys

	Unit	Mean	Median	Standard deviation
Farmers				
Number of observations		1,200	-	-
Gender head of household	share male	95.3	-	-
Level of education (years of schooling)	number	4.6	4.0	2.9
Experience in teff business	years	9.6	10.0	1.5
Rural wholesalers				
Number of observations		205	-	-
Gender	share male	94.6	-	-
Level of education (years of schooling)	number	7.9	9.0	3.9
Experience in teff business	years	9.5	8.0	7.8
Urban wholesalers/brokers				
Number of observations		75	-	-
Share brokers	share	65.3	-	-
Share traders	share	64.0	-	-
Gender	share male	100.0	-	-
Level of education (years of schooling)	number	8.7	8.0	3.4
Experience in teff business	years	8.9	7.0	6.7
Urban retailers				
Number of observations		282	-	-
Share mills	share	83.3	-	-
Share cereal shops	share	9.9	-	-
Share consumer cooperatives	share	6.7	-	-
Gender	share male	84.7	-	-
Level of education (years of schooling)	number	7.7	8.0	4.4
Experience in teff business	years	8.2	5.0	7.8

Source: Authors' calculations based on teff value chain surveys.

2.2. The milk value chain

The dairy sector is seen as an important high-value growth sector in the process of agricultural and economic transformation that, moreover, has the potential to provide good income opportunities for the poor (e.g., Gulati et al. 2007). Because of rapid urbanization, higher incomes in cities, and high-income elasticities for dairy, rural-urban milk value chains are rapidly growing in Ethiopia. As in the case of teff, we focused our research on urban markets in Addis Ababa and the supply of milk from its hinterland.

A survey of 955 dairy producers was fielded in two major dairy rural production zones around Addis Ababa, the zones of North and West Shewa; in suburban zones; and in the city of Addis Ababa in January and February 2018. Ninety-seven dairy farming households were interviewed in Addis Ababa, 256 in suburban areas in the *Oromia Special Zone surrounding Finfinne*, and 602 in rural areas. We also collected information from focus groups in the kebeles selected for the dairy survey and from 50 milk traders that were active in the woredas selected for the survey. Downstream in the value chain, 254 urban retailer outlets were randomly selected based on a stratified sampling scheme. In our analysis here of PHL, we focus only on those agents in the value chain that were involved in liquid milk markets. We do not study processed dairy products. This reduces our sample of farmers to 209. All the other agents of the dairy value chain interviewed were involved in liquid milk markets.

Table 2.2 provides descriptive statistics on the producers, traders, and retailers involved in liquid milk value chains that were interviewed. Only 10 percent of households are headed by females upstream while there is larger involvement of women midstream and downstream as 17 and 43 percent of firms are headed by women, respectively. Farmers have lower education levels, with an average of about 4.8 years of schooling. In comparison, midstream actors have about 10 years of schooling while retailers have on average 9 years. Stakeholders across the milk value chain have different levels of experience in the business. Agents upstream, midstream, and downstream have been involved in the value chain for 9, 13, and 5 years, respectively.

Table 2.2: Descriptive statistics on respondents to milk value-chain surveys

	Unit	Mean	Median	Standard deviation
Farmers				
Number of observations		209		
Gender head of household	share male	88.0	100.0	32.5
Level of education (years of schooling)	number	4.8	5.0	10.5
Experience in teff business	years	9.6	10.0	1.2
Rural milk wholesalers				
Number of observations		50		
Gender head of household	share male	83.3	100.0	37.7
Level of education (years of schooling)	number	10.0	10.0	3.8
Experience in teff business	years	12.8	11.0	5.0
Urban retailers				
Number of observations		254		
Share milk shops	share	40.7	0.0	49.2
Share traditional (regular) shops	share	39.5	0.0	49.0
Share modern retail	share	19.8	0.0	39.9
Gender	share male	56.8	100.0	49.6
Level of education (years of schooling)	number	9.1	10.0	4.7
Experience in milk business	years	4.8	2.0	7.0

Source: Authors' calculations based on milk value chain surveys.

2.3. Urban food retail

Based on a stratified sampling scheme representative of Addis Ababa as a whole, 1,226 food retail outlets were visited in March and April 2012. In this survey, data were gathered for four main cereals (teff, wheat, maize, and sorghum), five fruits and vegetables (tomato, potato, onion, banana, and orange), and four processed foods (edible oil, sugar, shiro (chick pea flour), berbere (a milled mixture of hot red pepper and other spices)). Each of these products is of considerable importance in the diet of urban consumers (Worku et al. 2017).

Depending on the food category and taking into account the relative number of the different food retail outlets, the following sampling scheme was set up:

- *At the sub-city level.* All the so-called supermarkets and minimarkets, consumer cooperatives, *kebele* shops, *Etfruit* shops, and private commercial farm shops in the selected sub-cities were surveyed.
- *At the kebele level.* All the flour mills were surveyed. 10 regular shops, 10 fruit and vegetable grocery shops, 5 cereal shops, and 5 *baltena* shops were randomly selected and surveyed.
- *At the ketena level.* Three informal micro sellers of fruits and vegetables were randomly selected and interviewed.

In total, 1,226 retail outlets were interviewed. Table 2.3 gives an overview of the selected outlets sampled in each category.

Table 2.3: Urban food retail survey sample set-up

Retail outlet type	Outlets sampled	Number of outlets in city as a whole
Supermarkets	160	627
Consumer cooperatives	109	221
Private commercial farm shops	2	4
Kebele shops	7	14
Etfruit shops	29	63
Flour mills	264	1,084
Regular shops	201	20,182
Fruits and vegetable grocery shops	187	3,526
Cereal shops	61	1,851
Baltena shops	99	1,362
Micro sellers (*gulits*)	107	5,083
Total	*1,226*	*34,019*

Source: Authors' calculations

3. POST-HARVEST LOSSES IN RURAL-URBAN FOOD VALUE CHAINS

3.1. The teff value chain

Structure of the teff value chain

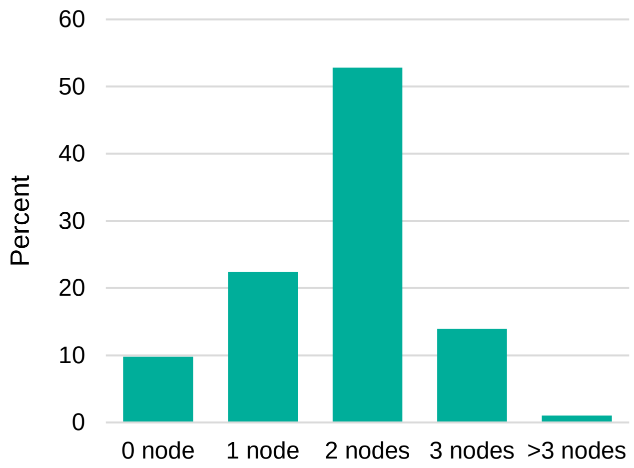
To understand the structure of the teff value chain, rural and urban wholesalers and urban retailers were asked from whom they obtained supplies and to whom they sold. For each of the five three-month intervals over the 15 months prior to the survey, the wholesalers were asked to recall the importance of each type of seller in terms of total supplies. This procurement information at each level allows us to quantify the prevalence of different value chain structures. We identify three main players in these value chains, i.e., the farmer-trader or rural assembler who operates in the village, the rural trader who operates in rural markets or in regional towns, and the urban trader or broker who operates in urban markets. We categorize the different value chains by the number of nodes between the teff farmer and the urban retailer. Based on procurement responses of the different value chain agents, there are 18 possible chains found from farmer to retailer, ranging from zero nodes where retailers buy directly from farmers to five nodes.

Figure 3.1 shows the surprisingly short supply chains that are commonly employed to ship teff to Addis Ababa. In 85 percent of the cases, there are two trade nodes or less between farmers and retailers.[3] The results are largely consistent if we triangulate the sales and procurement patterns at different levels. The most prevalent structure of the teff value chain from major production zones to the city follows from producer to regional trader to urban trader/broker to urban retailer (used in 48 percent of the teff supply transactions to Addis). In 28 percent of cases, urban retailers obtain their products directly in rural areas, bypassing the urban wholesale markets and therefore making the value chain shorter. On the other hand, the value chain can also be longer, as rural traders procure 13 percent of their produce from rural assemblers or farmer-traders, and 10 percent of the urban wholesalers/brokers obtain produce from other urban wholesalers/brokers. However, in the most common case, there are three intermediaries found between farmers and urban consumers. The

[3] Note that 86 percent of what these retail shops sell is sold directly to consumers. The rest of the buyers are mostly *injera* sellers and restaurants.

finding of the dominance of such relatively short teff value chain structures goes against conventional wisdom.[4]

Figure 3.1: Prevalence of different value chain structures between farmers and urban teff retailers



Source: Teff trader surveys.

Post-harvest loss estimates in the teff value chain

We estimate PHL using the most prevalent structure of the teff value chain discussed above, from farmer to rural wholesaler to urban wholesaler to urban retailer. To get at the level of PHL in the teff value chain, we asked actors at each level in the chain how much grain was lost in storage as well as during their last complete trade transaction over the time between acquisition and sale of the teff, possibly including during transportation. We then simply add up the stated PHL at each level in the chain for this most prevalent structure. This method gives a reasonable approximation of the total PHL in the value chain at harvest time and after storage.

Teff post-harvest losses upstream

Farmers were asked to quantify their grain losses in the teff threshing process. It is to be noted that threshing of teff in Ethiopia, as for most other products, is almost exclusively carried out using traditional methods. Table 3.1 presents statistics on reported losses during this process. 57 percent of farmers reported to have lost some of their harvest during the threshing process. Of those that reported losses, this amounted to a loss of 3.1 percent of the total harvest. If we take into account the large number of farmers that did not report any losses, the estimated amount of loss during the threshing process equates to 1.8 percent of the total teff harvest.

Storage of teff is done at several levels, i.e., by farmers, by traders, and by retailers. Only 32 percent of farmers indicate that they sell teff immediately after harvest. 60 percent of the farmers stated that they sell mainly in the middle of the period between the current and the next harvest, while 9 percent report selling mainly just before the next harvest. These percentages indicate that the practice of on-farm storage of teff is very important in Ethiopia. Nevertheless, very few modern storage facilities are used on-farm. Modern *gotera* are used by only 1 percent of farmers. Table 3.1 gives an assessment of the farmer's self-reported storage losses. Notably, the timing of these questions came just before the delivery of the new harvest, and therefore this enabled farmers to make a full assessment of their total storage of teff over the previous post-harvest period. Only 12 percent of farmers reported to have lost teff during storage on farm. For those that reported storage

[4] Fufa et al. state "The teff value chain is fragmented and involves many players. Most farmers sell to assemblers individually, who then sell on to traders and wholesalers. Most teff is sold at harvest when prices are low." (2011, 2)

losses, about 2 percent of the total harvest was lost. Aggregated over all households producing teff, it is estimated that a low 0.2 percent of all teff harvested is lost during storage at the farm level.[5]

Table 3.1: Descriptive statistics on teff post-harvest losses by farmers

	Unit	Mean	Median	Standard deviation
Threshing				
Share of farmers reporting losses	%	56.9		
For those reporting losses, share lost	%	3.1	1.9	3.7
For all farmers, share lost	%	1.8	0.5	3.2
Storage				
Share of farmers reporting losses	%	11.6		
For those reporting losses, share lost	%	2.0	1.4	2.7
For all farmers, share lost	%	0.2	0.0	1.1

Source: Authors' calculations based on teff value chain surveys.

Unfortunately, no data were collected on losses at the farm level during the use of different types of transportation. Two transport operations can be distinguished before commercialization – transport of teff from field to the house and transport from the house to the market. While we have no data on actual losses, data were collected for some transport-related indicators. For example, the average time taken to walk between house and plots is 17 minutes. The median is 10 minutes. This indicates that most of their teff plots are located close to their house for most teff farmers. Information was further collected on sales transactions. Most farmers travelled 1.5 hours to get to the point of sale. These results indicate that the distances covered by farmers to transport their produce were not that large, and that losses in the transport process were likely to be minimal. In further scenarios, we will assume an arbitrary low of zero percent loss and a high of 0.25 percent loss during transportation.

Teff post-harvest losses midstream and downstream

We also asked for information on storage behavior and storage losses by traders, brokers, and urban millers and retailers (Table 3.2). In the case of wholesalers or brokers, we see that few stored teff, with only 11 percent reported doing so. Often these traders acquire a truck full of teff from farmers and then sell it to clients, only keeping the teff for a short while. Eight percent of wholesalers reported losses of teff, amounting to 0.4 percent of the whole transaction on average. If this is aggregated over all wholesalers that reported storage in the last transaction, it is estimated that 0.3 percent was lost.

A similar exercise was done at the retail level. As retailers take some time to sell their produce, we assume that they all store teff. About one-quarter of the retailers reported losses during their last teff transaction. For those that reported losses, the loss made up 0.7 percent of their total purchase on average. When we aggregate this over all retailers, 0.2 percent of the teff purchased by retailers is reported lost at the retail level.[6]

[5] See Annex for a review of PHL at the farm level for cereals from other surveys.

[6] We also asked retailers about cleaning processes of teff. Traditional threshing methods often result in foreign material being included in the marketed bags of teff. The teff is therefore cleaned at the household by consumers, or more commonly at the mill by cleaners, who are usually paid separately for that cleaning. We asked the mill owners how much foreign material (impurity) was obtained. The average level of impurities of teff varies mostly between 2 and 4 kg per quintal (50 kg) of raw teff. It is to be noted that these impurities are not considered losses in the value chain, as they are stones, hay, or remains of the feces of the animals that did the threshing. These results will therefore not be used in further analysis.

Table 3.2: Teff post-harvest losses by traders and retailers

	Unit	Mean	Median	Standard deviation
Storage				
Wholesalers/brokers				
Share of wholesaler reporting losses during storage	%	8.0		
For those reporting losses, share lost	%	0.4	0.1	0.7
Share of wholesalers that stored	%	10.8		
For those that stored, share lost	%	0.3	0.1	0.6
Retailers				
Share of retailers reporting losses during storage	%	24.5		
For those reporting losses, share lost	%	0.7	0.3	0.8
Aggregated overall retailers, share lost	%	0.2	0.0	0.5
Transportation				
Wholesalers/brokers				
Share of wholesalers reporting losses during transportation	%	6.7		
For those reporting losses, share lost	%	0.2	0.1	0.1
Share of wholesalers that transported	%	9.5		
For those that transported, share lost	%	0.1	0.1	0.1
Retailers				
Share of retailers reporting losses during transportation	%	32.6		
For those reporting losses, share lost	%	0.4	0.2	0.6
Aggregated over all retailers, share lost	%	0.1	0.0	0.4

Source: Authors' calculations based on teff value chain surveys.

Losses during transportation might be another important factor accounting for PHL. Again, we work through the different levels in the teff value chain. Wholesalers and brokers were first asked whether they transported the teff in their last transaction. Only 9.5 percent of the traders surveyed indicated that they did. 6.7 percent of the wholesalers and brokers indicated that they had losses during the transportation process. For those that reported losses, 0.2 percent of their total load was lost. When we aggregate for all transported teff, we find a 0.1 percent loss on average during transportation.

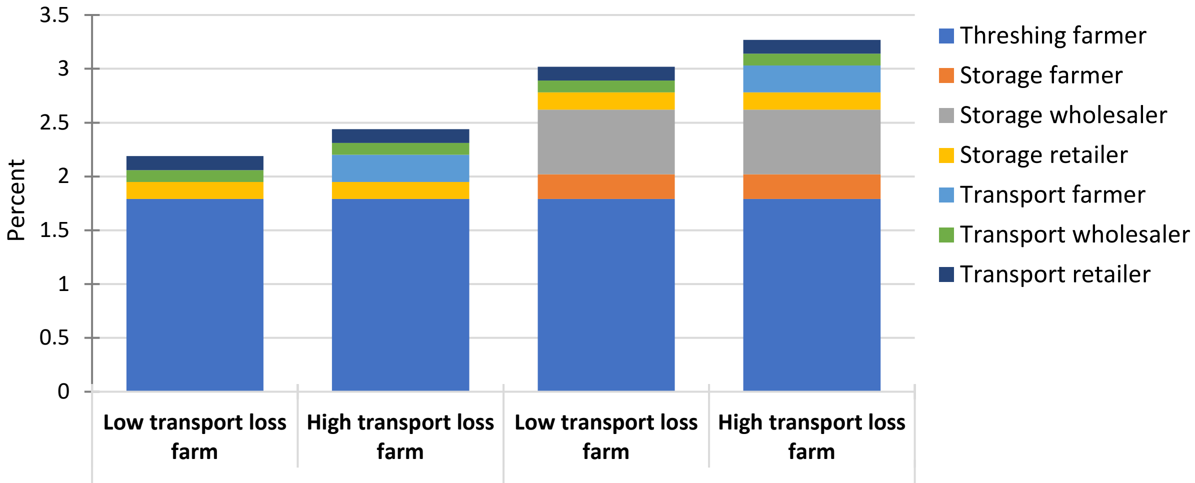
Most retailers obtain teff through the wholesale markets. They also were asked to indicate how much they lost during the transportation of teff from the wholesale market to their shop. One-third of the retailers indicated losses during transportation. For those that had experienced losses, their estimation of the loss was 0.4 percent of the whole transaction. When we aggregate losses over all retailers – assuming that all retailers transported teff, since the majority of retailers that buy their produce at wholesale markets then bring it to their retail outlet – we estimate that 0.1 percent of the teff at that level is lost in transport.

Teff post-harvest losses for most prevalent pathway in the value chain

Having evaluated the structure of the teff rural-urban value chain and having obtained estimates of the losses for most of the processes that occur between production by farmers and purchase by consumers, we aim to create a comprehensive assessment of total losses in the value chain. Figure 3.1 showed that there are several possible structures for shipping teff to Addis Ababa, from very short to quite long value chains. We evaluate the losses in the teff value chain using the most common value chain structure where teff is shipped from the farmer to the rural wholesaler to an urban wholesaler/broker and then to an urban retailer.

The most significant unknowns in our assessment are the losses incurred in transportation from field to house and from house to market. We evaluate two scenarios with arbitrary imputed losses in transport at that level of the value chain of zero and 0.25 percent of total production. We also evaluate two extreme cases where no storage is undertaken by any of the value chain agents, which means that teff is sold immediately after harvest and is not stored by traders and retailers. In a second scenario, we include storage at all levels. Four PHL estimates therefore are computed based on both lower- and upper-bounds on losses incurred during storage and on those incurred during transportation at farm-level. The results are presented in Figure 3.2.

Figure 3.2: Post-harvest losses in the teff value chain, four scenarios



Source: Authors' calculations based on teff value chain surveys.

Moving from more to less conservative estimates of loss, on the left side of Figure 3.2 is presented the case where there was no loss during transportation from the field to the house and from the house to the market, and there was no storage by farmers and wholesalers. However, we do assume that storage was done by urban retailers, as they usually take time to sell their produce. In this least conservative scenario, we find that losses in the value chain amount to 2.2 percent. If we move to the far right of Figure 2.2, we evaluate total losses by assuming that there were losses of 0.25 percent of total harvest during transport by the farmers from their field to their house and from their house to the market. We further assume that farmers stored and incurred losses during storage. We also assume that wholesalers were engaged in storage activities. In this conservative case, PHL amounted to 3.3 percent across the total teff value chain. Between these two extremes, the overall estimated losses in the teff value chain in two alternative scenarios – high transport losses at the farm and no storage by wholesalers and farmers; and low transport losses at the farm and storage by wholesalers and farmers – are 2.4 and 3.0 percent, respectively.

3.2. Milk value chains

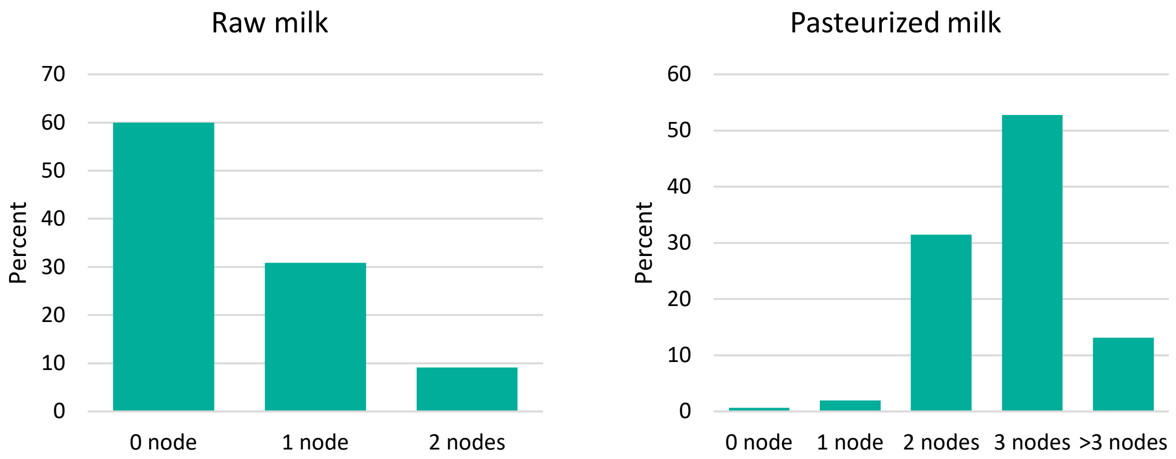
Structure of milk value chains

To understand the milk value chain serving dairy retailers in Addis Ababa, it is important to distinguish between raw and pasteurized milk. With growth in dairy consumption, we see increasing formalization of dairy markets with rapid growth in investments by dairy processing companies and consequently in the consumption of pasteurized milk (Minten et al. 2018). However, raw milk markets are still very important as well. As the two value chains are organized differently, we estimate their respective structures based on detailed questions to actors in the two different chains. We follow a similar strategy as done for teff where procurement details were asked from a large number of agents at each level of a specific value chain.[7]

[7] It is to be noted that a significant share of urban consumers obtain milk directly from urban dairy farms (Minten et al. 2018). We do not consider them part of the rural-urban value chains and we focus on procurement patterns of urban milk retailers only.

On the left side of Figure 3.3, we see that for the most common pathway of the raw milk supply chain no middlemen are involved and urban retailers obtain the milk that they sell in their shops directly from the producer, sometimes from their own farms. This procurement model represents 60 percent of the raw milk supply to urban retail shops. In 30 percent of the cases, a trader gathers the milk from farmers and delivers it to the shop (1 node between farmers and retailers). Longer raw milk value chains are rare.

Figure 3.3: Prevalence of different value chain structures for raw and for pasteurized milk between farmers and urban milk retailers



Source: Authors' calculations based on surveys for raw milk and pasteurized milk value chains.

In the case of pasteurized milk, we find longer supply chains. The most common structure is three nodes in the system between farmers and retailers, i.e., farmers sell to rural traders, who deliver to dairy processing companies, which then distribute to urban retailers through independent distributors or traders (44 percent of the supply chain). In 32 percent of the cases, there are two nodes. These two node structures involve either processing firms using milk collectors and then distributing the pasteurized milk themselves or the processing firms procuring milk directly from dairy producers and then distributing the pasteurized product through independent traders and distributors. As is the case with the teff value chain, overall we find that both raw milk and pasteurized milk value chains are rather short.[8]

Post-harvest loss estimates in milk value chains

Milk post-harvest losses upstream

Table 3.3 summarizes PHL for milk at the farm level. Farmers were asked to indicate the average use of milk produced during non-fasting periods.[9] One of the options was spoilage. Surprisingly, only 0.4 percent of farmers reported any such losses. Aggregated over all farmers, this implies that only 0.004 percent of all the milk produced was reported to have been spoiled (Table 3.3, Panel A). It is to be noted, however, that this surprisingly low number reflects an "average" assessment.

[8] This short value chain is a sign of the low development of the dairy value chain in Ethiopia. For example, in the case of Uganda, due to wide-spread availability of collection centers with chilling tanks – managed by cooperatives or the private sector – we see longer value chains that then also allow for further spatial outreach and an appropriate cold chain (Van Campenhout et al. 2019).

[9] During the fasting periods of Orthodox Christians – the Lent leading-up to Easter during which the fasting period lasts up to 56 days and the one before Christmas which lasts for about 40 days – no dairy products are consumed. While there are other fasting periods during the year, they are much shorter. According to the 2007 census, Orthodox Christians officially accounted for 43.5% of the entire population and they are therefore important for national milk consumption and value chains.

Table 3.3: Milk post-harvest losses for farmers

	Unit	Mean	Median	Standard deviation
Panel A				
Share of farmers reporting losses	%	0.40		
For those reporting losses, share lost	%	1.00	1	
Aggregated over farmers	%	0.004	0	0.06
Panel B				
Farmer tried to sell milk in the last 30 days but was not able to	%	18.18	0	38.65
Number of times that this happened	number	3.13	3	4.15
If sold milk over the last 30 days, number of transactions	number	31.13	30	8.72
Proportion of such incidences over total transactions	%	10.05		
Use of unsold milk:				
Threw away	% yes	15.56	0	36.65
Gave to animals	% yes	28.89	0	45.84
For those reporting losses, share lost	%	0.016		
Aggregated over farmers	%	0.003		
For those reporting losses, including giving to animals, share lost	%	0.045		
Aggregated over farmers	%	0.008		

Source: Authors' calculations based on surveys for raw milk and pasteurized milk value chains.

In a second PHL estimation method, questions were asked on sales behavior and losses that resulted from the farmer not being able to find a buyer for the milk. Five percent of the dairy farmers reported that they had not been able to always sell their milk when they tried to do so in the 30 days before the survey. For those farmers, on average this happened 3 times over a 30 days period, i.e., 10 percent of the attempts they made to sell milk. However, even if a farmer was unable to sell their milk, this did not mean that milk was lost. Farmers indicated that in the case of unsold milk, they mostly would consume it in their own home or process it into cheese or butter. Only 16 and 29 percent of the farmers that were unable to sell their milk reported that they threw it away or gave it to animals, respectively. Combining all of these reports on farm-level losses – and assuming that the whole quantity of unsold milk was lost for those that reported losses, this leads to a similarly low level of wastage as was seen with the first PHL estimation method. If giving unsold milk to animals is not considered to be a loss, the estimate share of milk lost is 0.003 percent, while if unsold milk given to animals is considered lost, the share is 0.008 percent (Table 3.3, Panel B).

Milk post-harvest losses midstream and downstream

Wholesalers, dairy processing firms, and retailers were asked about PHL. Wholesalers were asked to estimate the share of the milk that they obtained that they typically had to throw away. Table 3.4 shows the result of that question: 32 percent of milk wholesalers reported losses; aggregated over all wholesalers, 2 percent of the milk they obtained was typically lost. Follow-up questions were asked on these losses. One of the reasons for loss was rejection of milk by buyers – in the week prior to the survey, wholesalers reported that 4 percent of the milk they purchased was rejected. The reason for rejection was often linked to quality, i.e., low lactose content or sour milk, but sometimes wholesalers were not clear on the exact reason. However, milk rejected by buyers was seldom thrown away, but most often was processed into cheese or butter by the trader himself or, alternatively, sold to specialized butter and cheese processors.

To obtain information on the level of milk losses experienced by dairy processing firms, no large survey could be organized given their low number in Ethiopia, so we used key informants. We asked the chairman of the dairy processors' association to estimate typical average losses by dairy processing firms based on his own experience and on reports from members in his association. He put that loss at 0.1 percent. This number was then triangulated with answers from representatives of the two largest dairy processing firms in the country. The numbers reported by them were of similar magnitude, so we use the association chairman's estimates of losses experienced by dairy processing firms in calculating total losses in milk value chains.

Table 3.4: Post-harvest losses for milk traders, processors, and retailers

	Unit	Mean	Median	Standard deviation
Traders				
Share of traders reporting losses	%	32.00		
For those reporting losses, share lost	%	6.06	5	4.58
Aggregated over traders	%	1.94	0	3.82
Dairy processing firms				
Aggregated over processors	%	0.10		
Retailers fresh (raw) milk				
Share of retailers reporting losses	%	14.55		
For those reporting losses, share lost	%	14.63	10	14.19
Aggregated over retailers	%	2.13	0	7.29
Retailers pasteurized milk				
Share of retailers reporting losses	%	16.45		
For those reporting losses, share lost	%	7.86	5	8.62
Aggregated over retailers	%	1.29	0	4.51

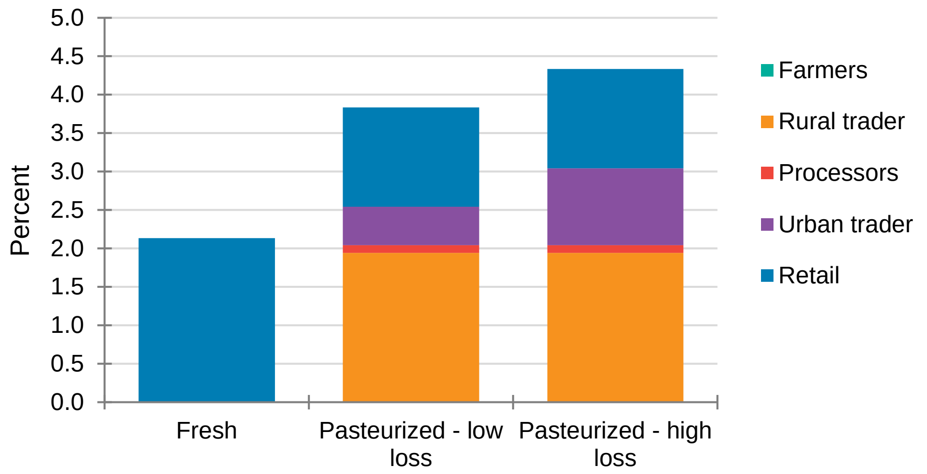
Source: Authors' calculations based on surveys for raw milk and pasteurized milk value chains.

Urban retailers were asked the percentage of the milk that they handled in the week before the survey that was wasted and had to be thrown away. 14 and 16 percent of the raw and pasteurized milk retailers, respectively, reported losses (Table 3.4). Average wastage levels are higher for the dairy shops that sell almost exclusively raw milk (15 percent) compared to those that sell pasteurized milk (8 percent). The average loss levels were evaluated at 2.1 percent for the former compared to 1.3 percent for the latter.

Milk post-harvest losses for most prevalent pathway in the value chains

We put the data together from the most prevalent structure of the raw and pasteurized milk value chains and the estimated losses at each level in order to compute PHL in these value chains. We have no data on losses by urban distributors and traders of pasteurized milk, so arbitrarily impute a low and high percentage loss of 0.5 and 1.0 percent, respectively, for two scenarios.

Figure 3.4: Post-harvest losses in the fresh (raw) and pasteurized milk value chains, with two scenarios for the pasteurized milk value chain



Source: Authors' calculations based on surveys for raw milk and pasteurized milk value chains.

Losses are lower in the raw milk value chain compared to our estimates for pasteurized milk, i.e., 2.1 percent for raw milk versus 3.8 percent for the low-loss and 4.3 percent for the high-loss scenario for pasteurized milk (Figure 3.4). While retail losses are higher in the case of raw milk, losses overall in the value chain are lower because, in the most common pathway, milk is obtained directly from the farm, while a much longer value chain is in place for pasteurized milk. The highest share of the losses for pasteurized milk is at the rural trader level in both scenarios – 51 percent if we assume low losses for urban distribution and 45 percent for the high-level scenario.

4. URBAN RETAIL

4.1. Post-harvest loss estimates

In Table 4.1 we report the results of a large-scale survey with urban retailers in Addis. For each retail outlet, losses were asked for all the varieties and types of the studied food products that the outlet was selling at the time of the survey. Respondents were asked to estimate the losses they had over the week prior to the survey. We note relatively low losses for cereals, with teff exhibiting the highest losses, likely because of the inclusion of foreign material in product as being part of the definition of losses used in the survey. While the median losses for all cereals considered are zero, means vary between 0.5 percent for wheat retailers to 1.9 percent for teff retailers. The picture however is significantly different for vegetables for which losses were more substantial. In the case of tomato, losses amounted to 6.7 percent, and for bananas, almost 12 percent. Median losses for fruits and vegetables are higher than zero. In the case of processed products, losses were lowest of the three categories considered, varying between 0.1 percent for edible oil and 0.5 percent for sugar.

Table 4.1: Self-reported post-harvest losses in food products handled by urban retailers

	Observations	Unit	Mean	Median	Standard deviation
Cereals					
Teff	328	%	1.94	0	3.92
Wheat	452	%	0.49	0	1.27
Sorghum	249	%	0.80	0	2.11
Maize	320	%	0.65	0	1.49
Fruits and vegetables					
Tomato	342	%	6.70	4	8.42
Potato	312	%	4.71	2	7.09
Orange	111	%	3.22	1	5.12
Onion	387	%	2.65	0.2	4.82
Banana	200	%	11.76	10	11.94
Processed products					
Edible oil	431	%	0.11	0	0.73
Shiro	340	%	0.31	0	1.46
Berbere	332	%	0.27	0	1.39
Sugar	361	%	0.54	0	3.85

Source: Authors' calculations based on urban retail survey.

4.2. Modern retail and post-harvest losses

We further test to what extent modern retail is associated with different levels of PHL at the urban retail level. Despite the prohibition of foreign direct investment in food retail in Ethiopia, a domestic modern private retail sector has quickly emerged. However, its share of food retail is still very small compared to most other developing countries (Assefa et al. 2016). Using the data of the retail survey described above, we run a regression with the share of product lost in the week before the survey as the dependent variable and look at its association with the type of retail outlet, controlling for the type of product and location. We follow Assefa et al. (2016) in applying their definition of modern retail as those outlets characterized by self-service and at least one cash register. Using this definition, 52 outlets in the survey sample were classified as modern retail shops. Given the high level of retailers that reported no losses, we rely on a left-censored tobit model in the empirical analysis. We estimate four specifications, one where we pool all products together and three specifications where we examine different food categories, i.e., fruits and vegetables, cereals, and processed foods. All regressions are estimated using robust standard errors.

The results of these regressions are presented in Table 4.2. In the overall regression, we find that modern retail is associated with statistically significantly lower losses compared to traditional retail. The size of the loss difference between modern and traditional retail is also economically significant. PHL are 2.2 percentage point lower for modern retailers than for traditional retailers. As average PHL for modern retailers are 2.2 percent, this indicates a 100 percent lower PHL rate for modern retail compared to traditional retail. Similar results hold when we split the sample by different food types. Cereals are associated with a reduced PHL of 4.7 percentage points, and fruits and vegetables, 2.7 percentage points. For processed foods, no significant difference is found, indicating that losses for those products are low across the board.

Table 4.2: Association of modern retail with post-harvest losses, quality, and packaging

		Unit	Regression model	Modern retail Coefficient	Modern retail t or z-value	Product dummy?	Location dummy?	R^2 or Pseudo-R^2	Observations
Post-harvest losses									
All		%	Tobit, left-censored	-2.22	-2.98***	yes	yes	0.11	4,165
Cereals		%	Tobit, left-censored	-4.77	-2.28**	yes	yes	0.04	1,319
Fruits and vegetables		%	Tobit, left-censored	-2.69	-2.78***	yes	yes	0.04	1,352
Processed products		%	Tobit, left-censored	-0.24	-0.15	yes	yes	0.05	1,464
Characteristics of types of products sold in modern retail									
Cereals									
Processed (not sold as grain)		0/1	Probit	2.06	6.67***	yes	yes	0.37	2,099
Packaged and branded (not loose)		0/1	Probit	4.75	7.08***	yes	yes	0.47	2,106
Fruits and vegetables – size of product (default = large)									
Tomato:	medium	0/1	Multinomial logit	-1.40	-2.50**	no	yes	0.08	322
	small	0/1		-16.67	-35.39***				
Potato:	medium	0/1	Multinomial logit	-1.75	-2.92***	no	yes	0.07	300
	small	0/1		-3.58	-3.02***				
Orange:	medium	0/1	Multinomial logit	-0.84	-1.58	no	yes	0.11	105
	small	0/1		-16.02	-24.18***				
Onion:	medium	0/1	Multinomial logit	-2.10	-4.26***	no	yes	0.07	388
	small	0/1		-3.09	-2.87***				
Banana:	medium	0/1	Multinomial logit	-1.00	-1.65	no	yes	0.14	201
	small	0/1		-15.19	-22.15***				
Processed products									
Packaged		0/1	Probit	1.31	4.62***	yes	yes	0.12	1,499
Packaged & branded		0/1	Probit	1.25	10.10***	yes	yes	0.42	2,746

Note: Robust standard errors; ***, **, *: significant at the 1%, 5%, and 10% level respectively

The lower PHL in modern retail outlets might be linked to a number of factors. First, modern retail usually procures products that meet higher quality standards and that are more homogenous. Consistent with findings from other countries (e.g., Minten and Reardon 2008; Gorton et al. 2011), we find that products in Ethiopian supermarkets are of significantly different and higher-valued quality compared to products in traditional retail outlets, such as wet markets and micro-sellers. This is seen in the greater share of larger-size fruits and vegetables on offer in modern retail (Table 4.2). To achieve these higher qualities, modern retail often relies on dedicated wholesalers or contract farmers directly (the latter, however, is not yet common in Ethiopia). Such procurement models require less grading of the product by the retailer after procurement, better quality overall, and lower PHL afterwards.

Second, modernization of marketing systems is associated with sales of more packaged products, as shown for rice in Asia (Reardon et al. 2014; Minten et al. 2013). The pattern of increased packaging in rice starts with millers putting their milled rice in unbranded bags. However, they then move quickly to branded bags, selling branded bags of milled rice at significantly higher prices when their brand names are better recognized. Modern retailers often start up their own brands of products as well. Such packaging will also better protect the product against damage and, therefore, help achieve lower PHL. Our analysis shows that branding and packaging is significantly more prevalent in modern retail in Addis Ababa, both for cereals and for processed products, compared to traditional retail outlets (Table 4.2). We also see higher levels of cereals being sold in milled (flour) form in modern retail. This form of sales also leads to lower PHL.

Third, modern retailers also have access to better storage, refrigeration, and sales facilities. The size of modern retail outlets in Addis Ababa - at 74 m^2 on average - is relatively small by international standards, but significantly larger than for traditional outlets in the city. A number of the traditional retail outlets – especially the *gulits* (micro-sellers) and wet market sellers – function in the open, so are less protected from weather vagaries (heat, sunlight, and rain) or losses due to animals. Moreover, some of the large modern retail outlets have access to either grid electricity or generators, allowing for refrigeration to keep their commodities fresh and at right temperature, reducing PHL that way. Many traditional retailers lack such facilities.

5. DISCUSSION AND CONCLUSIONS

We rely on unique large-scale datasets to assess PHL in the teff and milk value chains from rural producers to consumers in Addis Ababa and in urban retail in the city. We find that PHL vary between 2.2 and 3.3 percent in the teff value chain depending on assumptions on storage facilities and losses during transportation on the farm. In the case of milk, we find that PHL vary between 2.1 and 4.3 percent, depending on pasteurization and assumptions on losses during urban wholesale distribution. We further complement these detailed rural-urban value chain assessments with a large urban retail dataset. At the retail level, we find that the emerging modern retail sector has much lower PHL than traditional retail, possibly linked to higher quality requirements for procurement, the higher sales of packaged products, and better storage, refrigeration, and sales facilities.

The results of the evidence in our study therefore point to relatively low PHL in rural-urban value chains in these settings, especially compared to commonly assumed PHL levels (FAO 2011). As these are self-reported PHL, caution is required. However, we believe that these numbers likely paint a more reliable picture of PHL compared to other methods for estimating PHL in rural-urban food value chains for two reasons. First, information was asked at each level of the value chain from a large number of agents involved. Usually, PHL estimates are made based on a small number of purposely chosen and non-representative stakeholders. Second, we base our estimates on existing structures of the value chain, an issue that few researchers have looked at and on which significant uncertainty exists (e.g., Masters 2008; World Bank 2008, 2009; Mattoo et al. 2007; Trienekens 2011). This is important as value chain structures adjust endogenously to expected PHL. Moreover, our PHL estimates were reported by stakeholders that are heavily involved in these crops and are impartial to the under- or over-reporting of losses.

The lower than expected PHL estimates in this study might be due to bad measurements of total PHL in previous studies. However, it is also possible that due to the diffusion of innovations, such as the widespread use of storage chemicals and the spread of mobile phones, PHL in value chains also have been reduced in recent years, e.g., Jensen (2007) shows this to be the case for fish markets in Kerala, India. This is not to belittle the importance of post-harvest handling. It appears that some of the needed practices and investments have been already put in place to minimize PHL in Ethiopia. Moreover, it is likely that post-harvest performance in Ethiopia might be better because the quality threshold for when a food is judged to be unmarketable is lower in Ethiopia than in developed countries. In such countries, quality and cosmetic criteria are more severe, so that foods of lower quality are usually completely discarded from human consumption (Kader 2005; Parfitt et al. 2010).

The findings from this study that PHL in value chains serving Addis Ababa are low have a number of policy implications. First, achieving reductions in PHL entail costs and these costs might be substantial given the relatively low level of losses documented in this research. It is therefore crucial to look at the rate of returns to investments in facilities that might reduce PHL and the potential benefits of such facilities (e.g., Greeley and Boxall 2001; Greeley et al. 1978). The marginal costs of public policies to reduce PHL should be compared to the opportunity costs of alternative investments to reduce food insecurity or to promote agricultural development or environmental sustainability (e.g., de Gorter 2014). Second, modern retail – especially through foreign direct investment – is discouraged in some developing countries as there is a fear of negative spillovers on employment in traditional retail. However, there are also a number of benefits from such investments as shown in quality upgrading (e.g., Minten et al. 2013) and, as found in this case study, lower PHL.

While we believe that our research has generated novel insights on PHL, there are a number of caveats to this analysis that should be tackled in future research.

- First, we had to limit our producer surveys to an important and well-connected production area supplying commodities to the capital city. We therefore miss out on estimates from secondary cities and non-commercial areas.
- Second, no surveys were fielded at the consumer level – our PHL estimates only reach the point of sale by urban retailers. Better estimates of wastage by consumers should be collected in future surveys in order to extend our understanding of PHL in food value chains.
- Third, we have analyzed PHL based on self-reported losses by stakeholders. Other measurement methods could be pursued.
- Fourth, we looked at the impact of modern retail in an early stage of its roll-out. More data on PHL at a different stage of modern retail roll-out would be useful.
- Finally, we have focused on physical PHL only. Value losses and adulteration in these value chains were not assessed.

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ANNEX

Some researchers have looked at PHL in Ethiopia based on large-scale datasets at the farm level. Two studies are worthwhile mentioning.

First, Bachewe et al. (2018) analyzed PHL during storage based on two large datasets. The first dataset uses 5,092 households in the four major agricultural regions of the country. The second dataset covered about 7,500 households, sampled to represent 9 million households in areas of the country with high potential for grain production. They find that farmers' self-reported storage losses amount to an average of 4 percent of all grains stored and 2 percent of the total harvest. They further find that these storage losses differ significantly by socio-economic variables and wealth and also by crop and humidity.

Second, Hengsdijk and de Boer (2017) used data from the Ethiopian Socio-economic Survey (ESS) from 2,500 households and 5,500 cereal harvest observations. They found that 10 percent of households reported losses averaging 24 percent, indicating an average loss of 2.4 percent for the whole sample. They further report that rodent and other pests were mostly the cause of these losses.

We complement findings of this earlier research with analysis of other recently collected farm household data. Table A1 shows reported PHL based on a survey of households interviewed in regions of Feed-the-Future zone of influence in 2018. We find from this dataset that average reported PHL is not higher than 2 percent for any of the cereals. Maize has the highest PHL at 1.9 percent.

Table A1: Farmers' self-reported post-harvest losses in cereals, Feed-the-Future 2018 survey

Crop	Unit	Observa-tions	Mean	Median	Standard deviation
Teff	%	764	0.52	0.00	3.56
Wheat	%	484	1.07	0.00	4.82
Maize	%	948	1.86	0.00	5.85
Sorghum	%	173	1.71	0.00	6.01
Barley	%	356	0.80	0.00	2.63

Source: Authors' calculations based on FTF household survey, 2018

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