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The Last Mile(s) in Modern Input Distribution: Evidence from Northwestern Ethiopia

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ABSTRACT

Increasing adoption of modern inputs remains one of the best hopes towards higher agricultural production in developing countries. Based on unique data from a quasi-experimental setting in northwestern Ethiopia, this study examines the "last mile(s)"—from the input distribution center to the farmer—in the chemical fertilizer and improved seed distribution system. We find that increasing transaction and transportation costs over a 35 kilometer distance, along a route mainly accessible to foot traffic only, lead to a 50 percent increase of the prices of chemical fertilizer and to a 75 percent reduction in its use. Farmers who live about 10 km from the distribution center face per unit transaction and transportation costs as high as the costs needed to bring the fertilizer from the international port to the input distribution center (about 1,000 km). Tackling the "last mile(s)" costs should thus be a priority to improve modern input adoption in these settings.

Keywords: Modern inputs, chemical fertilizer, improved seed, Ethiopia, remoteness

1. INTRODUCTION

Agricultural productivity growth and increased modern input use are high on the international agenda.[1] Since the global food crisis began in 2008, a consensus has emerged regarding the need to increase agricultural production as the era of cheap food appears to be over. Some go so far as to argue that the planet is running out of food because of under-investments in the agricultural sector. This issue is especially pertinent to Africa where there is still a perceived potential for substantial productivity growth. The conventional wisdom is that the most promising way to increase agricultural production in Africa is through the more widespread adoption of modern inputs such as chemical fertilizers and improved seed, as the adoption of these new technologies remains lower in Africa compared to the rest of the world (World Bank 2008).

Reasons for the low adoption of modern technologies in Africa are diverse. One strand of the literature focuses on perceived profitability and motivation. Duflo, Kremer, and Robinson (2008, 2010) have shown that while modern fertilizer use in Kenya is highly profitable (a 70 percent return on an annualized basis), farmers' uptake of modern inputs has been limited due to procrastination issues. Interestingly, they also show some success with nudging practices (Duflo, Kremer, and Robinson 2010). To incentivize farmers to adopt, some advocates have suggested—and some governments have used—large subsidies to reduce market prices of modern inputs (Sachs 2004; Denning et al. 2009). However, despite the apparent success in some countries (e.g. Malawi became a net exporter of maize after the introduction of fertilizer subsidies), the design of such subsidy schemes has received criticism because private sector input suppliers tend to be crowded out and thus the overall impact is small while the fiscal costs are large (e.g. Xu et al. 2009a, 2009b; Morris et al. 2007; Minot and Benson 2009). Further, environmental externalities (World Bank 2008) and the regressive nature of fertilizer subsidies have drawn criticism (Donovan 2004; Pan and Christiaensen 2011).

A second strand of literature relates the low adoption of modern inputs to the lack of familiarity on the part of farmers with the new technologies. Researchers have studied institutional designs for stimulating changes in agricultural practices, the role that extension agents can play, and the type of extension systems that work best in leading to the sustainable adoption of modern inputs (e.g. Birner et al. 2009; Feder, Just, and Zilberman 1985). The jury is still out on what the appropriate interventions may be. For example, although Davis et al. (2012) find that farmer field schools have a large impact on agricultural production in East Africa, Feder, Murgai, and Quizon (2004) are much more critical of them. In some cases, the optimal interventions may be temporary ones. Krishnan and Patnam (2012) show that, for example, while extension agents play an important role in the early phases of the adoption process, it is the ongoing peer effects—learning from one's neighbors—that lead farmers to sustainably adopting modern inputs.

In this analysis, we use data from a unique survey in Ethiopia to explore the relationships of remoteness with modern input adoption. While Ethiopia is the biggest chemical fertilizer importer in Sub-Saharan Africa, fertilizer use per unit of land (50 kg/ha on average) is significantly below recommended levels (about 200 kg/ha), which is typical for other African countries. Our emphasis is on the transaction and transportation costs that farmers face in gaining access to modern inputs. In fact, these costs are often ignored in analyses where prices paid by farmers at the distribution point or prices charged by traders are taken as the effective price and are used as such in profit calculations and national supply/demand analyses for modern inputs (e.g. World Bank 2011; Omamo and Mose 2001; Jayne et al. 2003). However, these prices are less relevant if farmers face high transportation and transaction costs. The issue of these costs in agricultural input and output markets has received surprisingly little attention in the literature. While there has been some

[1] As reflected in the "L'Aquila" Joint-statement on Global Food Security announced by the G8 and a large number of other countries as well as international agencies in 2009.

empirical analysis in the area of modern input use (Alene et al. 2008), most of the existing research in this area has focused on theoretical models (Gollin and Rogerson 2010; de Janvry, Fafchamps, and Sadoulet 1991; and Platteau 1996).

The wedge between the price of modern inputs at the distribution center and the effective price faced by farmers may arise for two reasons. First, farmers face transportation costs—explicit costs as well as opportunity costs of time—from travelling to distribution points for modern inputs. Second, farmers may face administrative costs, often associated with direct government involvement in the distribution system.[2] To assess the importance of these two types of costs on modern input adoption, we conducted a household survey in an area that is characterized by high transportation costs (where farmers in the most remote areas travel 8 hours to reach a market). The setting for the survey can be described as quasi-experimental, because transport costs are not linked with soil quality. We collected detailed information on transportation costs and the different types of transaction costs faced by farmers before, during, and after the acquisition of modern inputs.

We estimate that the transaction and transportation costs overall add between 20 percent (for the least remote) and more than 50 percent (for the most remote farmers) to the effective fertilizer price charged at the input distribution center. We also find that contact with extension agents, knowledge of improved technologies, and modern inputs decrease significantly with increasing remoteness. While more than 80 percent of the farmers in the least remote areas know recommended fertilizer levels, this share declines to just over 20 percent in the most remote areas. We further find that adoption rates of modern inputs depend significantly on transportation and transaction costs. Farmers who live in the most remote villages of our sample and who face implicitly higher input prices and lower output prices, use 75 percent less chemical fertilizer and improved maize seed compared to the least remote farmers.

Our results might partly explain the puzzling low adoption of modern inputs in parts of Ethiopia, and Africa more widely, as in these settings, modern input markets are usually rather thin, the number of distribution centers, traders, and shops is limited, and farmers often live in remote areas (Dorosh et al. 2010). These results thus imply that the proposed nudging schemes (e.g. Duflo, Kremer, and Robinson 2010) and improved access to credit and insurance (Dercon and Christiaensen 2011) may only address part of the problem of low adoption of modern inputs in this environment. If adoption rates are to improve, policy changes and investments in the "last mile(s)" are needed. This can possibly be done in four ways. First, transaction costs could be lowered through improved management of cooperatives and through the participation of the private sector in the distribution in order to reduce transaction costs and to benefit from economies of aggregation. Second, given that transport infrastructure is underdeveloped in Ethiopia (e.g. Foster and Morella 2011) transportation costs faced by farmers could be significantly reduced through further investments in roads, and especially in feeder roads. Third, in light of the high responsiveness of improved varieties to chemical fertilizers (Evenson and Gollin 2003) and of the limited national supply of such seed varieties, profitability could be increased by assuring the more widespread availability of these varieties through an improved seed supply chain. Fourth, inclusion of the more remote farmers in extension efforts as to improve their knowledge of improved agricultural technologies would be helpful.

The structure of the paper is as follows. Section 2 provides background information on modern inputs in agriculture in Ethiopia. In Section 3, we discuss the data and methodology used. Some descriptive statistics are presented here as well. Section 4 assesses modern input use and the perceived constraints to adoption. Section 5 documents the transaction costs that farmers face in gaining access to modern inputs. Section 6 quantifies these costs and examines implicit prices and profitability over space. In Section 7 and 8, the relationship between remoteness on the one hand and agricultural extension and modern input adoption on the other hand is explored. Issues related to the external validity of the findings are discussed in Section 9. We finish with the conclusions in Section 10.

2. BACKGROUND

Modern input use and agricultural productivity growth are strongly linked (World Bank 2008). In Ethiopia, official statistics show rapid growth of agricultural production in the last decade. However, modern input use is still relatively low and has contributed little to overall agricultural growth (Yu et al. 2011; Asrat, Getachew, and Taffesse 2010). Since conventional sources of agricultural growth (e.g. land expansion) have largely run out, expansion of modern input adoption is seen as an opportunity for continued growth. This is reflected in the policy agenda of the Ethiopian government, where seed law changes are being considered to allow for a better and more efficient modern seed multiplication and distribution system in the country.

[2] Given that stimulating the adoption of modern inputs is often a deliberate policy strategy, governments frequently provide implicit and/or explicit subsidies for farmers (Morris et al. 2007; Minot and Benson 2009; Pan and Christiaensen 2011). As part of these policies, governments typically either impose specific rules to assure that the subsidies are targeted, or they organize the distribution themselves. Although they may be well intended, these interventions often lead to managerial problems, administrative costs, and subsequent transaction costs for farmers.

Fertilizer use in Ethiopia is, on average (50 kg per hectare), only one-fourth of the level recommended by the Ministry of Agriculture. Nonetheless, modern input use is increasing and total chemical fertilizer use is now four times higher than it was 15 years ago. In 2011, Ethiopia imported roughly 500,000 tons of fertilizer, valued at over 500 million USD (Tefera et al. 2012). A recent study of the structure of the supply chain of chemical fertilizer, from international markets to rural distribution centers, found that the difference between world market prices and prices in local distribution centers was as high as 26 percent in 2011 (Tefera et al. 2012). At the national level, problems of fertilizer distribution are linked to the limited port capacity in Djibouti, estimating demand and planning for accurate supplies, and large carry-over stocks (Tefera et al. 2012). [3]

Distribution of modern inputs to farmers is almost exclusively the purview of cooperatives. The private sector previously played an important role in distribution, but is currently of minor importance (World Bank 2011). It is not clear what this exclusive reliance on cooperatives for distribution means for inefficiencies and whether costs of modern inputs are higher or lower for farmers due to the cooperatives. While cooperatives might benefit from economies of scale, their effectiveness in delivering modern inputs may be hampered by a lack of competitive pressures, a lack of management experience, and the burden of demand for too many competing activities (Bernard et al. 2010).

Limited access to modern seed is a particularly important problem that is hindering sustainable agricultural productivity growth in Ethiopia. While the state-run seed distribution systems have generated some impacts in the past, they have been unable to satisfy the increasing demand for seed (Spielman, Kelemwork, and Alemu 2011). Further, because the current system is stretched thin, the quality of seed has fallen. There is thus an urgent need for reforms and for new procurement procedures that will encourage regional extension and input supply systems to purchase seed more extensively from the private sector (Spielman, Kelemwork, and Alemu 2011).

3. DATA

3.1. Data and Methodology

The sample area for this study is located in Alefa *woreda* (commune) in the rugged terrain of northwestern Ethiopia (see Appendix Figure A.1). The study site is an isolated area with little to no electricity and mobile phone access, and without any development or humanitarian assistance programs provided by non-governmental organizations. The starting point for the study area is the market town of Atsedemariam, which is connected to Gonder to the northeast by a gravel road that is passable year round. Trucks regularly ply the road between Atsedemariam and the product markets in Gonder and beyond with goods originating from and destined for Atsedemariam. To the west of Atsedemariam there exist communities whose access to the outside markets is available for the most part only through Atsedemariam because of the difficult terrain. Further, access to Atsedemariam (and onward to Gonder) is limited to paths along the route that are accessible mainly to foot traffic only, though motorcycles can pass along some portions.[4] To transport agricultural produce to Atsedemariam, community members rely on donkeys.

Farmers in the survey area rely on the cooperative office of Atsedemariam as their source of modern inputs.[5] Households were surveyed along a series of seven sub-districts (or *sub-kebeles*) along the route emanating from Atsedemariam. For sampling purposes, an equal number of households was interviewed in five different distance brackets (measured in travel time by donkey) from the market of Atsedemariam. 170 households were interviewed in each category, for a target of 850 households. Households were sampled evenly from sub-districts within each category to assure a relatively homogenous spread of households over the space between Atsedemariam and the most remote households in Fantaye. The sampling objective was to obtain a representation of households in the districts along the route from the market at Atsedemariam to Fantaye, rather than for the survey sample households to be representative of the population in the woreda. The survey took place over the course of five weeks in November and December 2011, which followed shortly after the main season (Meher) harvest. Community questionnaires were also completed by the survey team

[3] In an effort to bring fertilizer costs down, the Ethiopian government has recently started the construction of local fertilizer factories. This might possibly bring some savings to the country and will likely reduce the large import bill that it faces for it.

[4] Half way through the survey area from the town of Garasghe, it is possible to reach within two hours the town of Finjit which is also connected to Gonder by a mostly passable gravel road (depending on mudslides). However households in the survey still use Atsedemariam as their major output market since the market in Finjit is small. Some communities do gain access to modern inputs from Atsedemariam through Finjit.

[5] The cooperative office in Atsedemariam is manned by five permanent staff, with additional staff hired during the time of fertilizer distribution. The method used to determine the supply needed at the cooperative each year is not flexible. *Development Agents* from every *kebele* (village) submit their chemical fertilizer and improved seed requests to the cooperative office one year in advance. The cooperative office then submits that request to the Ministry of Agriculture. The effective prices to be charged and the quantities of modern inputs to be distributed are then determined by the regional Ministry. The cooperative office in Atsedemariam reported that it distributed 3,510 quintals (1 quintal = 100 kilograms) of urea, 6,383 quintals of DAP, and 520, 40, and 9 quintals of improved maize, teff, and wheat seeds, respectively, in 2010/11.

supervisors based on interviews with informed sources in each of the 33 villages. Information on access to services, infrastructure, and seasonal prices for major food and non-food items was collected.

Transport costs were measured based on information collected in the household portion of the survey. Using information that households provided on the cost of renting a donkey for a round-trip to Atsedemariam and on how many kilograms a donkey can carry for such a trip, we first calculated the cost of transporting one quintal (100 kilograms) on a donkey to Atsedemariam. However, because farming households almost always take their own products to the market by donkey, rather than hiring porters, a more complete measure of transport costs is one that includes the opportunity cost of the farmers' time. Thus our measure of transport cost is based on augmenting the cost of renting a donkey with the imputed value of farmers' travel time. To determine the value of time, we use the median harvest-period wage in the village to value the amount of time that households report that it takes to walk to Atsedemariam and back. This is the measure of transport costs that we use throughout the analysis as a measure of remoteness.[6]

In the remainder of the text, we will refer to transportation costs as those costs that are related to opportunity costs of time and cash travel expenses. Transaction costs are those costs that are incurred by farmers in order to fulfill the conditions and requirements needed to purchase modern inputs. The survey questionnaire includes detailed questions about transportation and transaction costs related specifically to accessing modern inputs for two cropping seasons, 2010 and 2011.

3.2. Descriptive Statistics

Table 3.1 presents some basic descriptives of the farmers in the survey area. Most of the farmers in the area are originally from the area. Even those farmers who moved to their current villages were mostly born in the woreda itself. Education levels of farmers are low, with only 26 percent of the household heads being literate. On average, it takes households in the sample 4.5 hours to travel one-way during the dry season to Atsedemariam. Farm sizes are generally very small in the sample, with an average cultivated area slightly greater than one hectare. Further, given that the average household has four plots, plot sizes are even smaller (0.3 hectares on average). Land rental markets are quite active in the sample, making up half of the cultivated land. An average household in the survey area produced 1.5 tons of output per year. About one quarter of that output was sold, at a value of 1,391 Birr (73 USD[7]). The most important crops planted by these farmers are the four major cereals in the country—teff (17 percent of the plots), maize (20 percent), sorghum (19 percent), and millet (17 percent).

[6] To minimize measurement errors in estimating travel times and costs, each household's transport cost is calculated as the average cost of the household's reported cost and the costs reported by its five nearest neighbors. The nearest neighbors are determined using the GPS coordinates for each household.

[7] Evaluated at the exchange rate in 2010 (September) of 16.35 Birr/USD.

Table 3.1—Basic descriptives of farmers in the sample area

	Unit	Mean	Median	Standard deviation
Number of observations		851		
Household characteristics				
Household size	number	5.8	6.0	2.3
Literate head of household	% yes	26.1		
Migration status head of household				
Non-migrant	%	74.3		
Migrant born in woreda, but not in village	%	21.5		
Migrant born outside woreda	%	4.2		
Total	%	100.0		
Average time to Atsedemariam				
Dry season	hours	4.5	5.0	2.1
Rainy season	hours	5.2	5.5	2.3
Area of land				
Cultivated and owned by the household	hectares	0.95	0.75	1.03
Owned but cultivated by another household	hectares	0.16	0.00	0.45
Rented in by the household	hectares	0.57	0.50	0.67
Total area owned by the household	hectares	1.11	1.00	1.04
Total area of land cultivated by the household	hectares	1.52	1.37	1.09
Number of plots cultivated by the household	hectares	3.70	4.00	2.47
Plot size	hectares	0.30	0.25	0.27
Output information 2010/2011				
Quantity produced	tons	1.54	1.35	1.11
Value of production	1000 Birr	4.12	2.50	1.30
Quantity sold	tons	0.38	0.27	0.55
Value of commercial surplus	1000 Birr	1.39	0.96	1.70
Percentage of plots allocated on major crops				
Sorghum	% of plots	19		
Maize	% of plots	20		
Millet (Dagussa)	% of plots	17		
Teff	% of plots	17		
Rest	% of plots	27		

Source: Survey data.

To understand the extent to which the profitability of modern input use in our sample is driven by the quality of the soil, we have to understand how soil quality varies over space. Direct comparisons of yields across the 3,111 plots cultivated by the 851 households in the sample would be misleading, however, because of different uses of inputs by these households. To net out these confounding factors, we estimate separate production functions for each of the four cereals of interest. Assuming constant returns to scale, let the log yield of the particular cereal on plot *p* be a function of a vector of inputs x_p and observed plot-specific weather shocks υ_p,

$$\log(y/a)_p = x_p'\beta + \upsilon_p + \varepsilon_p, \quad (1)$$

where ε_p is an error term representing plot-specific unobservables. After estimating (1), we calculate the residual ($e_p = \log(y/a) - x_p'\hat{\beta} - \hat{\upsilon}_p$) and add it to the mean yield to obtain plot-specific yields adjusted for weather shocks and input use:

$$\widetilde{y/a} = \exp\left(\overline{\log(y/a)} + e_p\right) \quad (2)$$

Equation (2) provides an estimate of plot-specific yields in which the effects of weather and pest shocks and input use on yields are netted out by adding to the mean the remaining variation in yields that is not accounted for by weather and pest shocks and input use.[8] We define this as the *adjusted* cereal yield.

For each of the cereals under consideration, we relate the adjusted yields to the distance from the market/cooperative office. As seen in Table 3.2, distance is shown not to have a significant effect on the adjusted cereal yields. Agricultural land productivity thus does not differ systematically and substantially across the study area for the four main cereals. As such, we can interpret the analysis as being quasi-experimental with transport costs *effectively* being placed randomly in

[8] We consider some variables such as plot characteristics to be fixed and not subject to choices made by the farming household. As such, these variables are not netted out (i.e. they are added back into the residual) of the adjusted yield.

the study area. In other words, we can interpret differences in observed land productivity as following from transport cost-induced household behavioral differences, not from differing geographic characteristics of the study area. A similar exercise is done for a number of other variables. We find that there is no significant difference over space in household characteristics. On the other hand, most of the variables measuring farm characteristics, off-farm activities, use of credit, and shocks do show significant variation over space. This indicates the need to control for some of these characteristics in further analysis and we therefore complement in the remainder of the text non-parametric graphs with multivariate regression analysis.

Table 3.2—Household and farm characteristics by transport costs

	Unit	Number of observations	Mean	Standard deviation	Effect transport costs* Coefficient	t-value/ z-value [a]
Adjusted cereal yields						
Maize	quintals/ha	590	19.88	11.77	0.002	0.08
Millet	quintals/ha	521	13.86	6.73	0.022	1.46
Sorghum	quintals/ha	607	14.56	7.61	0.025	1.12
Teff	quintals/ha	325	6.81	3.25	-0.011	-1.12
Household characteristics						
Household size	number	851	5.77	2.35	0.006	1.49
Gender of the head of household	male=1	850	0.91	-	0.004	1.23
Number of years of schooling	number	847	1.64	3.24	-0.002	-0.41
Age of the head of household	years	850	40.94	14.73	-0.002	-0.07
Farm characteristics						
Total area owned by the household	hectares	833	1.11	1.05	-0.012	-5.78
Total area of land cultivated by the household	hectares	833	1.52	1.10	-0.006	-2.63
Number of plots cultivated by household	number	847	3.70	2.47	-0.003	-0.67
Household owns a donkey	yes=1	849	0.29	-	-0.006	-2.66
Off-farm activities						
Household member earned income from wage income	yes=1	848	0.13	-	0.000	0.05
Household member earned income from business enterprises	yes=1	851	0.10	-	0.010	3.04
Use of credit						
Member of the household took out a loan in the last 12 months	yes=1	851	0.48	-	0.004	1.89
Shocks						
In the last 12 months, household was affected by a serious shock	yes=1	850	0.27	-	0.006	2.41

Source: Survey data.
Notes: * Intercept included but not reported. a/ OLS in the case of continuous variables as dependent variable, probit for dummies, tobit for censored variables.

4. MODERN INPUT USE AND PERCEIVED CONSTRAINTS

Despite how remote the survey area is in general, a surprisingly large share of farmers there uses chemical fertilizer (80 percent; see Table 4.1). On the other hand, fewer farmers use improved maize seed (26 percent). These figures are consistent with national level numbers which show the adoption of improved seed being much lower than chemical fertilizer. Among sample households, the expenditure on chemical fertilizer is clearly the largest of the two modern inputs expenses: 97 percent of the 893 Birr (55 USD) spent annually on modern inputs (defined in our case by expenses for chemical fertilizer and improved seed) by an average household went to chemical fertilizer.

Of the households not using modern inputs, 15 percent and 21 percent of them did try to buy chemical fertilizer and improved seed respectively, but were unable to do so (Table 4.1). The primary reasons given for not using modern inputs were lack of money at the time of need (40 percent for chemical fertilizer and 48 percent for improved seed), and the inability to find modern inputs (10 percent for seed and 6 percent for chemical fertilizers). Only around 10 percent of the farmers not using modern inputs were deterred by high prices of these inputs.

Even among those using modern inputs, not all were able to acquire as much as they desired. Only 31 percent of the farmers were able to buy as much fertilizer as desired in 2010, while 51 percent were able to acquire the quantity of

improved seed that they needed. The major reason given for these difficulties was lack of money, which may give credence to Duflo et al.'s (2010) claim that because farmers postpone, by the time that they need to buy inputs, liquidity becomes an issue. Problems related to the supply chain for improved seed appear to be greater than for chemical fertilizer. For those farmers using improved seed but reporting that they could not buy enough seed, 47 percent stated that they could not find the sufficient amount; for fertilizers this number is 4 percent. This is also an important reason why some farmers do not use improved seed at all.

Table 4.1—Modern input use

		Chemical fertilizer	Improved maize seed	All modern inputs
Did the household use…	% yes	80.2	26.0	
Average amount spent on modern inputs per household (Birr/year)				
Modern inputs in total	mean			893
	median			740
Chemical fertilizer	mean	862		
	median	728		
Improved seed	mean		31	
	median		0	
For non-users:				
Major reason for not using modern input				
I lacked the money at the time of need	%	39.7	47.6	
No need	%	17.0	0.0	
No need because of share cropped out	%	14.2	5.4	
Fertilizers/improved seed are too expensive	%	12.8	8.9	
I do not have enough land	%	5.0	2.7	
I was unable to find them	%	5.7	10.4	
There is too much hassle/transactions cost	%	2.1	2.9	
I do not know how to apply them	%	2.1	2.3	
Lack of oxen for ploughing	%	0.0	0.0	
Other	%	1.4	2.3	
Lack of transportation	%	0.0	0.4	
I don't grow maize	%	0.0	17.2	
Total	%	100.0	100.0	
Farmers tried to buy modern inputs but could not obtain them	% yes	15.0	21.2	
For users:				
Farmer was able to buy as much modern inputs as desired	% yes	30.7	51.1	
Reason for not buying enough modern inputs				
I lacked the money to buy more	%	86.5	42.5	
There is too much hassle/transactions cost	%	5.4	8.5	
Lack of transportation	%	4.1	0.9	
I was unable to find enough	%	3.9	47.2	
The topography of the land does not encourage	%	0.2	0.0	
Others	%	0.0	0.9	
Total	%	100.0	100.0	
Farmer is aware of recommended fertilizer on plot	% of plots	37.1	-	

Source: Survey data.

The characteristics of the more than 1,200 modern input transactions made by farmers in the sample in 2010 appear in Table 4.2. Farmers generally acquired their modern inputs in the months just before or at the time of planting. The quantities were rather small, with an average of 71 kg of chemical fertilizer per transaction, and 6 kg of improved maize seed. When seed and fertilizer were combined in one transaction, an average of 121 kg of fertilizer and 7 kg of improved seed were acquired. While the majority of the modern inputs were distributed directly from the cooperative union (81 percent and 86 percent of the chemical fertilizer and improved seed transactions, respectively), private traders and other farmers accounted for over 10 percent of the transactions in the survey zone despite these transactions ostensibly being illegal. Access to modern inputs from private traders and other farmers appears to be especially important in the most remote villages. Further, although Atsedemariam is the most important location for acquiring inputs, it is not the only place available to farmers. With respect to payment, 83 percent and 97 percent of the farmers paid the full costs of fertilizer and improved seed respectively at the time of acquisition, while 11 percent paid only half of the costs initially and

then paid the rest later. Three-quarters of the farmers purchased modern inputs through groups, since group applications are often a requirement of the cooperative in the area, even when credit is not involved.[9] The farmers reported spending significant time into putting these groups together. On average, 5 hours were devoted to forming groups to acquire chemical fertilizers, and 7 hours were needed for improved seed groups.

Table 4.2—Characteristics of modern input transactions

	Unit	Chemical fertilizer*	Improved seed
Quantities and values of inputs:			
1. Fertilizer transactions	number of obs.	1003	
Quantity bought (kg)	mean	71.0	-
	median	50.0	-
Total amount paid in Birr	mean	583.0	-
	median	447.0	-
2. Improved seed transactions	number of obs.		123
Quantity bought (kg)	mean		6.5
	median		5.0
Total amount paid in Birr	mean		90.0
	median		80.0
3. Combined transactions	number of obs.	95	95
Quantity bought (kg)	mean	121.0	7.0
	median	100.0	6.0
Total amount paid in Birr	mean	1010.0	96.0
	median	880.0	90.0
Most important months of purchase:			
Ginibot (May, 9th–June, 7th)	%	31.3	57.2
Sene (June, 8th–July, 7th)	%	45.4	35.6
Hamle (July, 8th–August, 6th)	%	17.8	0.0
Other	%	5.5	7.2
Total	%	100.0	100.0
Input purchased from:			
Cooperative	%	81.1	85.6
Committee	%	4.7	3.6
Private trader	%	7.6	6.5
Other farmer	%	6.6	4.3
Total	%	100.0	100.0
Place of input purchase			
Atsedemariam	%	76.2	79.7
Garasghe	%	10.8	5.8
Finjit	%	8.3	5.1
Shahura	%	2.5	5.1
Other	%	2.2	4.3
Total	%	100.0	100.0
Down payment			
100%	%	82.6	97.1
51–99%	%	0.9	0.0
50%	%	11.2	1.5
<50%	%	5.3	1.5
Total	%	100.0	100.0
Purchased as a group?	% yes	73.9	76.1
Time spent organizing group	hours	5.1	7.4

Source: Survey data.
Note: * Including combined transactions.

[9] In the year just prior to the survey (2011), the cooperatives supplied modern inputs on credit through group lending. However, the timing of access to inputs depended on the type of credit required. For example, farmers who paid the full amount in cash could purchase their modern inputs in May and June, while farmers willing to pay only 50% upfront, could obtain them from June onwards. Beginning of July, fertilizer could be obtained without any down payment. In order for farmers to apply for credit, they had to do so as part of a group. In 2010/11, the cooperative in Atsedemariam provided an estimated 28%, 39% and 32% of total modern supply distribution with 100%, 50%, and 0% down payment, respectively.

5. TRANSACTION COSTS

For each modern input transaction in 2010, survey respondents were asked detailed questions about the transaction costs they faced before, during, and after the acquisition of modern inputs.

(a) Transaction costs before acquisition

Nearly half and one-third of farmers who used fertilizers and improved seed respectively needed to visit the cooperative office at least once before acquiring the inputs (Table 5.1). For chemical fertilizer, 16 percent of the transactions required one pre-acquisition trip, 16 percent required two such trips, and 16 percent required more than 2 trips. Given that an average trip for fertilizer takes about 13 hours (3.5 hours of walking each way and 6 hours at the place of sales), these additional trips take up valuable time during peak labor demand periods. Although the average time spent on pre-acquisition trips for improved seed is less, this is a consequence of these seeds primarily being acquired by less remote households. If these trips to the cooperative also served other purposes such as purchasing consumption goods or selling produce, then the fertilizer transaction costs would be less. This, however, does not appear to be the case, since 97 percent and 93 percent of the pre-acquisition trips for chemical fertilizer and improved seed, respectively, were taken for the sole purpose of acquiring these modern inputs.

Farmers reported two major reasons why so many additional trips were necessary in order to acquire modern inputs. The first is related to management problems on the part of the farmers themselves. Getting the appropriate paperwork in order was an important constraint for a large number of farmers. Either the groups did not have enough members registered to qualify for access to inputs (31 percent of those with unsuccessful trips for chemical fertilizer and 36 percent of those for improved seed) or they did not have the required signature of an official from their village (8 percent and 11 percent for chemical fertilizer and improved seed, respectively). The second major reason for additional trips is linked to problems associated with the management of the cooperative office. Long queues (14 percent and 24 percent of the reasons for failed trips in the case of chemical fertilizers and improved seed, respectively), the cooperative office being closed (11 percent and 16 percent), a lack of modern input supplies (9 percent and 11 percent), and the money collector being absent (1 percent and 4 percent) at the time of the visit all contributed to the need for additional visits to the cooperative.[10]

Table 5.1—Transaction costs before acquisition

	Units	Chemical fertilizer*	Improved seed
For each transaction: **Number of trips made to the cooperative or committee before the farmer was able to pick up modern inputs**			
0 trips	%	52.5	65.9
1 trip	%	15.7	13.0
2 trips	%	16.1	12.5
3 trips	%	9.2	4.8
> 3 trips	%	6.5	3.8
Total	%	100.0	100.0
Reasons for the unsuccessful trip:			
Form issues		*39.4*	*46.9*
Form did not have signature of an official	%	8.4	11.2
Not enough people registered on the form	%	31.0	35.7
Problems cooperative management		*52.4*	*37.1*
Cooperative office not open	%	15.5	11.2
Cooperative office was open but there was no supply	%	9.2	10.5
Cooperative office was open but too long queue	%	23.7	14.0
Money collector was not there	%	4.0	1.4
Looking for/met with committee member	%	4.2	5.6
Other	%	4.1	10.5
Total	%	100.0	100.0
Average time spent on each trip:			
Travel there	hours	3.7	1.9
Time at location	hours	5.7	6.0
Travel back	hours	3.5	2.4
Money spent on trip	Birr	14.5	12.5
Purpose of trip was solely to acquire modern inputs	% yes	96.8	92.8

Source: Survey data. Note: * Including combined transactions.

[10] The reasons given are consistent with the international literature on the problem of absenteeism in social service delivery in developing countries (e.g. Chaudhury et al. 2006; Kremer et al. 2005).

(b) Transaction costs at acquisition

The average trip for which an acquisition actually took place took 12 hours for chemical fertilizer and 9 hours for improved seed. In most cases, farmers relied on rented donkeys to transport fertilizer back to their farms, but tended to carry improved maize seed by foot given the small quantities involved. In 26 percent of the cases, an additional trip was required after the acquisition of chemical fertilizers in order to transport the fertilizer back to the farm (Table 5.2). The potential reasons for these additional post-acquisition trips are twofold. First, in some cases the loads were too large to carry in one go. Second, given the uncertainty over the timing of the acquisition, some farmers waited until the fertilizer was available before organizing transport as to avoid paying unnecessarily for rented donkeys. Second trips typically took less time since less time was needed at the center (3.4 hours compared to 5.5 hours in first trip) as farmers just needed to pick up the fertilizer and did not need to complete any more paperwork.[11]

Table 5.2—Transaction costs at time of acquisition

	Unit	Chemical fertilizer*	Improved seed
Average time spent on acquisition trip			
Travel there	hours	3.2	2.3
Time at location	hours	5.5	5.0
Travel back	hours	3.6	2.0
Money spent on trip (average)	Birr	14.4	10.7
Most important means of transportation			
Rented donkey	%	49.6	5.7
Own donkey	%	29.4	11.4
By foot	%	12.1	77.3
Borrowed cart/donkey	%	7.3	2.1
Other	%	1.6	3.6
total	%	100.0	100.0
Treatment after purchase			
Was input stored between the time of acquisition and transport	% yes	42.5	8.5
Number of days stored	days	3.4	1.2
% of fertilizer lost during that storage	% yes	0.7	0.0
Money spent for storage and guards (average)	Birr	1.3	2.1
% of transactions where second trip was required	%	26.1	4.0
Average time spent on second trip			
Travel there	hours	3.1	0.2
Time at location	hours	3.4	0.6
Travel back	hours	3.6	0.3
Money spent on trip (average)	Birr	8.6	4.9

Source: Survey data.
Note: * Including combined transactions.

(c) Transaction costs after acquisition

For farmers who acquired inputs on credit, additional trips back to the cooperative office were necessary to repay the loans. Since only a handful of farmers purchased improved seed on credit, these post-acquisition trips relate primarily to chemical fertilizers.

As with acquiring fertilizer itself, paying off the loans for the fertilizer is not always straightforward. For example, one third of the farmers who received credit, had to make at least two trips to the cooperative office before they were able to make their repayments (Table 5.3). Indeed, some 5 percent of the farmers had to travel three or more additional times in order to make their payments. The reasons for these repeated trips were primarily related to management problems in the cooperative office that included lost forms (32 percent), the cooperative office being closed (21 percent), long queues (18 percent), and absent money collectors (23 percent).

[11] Given that there were only a couple of cases where a second trip for improved seeds was noted, data in this case were limited.

Table 5.3—Transaction costs after acquisition

	Unit	2010 Chemical fertilizer*
Second payment was made	% yes	98.1
For each transaction: **Number of trips made to the cooperative or committee before the farmer was able to pay (exclude payment trip)**		
0 trips	%	66.4
1 trip	%	18.3
2 trips	%	10.2
3 trips	%	5.1
Reasons for the unsuccessful trip:		
Form was lost	%	32.4
Money collector was not there	%	22.5
Cooperative office was not opened	%	21.1
Cooperative office was opened but queue too long	%	18.3
Other	%	5.6
Total	%	100.0
Average time spent on each trip:		
Travel there	hours	2.2
Time at location	hours	4.5
Travel back	hours	2.3
Money spent on trip	Birr	12.6

Source: Survey data.
Note: * Including combined transactions.

An additional and important issue related to the modern input distribution system is delays in delivery. This is especially problematic in countries like Ethiopia where agricultural production is highly dependent on seasonal rainfall, and where timely application of seed and chemical fertilizer is thus important. When input delivery is delayed and planting takes place late as a result of this, the consequent reduction in growing periods usually has important implications for agricultural productivity. In our sample, late planting occurred on 20 percent of the plots due to late access to fertilizer. Further, these delays were not trivial. For those who experienced delays due to later fertilizer delivery, the delays were 8 days on average.

These results indicate that fertilizer acquisition in these settings is characterized by important transaction costs. The addition of transaction costs to the observed prices increases the implicit prices faced by farmers, reducing the incentives to use modern inputs. Such transactions costs can be relatively large especially given the relatively small amounts of modern inputs purchased and the relatively expensive means of transport (because of the opportunity cost of time). We now turn to the relative magnitude of these costs.

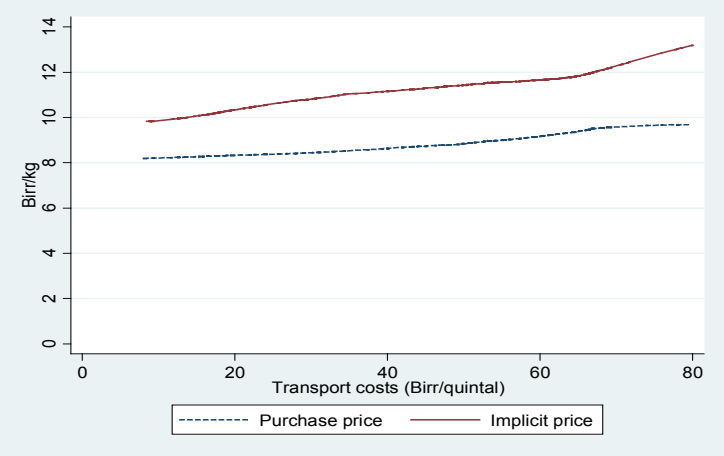
6. THE LAST MILE(S), PRICING, AND PROFITABILITY

6.1. Pricing of Modern Inputs

To estimate the implicit costs of modern input purchases, we add to the cash price observed at the time of acquisition the value of time spent on the transaction (opportunity costs of time) as well as the effective costs of travel and storage (away from home). We value the opportunity costs of time at 3 Birr/hour. Although the median wage for planting and soil preparation activities around the time when improved inputs are acquired is roughly 40 Birr/day, based on data from the community survey, we opt for a conservative estimate of time value. The results of a non-parametric regression on the relationships between cash and implicit fertilizer prices and remoteness are shown in Figure 6.1. The lower line shows the average cash price that was paid for fertilizer. If all farmers bought fertilizer directly from the cooperative, this would be a horizontal line since the cooperative charges one price to all farmers at the distribution center. But this price increases slightly for farmers living further away from the market town, indicating that although it is illegal, traders or other farmers are selling fertilizer to these farmers at a higher price than the prices charged at the distribution center. The upper line illustrates how the implicit prices (cash prices plus transaction and transportation costs) for chemical fertilizer vary over space. Transaction and transportation costs increase the effective price for chemical fertilizer by about

20 percent for those farmers that live close to the distribution center, and for farmers in the most remote areas this difference is more than 50 percent.[12]

Figure 6.1—Fertilizer prices by remoteness



Source: Survey data.
Notes: Implicit prices are defined as cash prices plus the value of transportation and time needed to deliver the fertilizer to the farm. Remoteness is defined by transportation costs from the location to the market in Atsedemariam. Given large outliers in implicit prices, the number of observations for the locally weighted regression was trimmed by deleting the lowest 5% and highest 5%.

These results illustrate that the "last mile" costs for modern inputs are considerable. In the case of chemical fertilizer, these costs for the more remote households are roughly twice as high as the expenses that are incurred to bring fertilizer from international markets to rural Ethiopia (approximately 160 USD per ton in 2012; Tefera et al. 2012). This is remarkable given the much larger distances involved in bringing fertilizer into Ethiopia. The distance from the port of Djibouti to the rural distribution center in the study area is roughly 1,000 km compared to the 35 km from the most remote villages to the distribution center. To put the magnitude of these costs further into perspective, consider that farmers who live at about 10 km from the distribution center face per unit transaction and transportation costs as high as the expenses incurred for bringing the fertilizer from the international port to the input distribution center.[13]

Simple multivariate regressions of the log of implicit modern input prices can provide insights into the other factors which are associated with the formation of modern input prices. First, we present a parsimonious model where the logarithm of the distance to the cooperative office (expressed in Birr as a travel time cost) is used as the only covariate. In the second specification, we add other covariates such as household and transaction characteristics.

Several important findings emerge from Table 6.1 where we present the model with fertilizer prices as the dependent variable. First, the impact of the distance declines significantly when other covariates are added. This suggests that the distance variable on itself captures significant variation from the other variables that differ with remoteness. Second, an important determinant of the price of fertilizer is the quantity bought. The larger the quantities purchased, the lower the implicit price. A doubling of the quantity of fertilizer purchased reduces the implicit fertilizer price by 23 percent. This indicates the large benefit from being able to aggregate loads (for different acquisitions of the same farmer or for combining loads of different farmers) since some of these transaction costs are independent of the quantities purchased (e.g. pre-acquisition trips). Third, the prices charged by private traders and other farmers appear to reflect the implicit prices faced by farmers, as shown by the insignificant parameter estimates for the trader and other farmer dummy variables. Fourth, the few farmers who were able to acquire fertilizer in markets that are closer to their homes, such as Garasghe and Finjit, faced a significantly lower price. Finally, none of the variables reflecting household characteristics (except for access to extension) are associated with different fertilizer prices.

[12] A similar analysis is done for improved seed prices. Given that seeds are usually bought in very small quantities (6 kg per transaction on average), the relative importance of transaction costs based on time values compared to chemical fertilizer transactions is significantly higher. For example, the implicit price of seeds in areas close to the distribution center is 65% higher than the price paid at the distribution center, while it is 80% in the most remote areas. Note that there are very few observations for improved seed purchases in the most remote villages.
[13] 160 USD/ton equals about 2.6 Birr/kg.

Table 6.1—Correlates of implicit fertilizer prices

Dependent variable = log(Birr/kg)	Unit	Implicit prices			
		Coeff.	t-value*	Coeff.	t-value*
Distance from cooperative office (in Birr)	log()	0.162	**8.84**	0.065	**3.51**
Transaction characteristics					
Quantity bought	log()			-0.226	**-14.42**
Fertilizer is DAP (default=urea)	yes=1			0.145	**5.58**
Month of purchase (default earlier than month 10):					
Month 10	yes=1			-0.009	-0.45
Month 11	yes=1			-0.070	**-2.41**
Seller (default cooperative):					
Committee	yes=1			0.031	0.69
Private trader	yes=1			0.005	0.09
Other farmer	yes=1			-0.070	-1.33
Place of purchase (default is Shahura):					
Atsedemariam	yes=1			0.045	1.12
Garasghe	yes=1			-0.183	**-3.28**
Finjit	yes=1			-0.093	**-2.02**
Other	yes=1			-0.177	**-2.60**
Household characteristics					
Gender of head of household	male=1			-0.020	-0.39
Age of head of household in years	log()			-0.010	-0.64
Education of the head of household	years			0.003	1.30
Size of the household	number			0.002	0.56
Household owns a donkey	yes=1			-0.008	-0.46
Household owns a mobile phone	yes=1			0.049	1.05
Household is member of the fertilizer committee	yes=1			-0.013	-0.59
Household received visit of extension agent in last 5 years	yes=1			0.032	**1.88**
Intercept		1.810	**26.77**	2.977	**23.50**
Number of observations		983		976	
F( )		78.10		18.73	
Prob > F		0.00		0.00	
R-squared		0.08		0.38	
Root MSE		0.30		0.25	

Source: Survey data.
Note: * t-values of coefficients that are significant at the 5% level are in bold.

Similar patterns show up when we look at the correlates of implicit improved seed prices (Appendix Table A.1). Distance, however, is not a significant correlate of implicit seed prices, indicating that non-distance related transaction costs are more important for seed than for fertilizer. As with fertilizer, there are important economies of scale as relatively fixed transaction costs can be spread out over larger quantities purchased. These same scale benefits also hold when seed is purchased in combined transactions with chemical fertilizer. It is worth nothing that half of the improved seed purchases were made in the form of a combined transaction. Finally, as in the case of chemical fertilizers, household characteristics are not highly correlated with seed prices.

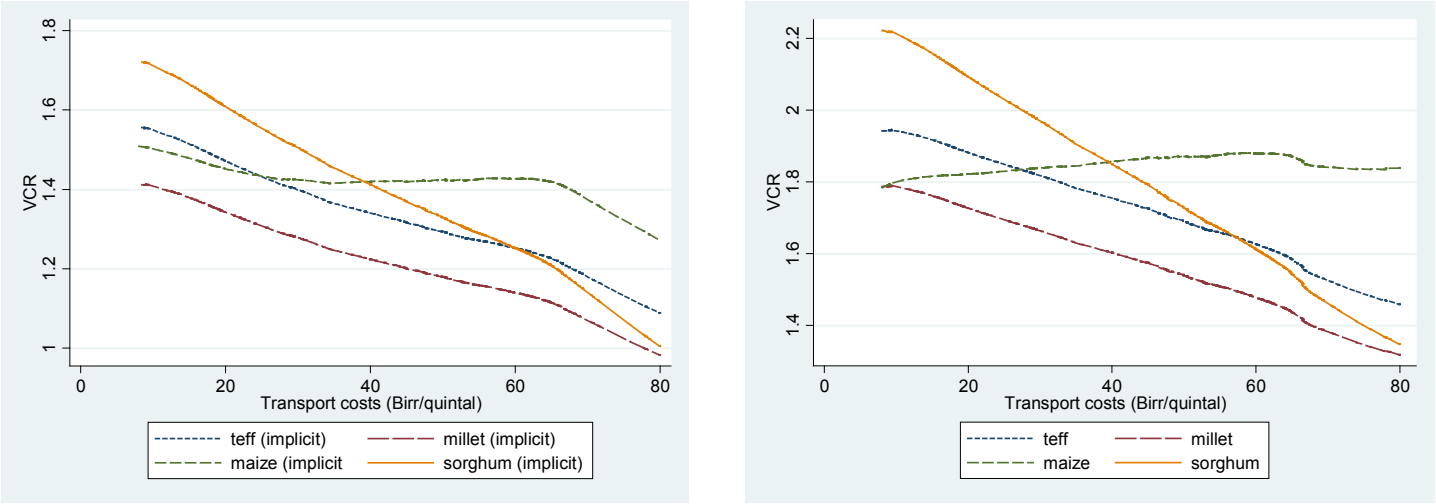
6.2. Profitability

Given the importance of profit incentives vis-à-vis farmers' adoption of modern inputs, we now turn to estimates of the profitability of modern inputs. We limit this analysis to fertilizers since they are the most important modern input in our sample and they are used on most of the cereals produced in the survey area. The profitability of fertilizer use depends on two important factors (Yanggen et al. 1998): (1) the technical response of output to fertilizer use; and (2) the relationship between output prices and fertilizer prices. The value–cost ratio (VCR), which combines both of these measures is thus the yardstick that is often used to evaluate profitability of fertilizer use. It is defined as $\left(\frac{O}{N}\right)\left(\frac{P_N}{P_O}\right)$ where O are the units of outputs produced from one unit of nutrient (N), P_N is the price of fertilizer, and P_O is the price of output. A rule of thumb is that a VCR greater than 2 is likely to provide enough incentive for farmers in developing countries to use fertilizer (Yanggen et al. 1998; Morris et al. 2007). In this analysis we assess how the VCR differs by remoteness, and for implicit as well as cash fertilizer prices.

To calculate the VCR, we use the average $\frac{O}{N}$ ratio as estimated in production function regressions for teff, maize, and millet (see Appendix Table A.2). Since fertilizer was not used on any sorghum plots in our sample, we used the lower $\frac{O}{N}$ value for Eastern Africa (i.e. 4) reported in Morris et al. (2007). For output prices (P_O), we use reported sales prices for the four major cereals at the village level in the output-marketing season. Since we have only sub-sub-kebele level output prices, we simulate household level output prices using a model of log prices regressed on a distance variable and season dummies (see Appendix Table A.3). This is done for each household by plugging the distance at which the household is located and the month when most sales of the product occur into the regression results reported in Appendix Table A.3.

Non-parametric regressions of the VCR by remoteness are shown in Figure 6.2. While this method is only an approximation (and, for example, does not look at marginal productivity), it does illustrate the large effect that remoteness plays on the profitability of modern inputs. Several important findings emerge. First, VCRs calculated for cash prices are, not surprisingly, significantly higher than for implicit prices. The transaction and transportation costs that drive a wedge between the cash and implicit prices also act to reduce the profitability of fertilizers as illustrated by the differing VCRs. If improved distribution systems can reduce implicit fertilizer prices closer to cash prices, farmers' incentives to adopt chemical fertilizer would increase. Second, we generally find that the VCRs fall dramatically with remoteness, and that these declines are greater for implicit fertilizer prices than for cash prices. While the VCR of sorghum is as high as 2.2 in the least remote areas, this declines to as low as 1.4 in the most remote area, a difference of 0.8. In the case of implicit prices, VCRs differ by 1 between the least and most remote areas in the survey. Third, since maize prices do not differ much by remoteness, we observe the least differences in VCRs for prices of maize. Fourth, given that the estimated returns to fertilizer are lowest for teff, the spread between the VCRs calculated with cash and implicit prices is not very large for this crop.

Figure 6.2—Value–cost ratio (VCR) for the four main cereals by remoteness (for implicit (graph on the left) and cash (graph on the right) prices for chemical fertilizer)



Source: Survey data.
Notes: Implicit prices are defined as cash prices plus the value of transportation and time needed to deliver the fertilizer to the farm. Remoteness is defined by transportation costs from the location to the market in Atsedemariam. Given large outliers in implicit prices, the number of observations for the locally weighted regression was trimmed by deleting the lowest 5% and highest 5%.

7. THE LAST MILE(S), AGRICULTURAL EXTENSION, AND AGRICULTURAL KNOWLEDGE

Access to agricultural extension agents is often viewed as an important determinant of the adoption of improved technologies. In the survey, a number of questions were asked on contacts with extension agents as well as on the knowledge of improved technologies (Table 7.1). Despite the large investments by the Ethiopian government towards improving agricultural extension in the country, the results show that contacts of the farmers with the agricultural extension system in this remote area are still rather limited. Only 37 percent of the farmers reported that they had visited or were visited themselves by an agricultural extension agent in the last five years, 10 percent visited in the last year a demonstration plot, a demonstration home, or a research station, and 16 percent of the farmers visited in the last year the office of agriculture. In all cases we see a significant decline of these contacts for the more remote farmers.

Table 7.1—Extension and agricultural knowledge

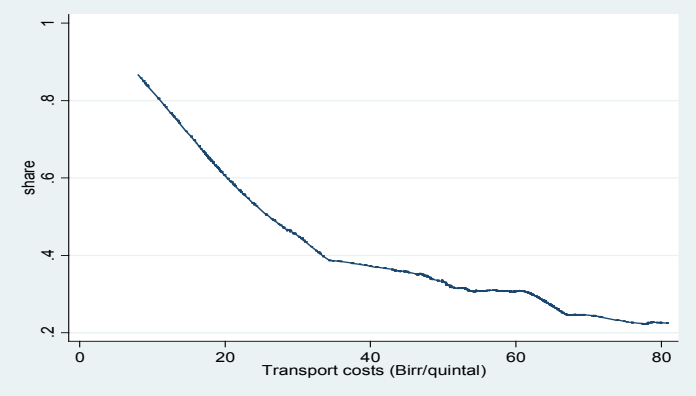
	Unit	Number of observations	Mean	Standard deviation	Effect transport costs* Coefficient	t-value/ z-value [a,b]
Access to and use of agricultural extension						
Visited in the last five year an agricultural extension agent	yes=1	850	0.37	-	-0.016	**-6.68**
Number of times talked to extension agent in the last year	number	851	1.51	5.15	-0.383	**-8.17**
Number of times participated in community meetings to discuss agr. issues in last year	number	845	2.05	3.43	-0.079	**-7.86**
Visited in last year demonstration plot, demonstration home or research station	yes=1	845	0.10	-	-0.021	**-6.59**
Visited in last year government office of agriculture	yes=1	843	0.16	-	-0.017	**-6.06**
Knowledge of technologies						
Farmer knows how to apply/carry out soil conservation measures	yes=1	856	0.71	-	-0.012	**-4.54**
Years since farmer knows how to apply/carry out soil conservation measures	years	856	4.97	8.11	-0.136	**-7.00**
Farmer knows how to apply/carry out chemical fertilizers (application/dosage)	yes=1	842	0.59	-	-0.009	**-3.63**
Years since farmer knows how to apply/carry out chemical fertilizers	years	843	3.48	4.72	-0.083	**-6.12**
Farmer knows how to apply/carry out chemical/mechanical weeding	yes=1	846	0.72	-	-0.012	**-4.73**
Years since farmer knows how to apply/carry out chemical/mechanical weeding	years	847	6.41	9.92	-0.121	**-5.03**
Farmer knows how to apply/carry out compost preparation	yes=1	850	0.54	-	-0.017	**-6.79**
Years since farmer knows how to apply/carry out compost preparation	years	851	1.90	2.53	-0.081	**-10.77**
Farmer knows how to apply/carry out manure application	yes=1	845	0.78	-	-0.005	**-1.98**
Years since farmer knows how to apply/carry out manure application	years	845	10.81	11.40	-0.038	-1.46

Source: Survey data.

Notes: * Intercept included but not reported. a/ Probit for dummies as dependent variables, tobit for censored variables. b/ t-values and z-values of coefficients that are significant at the 5% level are in bold.

Further questions were asked on the knowledge of different agricultural technologies and the number of years of experience with these technologies (Table 7.1). Questions were asked on five technologies: soil conservation measures, chemical fertilizers, chemical and mechanical weeding, compost preparation, and manure application. The best known practice is manure application (78 percent of the households) and the least known is compost (54 percent). For all the practices, knowledge declines significantly with increasing remoteness. A final question was asked at the plot level if the farmer was aware of the recommended fertilizer use for the chosen crop on that particular plot (and he was then asked to state the recommended level). Figure 7.1 shows that this knowledge drops significantly with increasing remoteness. While more than 80 percent of farmers for the least remote villages are aware of the recommended levels, this share drops to just over 20 percent for the most remote villages.

Figure 7.1—Knowledge of recommended fertilizer use for the planted crop on each plot (share of plots) by remoteness

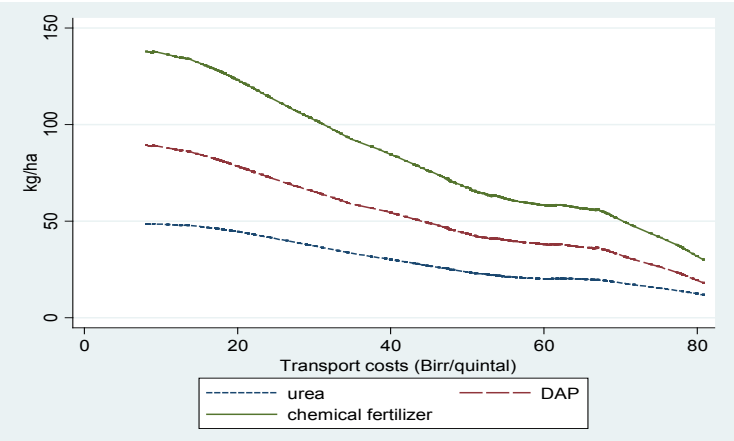


Source: Survey data.

8. THE LAST MILE(S) AND ADOPTION OF MODERN INPUTS

The differences in profitability of fertilizer use and in the knowledge of use of modern inputs by remoteness are reflected in the substantial differences in adoption of modern inputs over this same space. Non-parametric regressions of chemical fertilizer and improved maize seed use by remoteness in Figures 8.1 and 8.2, respectively, illustrate the impact of distance on the quantities of modern input used. Fertilizer use, for example, drops from almost as high as 140 kg per hectare on average for the households living close to the cooperative office, to less than 40 kg per hectare for those households living in the most remote villages (Figure 8.1). Similar reductions are seen for urea as well as DAP use. Similarly, improved maize seed[14] use drops from more than 15 kg per hectare in the least remote areas to less than 5 kg per hectare in the most remote villages (Figure 8.2).

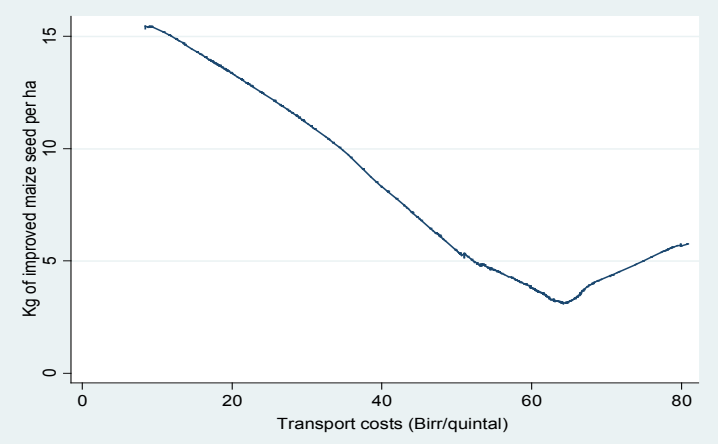
Figure 8.1—Adoption of chemical fertilizer (kg/ha) by remoteness



Source: Survey data.

[14] Note that we focus on maize only as that is the only crop where improved seeds are being distributed in a significant way by the cooperative office.

Figure 8.2—Adoption of improved maize seed (kg/ha) by remoteness



Source: Survey data.

To better understand what other factors affect the choice to adopt modern inputs as well as the quantity used, we estimate a double-hurdle model (Cragg 1971). In such a set-up, the "first hurdle" is used to estimate the factors which determine modern input use on a specific plot, while the "second hurdle" analyzes the determinants of the quantities of modern inputs used conditional on being used. Ricker-Gilbert, Jayne, and Chirwa (2011) argue that this is often the most appropriate way to model modern input use in Africa, especially given the large number of farmers that do not use modern inputs, and consequently given the importance of modeling corner solutions correctly in such situations.

The results of this model (Table 8.1) confirm that remoteness affects both the choice to adopt chemical fertilizers and improved seed as well as the quantity of chemical fertilizer applied. To assess the magnitude of these effects, we report in the bottom row of the table average partial effects (APE) of distance to Atsedemariam that reflect the overall impact on modern input use —including both the first (reported in top half of table) and second (reported in bottom half of table) hurdles.[15] The highly significant unconditional APE of remoteness on chemical fertilizer use of -44 indicates that a doubling of the distance to the cooperative office and market (or about 20 km) reduces fertilizer use by 44 kg per ha. For improved maize seed use, the APE of -6 indicates a reduction by 6 kg per hectare when doubling the distance to the cooperative office and market. These impacts of remoteness on the adoption of modern inputs are substantial.

[15] Standard errors for the unconditional APE were obtained from bootstrapping the model with 100 repetitions.

Table 8.1—Determinants of chemical fertilizer/improved seed use, double hurdle regression estimates

	Unit	Chemical fertilizer		Improved maize seed	
		Coefficients	z-value*	Coefficients	z-value*
Use (yes/no) of modern inputs					
Distance Atsedemariam	log(Birr)	-0.676	**-14.24**	-1.100	**-9.97**
Characteristics plot					
Lem (fertile) soil	yes=1	-0.142	**-2.72**	0.038	0.27
Teuf (infertile) soil	yes=1	-0.156	**-2.54**	0.005	0.03
Distance house to plot	minutes	-0.003	**-4.06**	0.011	**2.72**
Certified plot	yes=1	0.022	0.30	-0.068	-0.41
Share cropped in	yes=1	0.154	**2.21**	0.299	1.72
Brown soil	yes=1	-0.004	-0.07	-0.114	-0.76
Black soil	yes=1	-0.077	-1.14	0.300	1.67
Tan soil	yes=1	0.125	1.24	-0.307	-1.08
Slightly sloped plot	yes=1	-0.132	**-2.68**	0.318	**2.44**
Steep plot	yes=1	-0.271	**-3.17**	0.254	0.91
Soil difficult to plow	yes=1	-0.114	**-2.02**	0.121	0.70
Characteristics household					
Gender of head of household	male=1	0.269	**2.24**	0.250	0.93
Age of head of household in years	log()	-0.013	-0.22	-0.031	-0.23
Education of the head of household	years	0.005	0.82	0.049	**2.99**
Size of the household	number	0.010	0.84	-0.036	-1.22
Household owns a donkey	yes=1	0.114	**2.31**	0.282	**2.23**
Household owns a mobile phone	yes=1	-0.180	-1.33	0.259	0.73
Household is member of the fertilizer committee	yes=1	0.062	0.94	0.112	0.64
Household received visit of extension agent in last 5 years	yes=1	0.073	1.56	0.195	1.63
Total land owned	log(x+1)	-0.110	-1.49	0.217	1.11
Intercept		2.511	**9.20**	2.852	**4.77**
Quantity used of modern inputs					
Distance Atsedemariam	log(Birr)	-155.770	**-2.40**	10.815	1.05
Characteristics plot					
Lem (fertile) soil	yes=1	220.601	**2.67**	4.402	0.37
Teuf (infertile) soil	yes=1	107.709	1.16	-2.371	-0.13
Distance house to plot	minutes	-2.842	-1.53	-0.443	-1.33
Certified plot	yes=1	-138.256	-1.53	-15.155	-1.11
Share cropped in	yes=1	-551.969	**-3.85**	-22.789	-1.48
Brown soil	yes=1	-5.232	-0.07	-3.623	-0.27
Black soil	yes=1	-87.787	-0.92	10.027	0.75
Tan soil	yes=1	-251.484	-1.79	-28.391	-0.94
Slightly sloped plot	yes=1	68.841	1.04	10.176	0.91
Steep plot	yes=1	-115.220	-0.80	6.132	0.24
Soil difficult to plow	yes=1	-58.836	-0.71	-11.492	-0.77
Characteristics household					
Gender of head of household	male=1	-82.274	-0.57	6.886	0.28
Age of head of household in years	log()	-127.392	-1.85	-7.366	-0.95
Education of the head of household	years	11.750	1.37	0.429	0.34
Size of the household	number	-9.144	-0.58	3.992	1.47
Household owns a donkey	yes=1	144.282	**2.03**	-0.411	-0.04
Household owns a mobile phone	yes=1	0.955	0.01	-19.509	-0.78
Household is member of the fertilizer committee	yes=1	9.883	0.12	-5.006	-0.36
Household received visit of extension agent in last 5 years	yes=1	38.277	0.61	4.756	0.45
Total land owned	log(x+1)	-342.779	**-2.78**	-9.368	-0.59
Intercept		593.213	1.95	-41.204	-0.78
Sigma		407.120	8.10	35.611	5.97
Number of observations		3544		697	
Wald chi2()		359.53		184.91	
Prob>chi2		0.00		0.00	
Average partial effect - APE (100 iterations)					
Distance Atsedemariam	log(Birr)	-43.98	**-12.29**	-6.17	**-6.42**

Source: Survey data.
Note: * z-values of coefficients that are significant at the 5% level are in bold.

9. EXTERNAL VALIDITY

This analysis focuses on the adoption and pricing of modern inputs in a particular remote setting in rural Ethiopia. This naturally raises questions about the relevance of the findings to the rest of the country and to other countries. As such, in this section, we address a number of temporal and spatial concerns to establish the external validity of the results.

First, our analysis has focused on modern inputs acquired in the year 2010. But our survey also included similar information on transaction and transportation costs for the year 2011 that we can use for comparison purposes.[16] Some changes did take place in how modern inputs were made available to farmers in the sample area. In particular, farmers were able to pick up their fertilizer acquired through the cooperative at an alternative place (Finjit), not just at the market town, Atsedemariam. This likely led to changes in access rules and to lower implicit costs for modern inputs. Nonetheless, when Tables 4.1 through 5.3 are updated using the 2011 data, the patterns do not change substantively, suggesting that 2010 was a typical year.

Second, given that prices of inputs and outputs can vary significantly throughout the country and over time, the returns to inputs calculated as VCRs in the survey area can differ substantially from those calculated elsewhere in Ethiopia and at different time periods. Various analyses of the nationally representative Agricultural Sample Survey from 2007/08 find that most VCRs throughout the country for various crops are less than 2 (Asrat, Getachew, and Taffesse 2010; Spielman, Kelemwork, and Alemu 2011; and Tefera et al. 2012), which confirms the orders of magnitude found in our survey site (especially those close to the distribution center).

Third, while alternative surveys suggest that transaction costs, shortage of supply, and late delivery of inputs are not an overwhelming issue elsewhere in Ethiopia, and indeed are likely to be even less of an issue in more accessible areas, there is still a sizable portion of Ethiopian farmers for whom these are real problems. For example, 20 percent of the 8,000 farmers recently surveyed in high potential areas of Ethiopia[17] indicated that a major constraint for fertilizer adoption was a shortage of supply, while 12 percent complained of late arrivals of fertilizer supply (Berhane et al. 2012). Some 11 percent of farmers in the nationally representative Agricultural Sample Survey of 2007/08 did not use chemical fertilizer because of a lack of availability of supply (Asrat, Getachew, and Taffesse 2010).

Fourth, we conducted our survey in a very remote area of Ethiopia where farmers are located relatively far from markets and from offices of cooperative unions. Evidence suggests that this degree of remoteness is not the norm in Ethiopia. First, in a recently collected household survey representative of the Agricultural Growth Program area of intervention, it was reported by 20 percent of the farmers that they lived at least 2 hours travel from an input distribution center. Second, using GIS data on the location of households as well as cooperatives in the Tigray region[18] and modeling a travel time grid surface using infrastructure (road networks), biophysical features (rivers, lakes, and land cover), and topographic data (slope) in the same way as Schmidt and Kedir (2009), it is found that about 13 percent of the farmers in that region live at more than 2 hours from a cooperative distribution center. This compares to 77 percent of the households in our dataset. Third, according to the census of cooperative unions in the Amhara region, there are 6.57 unions per 1000 km^2. If these unions were located at equal distances from each other, the furthest that a farmer would live from a cooperative office would be about 8.5 km, which is one-fourth of the distance for the most remote household in our dataset.[19] While these data suggest that households in our survey area are more remote than other rural households in Ethiopia, it is also likely that there are a significant number of farmers that operate in similar situations. After all, cooperatives and populations are not evenly distributed over space, paths traveled between farms and cooperatives are not straight, and Amhara is one of the most densely populated regions in the country.

10. CONCLUSIONS

We study the link between transaction and transportation costs and modern input use in Ethiopia. Implicit prices are calculated in this analysis by adding to the observed cash prices the opportunity cost value of time and transportation costs. The implicit prices of chemical fertilizer for the most remote households, that live some 35 km from the fertilizer distribution center along a route mainly accessible to foot traffic only, are over 50 percent higher than the cash prices paid at the central distribution center. Farmers who live 10 km from the distribution center face per unit transaction and transportation costs (160 USD/ton) as high as the expenses that are incurred to bring the fertilizer from the international port to the input distribution center (about 1,000 km).

[16] Note that because the crops for the 2011/12 season had not been harvested at the time of the survey, value–cost ratios (VCRs) for inputs purchased in 2011 could not be calculated.
[17] Commonly referred to as the "AGP woredas" (AGP is the Agricultural Growth Program, a large agricultural investment program started in 2011).
[18] This is the only region for which such data are available. This region is located north of the studied Amhara region.
[19] A straight-line distance with neighboring unions would be 12.3 km. Half the distance of the diagonal would be sqrt (12.3^2+12.3^2) = 8.5 km.

We find that farmers face important wedges between the cash prices they pay and the effective prices they encounter for modern inputs. Transportation and transaction costs are relatively high in these settings because transportation is expensive, small quantities are traded, and economies of scale are not achieved. Administrative costs also appear to be a problem. For example, almost half of the adopting households in our sample needed to take at least two trips to the distribution center before they were able to acquire chemical fertilizer for their farms. These “last mile” transportation and transaction costs to markets where products are sold and from where modern inputs are obtained play a very important role in explaining variation in adoption of modern inputs. The results of a double-hurdle model suggest that a 20 km increase in the distance to the modern input distribution center and output market leads to a 44 kg/ha and 6 kg/ha reduction in chemical fertilizer and improved seed use, respectively.

Improving the modern input provision system is enormously important for sustaining agricultural growth given that the traditional sources of growth in Ethiopian—and African—agriculture are increasingly running their course (e.g. extensification of cultivated land). Our study shows that if the government of Ethiopia is serious about stimulating agricultural productivity through greater adoption of modern inputs, it should focus on addressing profitability and agricultural extension issues in the “last mile(s)”. This could be done in several ways.

First, road infrastructure investments would improve profit incentives for farmers who are considering adopting modern inputs by reducing transportation costs. More widespread access to feeder roads would increase output prices in agricultural surplus areas and reduce input prices. This is especially relevant in Ethiopia where transport infrastructure is not well developed (Foster and Morella 2011), where 12 percent of the population in 2007 lived more than 10 hours away from a city (Schmidt and Kedir 2009), and where the benefits and returns to investments in feeder roads are extremely high in these settings (Stifel et al. 2012).

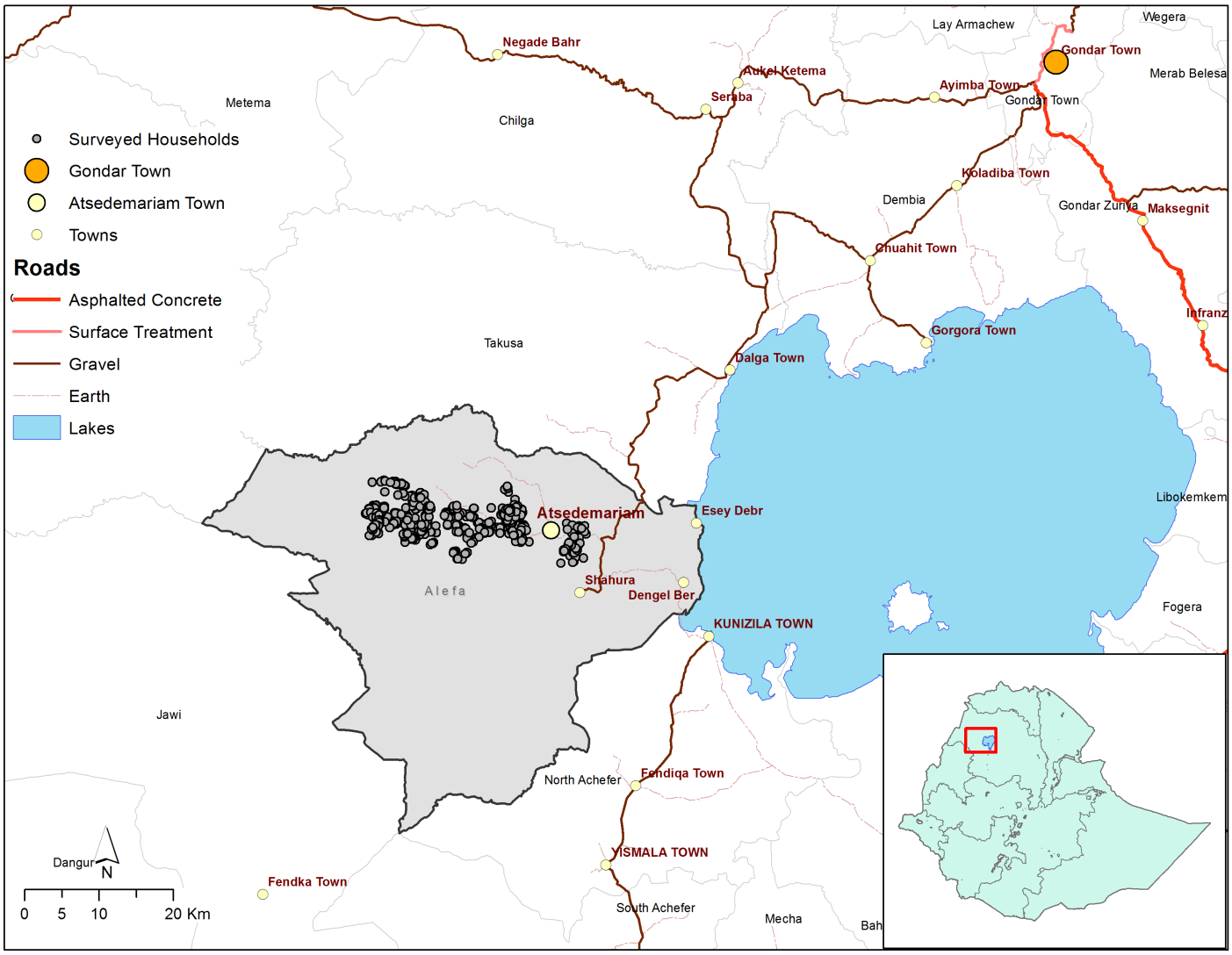
Second, more efficient cooperative unions could improve the current input distribution system by reducing important transaction costs. Given the fast growth in the number and the scope of these cooperatives over the last decade, some cooperatives are likely still encountering steep learning curves. Additional exposure to professional management experience is destined to result in improved service delivery, as will further investments to develop the capacities of the cooperatives. But strengthening the cooperatives is not the only approach. De-licensing of the input sector and allowing private traders in to assure a more competitive environment—with the aim of assuring greater spatial dispersion of input suppliers in farming areas as suppliers compete for customers, bringing input supplies closer to the farms where the inputs are used—could result in improved and timely delivery mechanisms and lower prices. It appears that fertilizer distribution, especially in the “last mile”, could very well benefit from economies of scale through aggregation, which could be achieved by allowing traders in areas where no cooperative unions are present.

Third, access to extension agents and knowledge of modern technologies are strongly linked with remoteness and it seems that more efforts are needed from the extension system to include the farmers that are located in less easy accessible areas.

Finally, improved seed varieties need to be made more readily available. Farmers in our dataset complained especially about the lack of supply of improved seed. Better availability would not only lead to higher productivity, but would also improve the profitability of fertilizers because these improved varieties often have much higher fertilizer response rates than do traditional seed varieties (Evenson and Gollin 2003).

APPENDIX

Appendix Figure A.1—Sample area



Source: Ethiopia Rural Transport Survey 2011

Appendix Table A.1—Correlates of implicit seed prices

Dependent variable = log(Birr/kg)	Unit	Implicit prices			
		Coeff.	t-value*	Coeff.	t-value*
Distance from cooperative office (in Birr)	log()	0.024	0.35	0.018	0.27
Transaction characteristics					
Quantity bought	log()			-0.368	**-6.82**
Improved seed is maize	yes=1			0.400	1.97
Combined transaction with chemical fertilizer	yes=1			-0.632	**-11.53**
Month of purchase (default earlier than month 10):					
Month 10	yes=1			0.088	1.33
Month 11	yes=1			-0.490	**-3.30**
Seller (default cooperative):					
Committee	yes=1			0.055	0.38
Private trader	yes=1			-0.346	**-2.04**
Other farmer	yes=1			0.115	0.58
Place of purchase (default is Shahura):					
Atsedemariam	yes=1			-0.038	-0.31
Garasghe	yes=1			-0.148	-0.83
Finjit	yes=1			-0.245	-1.26
Other	yes=1			-0.313	-1.85
Household characteristics					
Gender of head of household	male=1			0.048	0.35
Age of head of household in years	log()			-0.044	-0.43
Education of the head of household	years			-0.004	-0.57
Size of the household	number			0.022	1.86
Household owns a donkey	yes=1			-0.053	-0.96
Household owns a mobile phone	yes=1			-0.218	**-2.43**
Household is member of the fertilizer committee	yes=1			-0.022	-0.35
Household received visit of extension agent in last 5 years	yes=1			0.036	0.56
Intercept		3.065	**13.26**	3.646	**7.42**
Number of observations		217		216	
F( )		0.12			
Prob > F		0.72			
R-squared		0.00		0.55	
Root MSE		0.56		0.39	

Source: Survey data.
Note: * t-values of coefficients that are significant at the 5% level are in bold.

Appendix Table A.2—Production functions of major cereals

Dep. variable= Level of output in kg	Unit	Black teff		Maize		Millet	
		Coefficients	z-value*	Coefficients	z-value*	Coefficients	z-value*
Inputs							
Weeding frequency	number	9.14	1.73	-8.84	-0.83	1.66	0.34
Manure use	yes=1	15.10	0.82	-4.76	-0.27	41.92	1.31
Compost use	yes=1	-59.46	**-2.73**	44.91	1.61	-51.41	-1.63
Herbicide use	yes=1	23.40	**2.19**	-55.19	-1.65	72.13	**2.95**
Chemical fertilizer used	kg	2.57	**8.03**	4.43	**9.9**	4.31	**4.97**
Total land cultivated	hectare	-0.98	-0.18	30.42	1.83	28.09	**2.03**
Labor used for land preparation	person-days	3.54	**2.71**	2.02	0.66	6.37	**2.38**
Labor used for cultivation	person-days	2.37	1.88	8.91	**4.33**	6.75	**3.55**
Improved seed	yes=1	-	-	61.73	**2.61**	-	-
Fertilizer amount*late planting		-3.15	**-5.64**	-0.30	-0.52	0.52	0.48
Household characteristics							
Gender head of household	male=1	80.11	**5.11**	107.90	**3.23**	116.94	1.74
Education head of household	Years	-1.74	-1.21	-0.82	-0.24	1.49	0.49
Size of household	number	-0.18	-0.07	-11.15	**-2.33**	-4.06	-0.84
Plot characteristics							
Lem (fertile) soil	yes=1	31.16	**2.28**	48.60	1.65	28.68	1.21
Lem_teff soil	yes=1	15.60	1.33	31.17	0.9	12.95	0.55
Distance from house to plot	minutes	0.26	1.11	1.47	1.56	-0.44	-0.98
Plot has certificate	yes=1	-0.07	-0.01	9.25	0.4	-36.18	-1.65
Shock variables (default=less than normal)							
More rain than normal	yes=1	13.41	0.51	98.24	1.54	85.43	1.43
Later rain than normal	yes=1	-24.78	-1.37	-15.13	-0.37	1.20	0.04
More frosts than normal	yes=1	18.20	0.84	17.71	0.43	40.49	0.56
More pest/disease than normal	yes=1	23.49	1	71.86	1.29	-235.09	**-2.04**
Normal frosts	yes=1	38.10	**2.41**	39.83	1.04	73.03	1.16
Normal pests/diseases	yes=1	-21.49	-1.27	38.76	1.11	-216.89	-1.89
Normal amounts of rain	yes=1	5.90	0.41	-5.13	-0.18	50.92	1.54
Rain on time	yes=1	-18.60	-1.11	-10.18	-0.24	8.65	0.29
Intercept		-29.10	-0.8	-60.24	-0.7	114.07	0.95
Number of observations		414		718		624	
F( )		7.06		17.28		5.50	
Prob > F		0.00		0.00		0.00	
R-squared		0.34		0.51		0.28	
Root MSE		97.41		267.76		227.71	

Source: Survey data.
Note: * z-values of coefficients that are significant at the 5% level are in bold.

Appendix Table A.3—Correlates of producer prices

Dependent variable = log(Birr/kg)	Unit	Teff		Maize		Millet		Sorghum	
		Coeff.	t-value*	Coeff.	t-value*	Coeff.	t-value*	Coeff.	t-value*
Distance from cooperative office (in Birr)	log()	-0.061	**-3.720**	0.087	3.390	-0.036	-1.970	-0.130	-7.230
Monthly dummies									
Meskerem (Sep/Oct) (default)									
Tikimt (Oct/Nov)	yes=1	0.005	0.110	-0.011	-0.150	0.006	0.100	0.008	0.150
Hidar (Nov/Dec)	yes=1	-0.033	-0.750	-0.034	-0.490	-0.013	-0.210	0.013	0.260
Tahsas (Dec/Jan)	yes=1	-0.065	-1.520	-0.027	-0.360	-0.023	-0.390	-0.002	-0.030
Tir (Jan/Feb)	yes=1	-0.073	-1.790	-0.038	-0.510	-0.046	-0.770	-0.030	-0.590
Yekatit (Feb/Mar)	yes=1	-0.078	-1.790	0.042	0.570	-0.034	-0.590	-0.071	-1.360
Megabit (Mar/Apr)	yes=1	-0.049	-1.100	0.080	1.140	-0.038	-0.730	-0.071	-1.420
Miazia (Apr/May)	yes=1	-0.005	-0.100	0.126	1.810	-0.030	-0.580	-0.035	-0.670
Guienbot (May/Jun)	yes=1	0.074	1.390	0.194	**2.660**	-0.003	-0.060	-0.007	-0.150
Sene (Jun/Jul)	yes=1	0.095	1.890	0.239	**3.290**	0.086	1.490	0.015	0.310
Hamle (Jul/Aug)	yes=1	0.172	**3.390**	0.355	**5.660**	0.153	**2.740**	0.116	**2.460**
Nahassie (Aug/Sep)	yes=1	0.193	**4.200**	0.395	**6.060**	0.190	**3.340**	0.150	**3.120**
Pagume (Sep)	yes=1	0.193	**4.200**	0.395	**6.060**	0.190	**3.340**	0.154	**3.160**
Intercept		1.835	**29.450**	0.686	**7.190**	1.219	**15.560**	1.781	**24.550**
Number of observations		403		403		390		377	
F( )		11.70		16.06		5.49		9.4	
Prob > F		0.00		0.00		0.00		0.00	
R-squared		0.24		0.26		0.15		0.24	
Root MSE		0.19		0.28		0.21		0.19	

Source: Survey data.
Note: * t-values of coefficients that are significant at the 5% level are in bold.

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The Ethiopia Strategy Support Program II is an initiative to strengthen evidence-based policymaking in Ethiopia in the areas of rural and agricultural development. Facilitated by the International Food Policy Research Institute (IFPRI), ESSP II works closely with the government of Ethiopia, the Ethiopian Development Research Institute (EDRI), and other development partners to provide information relevant for the design and implementation of Ethiopia's agricultural and rural development strategies. For more information, see http://www.ifpri.org/book-757/ourwork/program/ethiopia-strategy-support-program or http://essp.ifpri.info/ or http://www.edri.org.et/.

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