Market Access, Well-Being, and Nutrition:
Evidence from Ethiopia

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Abstract:

We use a unique data source from a rural area in northwestern Ethiopia to analyze the relationship between household/individual well-being, nutrition, and market access. We find that households residing in relatively more remote areas consume substantially less than households nearer to the market, they are more food insecure, and their school enrollment rates are lower. Although their diets are also less diverse, we find no significant differences in mother and child anthropometric measures. Part of these differences in well-being that we do observe can be attributed to lower household agricultural production in remote areas. Nonetheless agricultural production differences alone do not account for all the differences in household consumption levels for remote households. An additional contributing factor is the terms of trade for remote households that negatively affect both the size of the agricultural surplus that these households market and the quantity of food items that they purchase. Reducing transaction costs for remote households and facilitating migration could help equalize well-being among more or less favored locations.

Keywords: market access, transport costs, rural infrastructure, agricultural production, well-being, nutrition, Ethiopia

1. INTRODUCTION

Achieving efficient access to markets through improved rural road infrastructure is often seen as a promising way of improving the well-being of poor rural populations in developing countries (World Bank 2012). Improved rural road infrastructure has been shown to be associated with lower poverty (Gibson and Rozelle 2003; Lokshin and Yemtsov 2005; Khandker et al. 2009), higher household consumption (Dercon, et al. 2009; Stifel et al. 2016), and improved health outcomes (Ahmed and Hossain 1990; Lokshin and Yemtsov 2005). The reasons advanced for these desirable associations are typically reduced transport and input costs, which are believed to result in higher agricultural productivity (Stifel and Minten 2008; Gollin and Rogerson 2010) and greater non-farm production (Binswanger et al. 1993; Fafchamps and Shilpi 2003; Jacoby and Minten 2009).

Much of the economics literature on the topic focuses primarily on identifying the causal impact of rural infrastructure on household well-being, and not on the mechanisms that perpetuate the impact (e.g. van de Walle 2009). Moreover, despite the recent policy emphasis on making functional improvements to agricultural value chains and on assuring better market access in order to achieve better nutritional and health outcomes in developing countries (FAO 2013; GAIN 2013), there is little solid evidence of the impact of improved market access and lower transport costs on nutritional outcomes (e.g., von Braun and Kennedy 1994; Hirvonen and Hoddinott 2014; Hoddinott et al. 2013; Vitzthum 1992).

We contribute to this gap in the economics literature by using a unique data source that not only permits us to estimate gradients of different measures of household and individual well-being (household consumption, education, food security, dietary diversity, and mother and child nutrition outcomes) over rural feeder roads (or the absence of such roads), but also allows us to explore the pathways through which remoteness from markets is related to well-being.[1] This is important because it can help us to identify the appropriate policy environment that complements the substantial investments needed to build and maintain physical infrastructure. We find that households' access to markets, as measured by transaction costs to the nearest market (in this case, the same market), indeed is positively associated with household consumption and food security through the link between agricultural production and marketing. Further, there is room for additional agricultural investments, such as increased extension and modern input provision, in order to reach the most remote households. Finally, rural markets play an important role in the remoteness-well-being relationship. Efforts to reduce transaction costs associated with remoteness through improved feeder roads[2] may pay dividends by facilitating households' abilities to transform marketed surpluses into consumption goods and into healthier, more diverse diets. Given that we do not find a significant relationship between mother and child anthropometric measures and remoteness, however, the improved diets associated with greater market access appear to be insufficient to translate into improved nutrition outcomes.

Since roads are not randomly placed, an empirical challenge common to all studies that estimate the impacts of roads and improved market access on various outcomes is that the causal relationship between improved road access and the apparent outcomes (benefits) of this access are difficult to distinguish. In other words, it is difficult to determine if roads are placed in higher productivity or

[1] We use remoteness from markets as a measure of market access. For a discussion of different measures of market access, see Chamberlin and Jayne (2013).

[2] Although distance from markets is an important component of remoteness, the emphasis here is on the transaction costs associated with poor roads. After all, improved infrastructure can reduce the transaction costs associated with transportation over the same distance.

higher income areas, or if incomes and productivity are higher as a result of the roads.[3] We address this problem of causation by conducting a household survey in a region in northwestern Ethiopia in which land quality characteristics do not differ systematically in the region.[4] This sample area was selected purposefully in order that the primary differences between communities in the region are the transport costs between the communities and the particular market to which community members travel. In our study area, these transportation costs differ substantially within the region, not because of road placement but because of the geography of the region.[5] Ideally, this implies that transportation costs are effectively placed randomly in the survey area, and that market access can be interpreted as having a causal impact on measures of well-being. Although, we cannot concretely establish this, our sensitivity analysis, in which we show that land productivity does not differ systematically in the survey area, supports it.

The structure of the paper is as follows. Section 2 provides a description of the data, and Section 3 documents the relationship between household/individual well-being and market access. Section 4 explores the pathways that may explain the market access and well-being relationship. Discussion and concluding remarks are presented in Section 5.

2. THE STUDY AREA, DATA AND DESCRIPTIVE STATISTICS

The sample area for this study is located in Alefa *woreda* (commune) in the rugged terrain of northwestern Ethiopia (see Figure 1). This area was chosen because the large variation in transportation costs over a relatively short distance allowed us to carefully assess the impact of these varying costs in a situation of similar physical and climatic conditions. 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 a major metropolitan area, Gonder, to the northeast by a gravel road that is passable all year round.

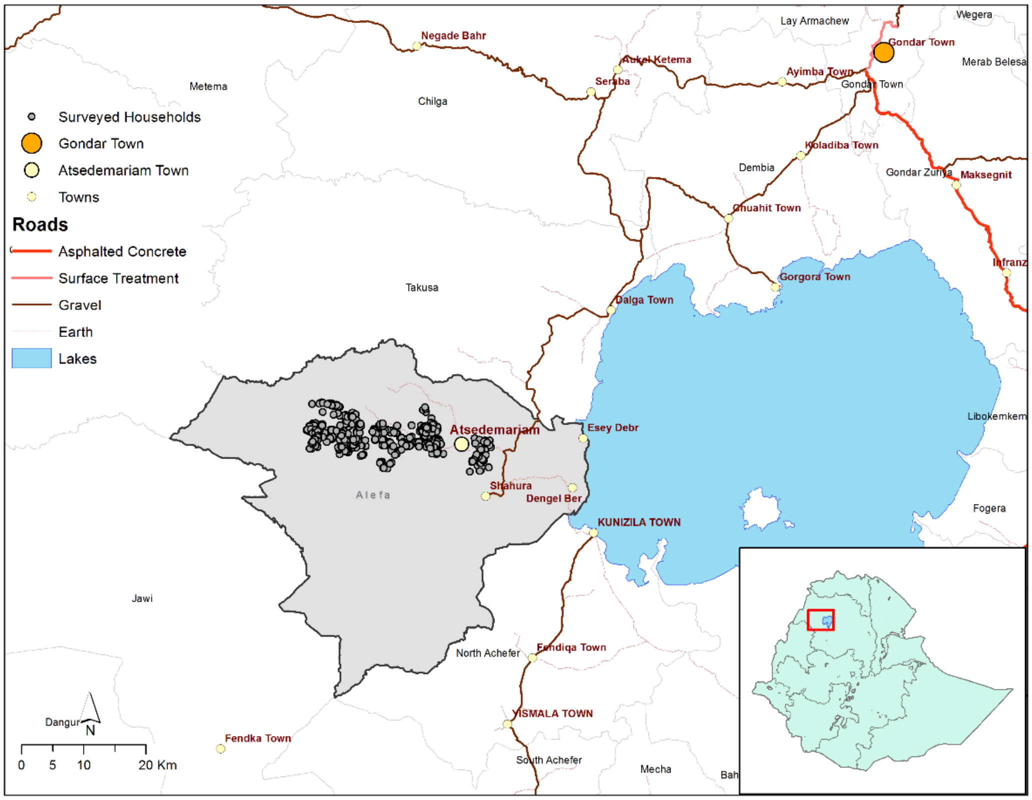
Trucks regularly ply the road between Atsedemariam and the markets in Gonder and beyond with goods originating from and destined for Atsedemariam. Communities exist to the west of Atsedemariam where access to outside markets is available for the most part only through Atsedemariam because of the difficult terrain. Further, access to Atsedemariam (and onward to Gonder) is limited to routes that are accessible mainly to foot traffic only, although motorcycles can pass along some portions. To transport agricultural produce to Atsedemariam and to transport agricultural inputs and consumer goods back from Atsedemariam, community members rely on donkeys. Farmers in the survey area rely on the cooperative office of Atsedemariam as their source of modern inputs.

[3] Various approaches to handling the issue of endogenous road placement include panel data methods, difference-in-differences, propensity score matching, and instrumental variables methods (Binswanger et al. 1993; Lokshin and Yemtsov 2005; Mu and van de Walle 2007; Dercon et al. 2009; Khandker et al. 2009). Given the long-term nature of the effects of roads, the time frame for longitudinal data needs to be sufficiently long in addition to being initiated prior to the construction or rehabilitation of the roads (Mu and van de Walle 2007; Jacoby and Minten 2009).

[4] Stifel, et al. (2016) show that although there is variation in plot and soil quality characteristics in the sample area, it is not correlated with remoteness.

[5] Indeed, there are no roads in the region. Jacoby and Minten (2009) argue that when a sample is identified in this manner, "a comparison of household behavior along this steep transport cost gradient approximates the long run adjustments to an exogenous road improvement." We thank a referee for pointing out that it is also possible that behavioral differences along the gradient instead represent a temporary equilibrium as households and individuals are unable to equalize opportunities across locations due to constraints on migration and land or labor transactions.

Figure 1. Map of the Survey Area



Source: Ethiopian Rural Transport Survey 2011

Households were surveyed in a series of seven sub-districts (or *sub-kebeles*) along the route emanating from Atsedemariam. For sampling purposes, equal numbers of households were interviewed in five different distance brackets, measured in travel time by donkey, from the market of Atsedemariam. With a target of 850 households, 170 households were interviewed in each distance category.[6] 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 sub-district. The purpose of this sampling method was to obtain a representation of households in the sub-districts along the route from the market at Atsedemariam to Fantaye, not to be representative of the population in the woreda. The survey took place over a five-week period in November and December 2011. The timing of the data collection, which followed shortly after the main season (Meher) harvest, was intended to increase the precision of the agricultural production estimates as the quantities were fresh in the minds of the respondents. It is worth recognizing, however, that the results of this analysis may be affected by seasonality. Indeed, given that Darrouzet-Nardi and Masters (2015) find that remoteness makes consumption smoothing difficult, the gradients described in the next section could be less severe than had the survey taken place in the hungry season prior to the main harvest. Although the use of "typical month" recall over the past year in the household expenditure module was used to minimize the effect of seasonality (Deaton and Grosh, 2000), it is difficult to eliminate it entirely.

[6] Due to an enthusiastic enumerator, one extra household was interviewed beyond the target, which resulted in a sample size of 851.

Community questionnaires were also completed by the survey team supervisors based on interviews with informed sources in each of the 33 sub-sub-districts (villages). Information on access to services, infrastructure, and seasonal prices for major food and non-food items was collected.[7]

Transport costs – our measure of market access – were measured using information collected in the household portion of the survey. Information provided by households 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 was used to calculate the cost of transporting a one quintal (100 kilograms) load 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 farmers' time, we use the median non-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.[8]

Table 1 presents some basic summary statistics for households in the sample, along with test statistics to examine if variables are systematically linked with remoteness, i.e., we regress each variable on the transportation cost to Atsedemariam variable. On average, it takes households 4.5 and 5.2 hours to travel one-way during the dry and wet seasons respectively to the market in Atsedemariam. On average, households incur a cost of 48.6 Birr to transport a quintal to Atsedemariam. This varies from 8.1 Birr/quintal for the least remote household, to 80.7 Birr/quintal for the most remote. We find that there is no significant difference (at the 5% significance level) in household characteristics (household size, share of male-headed households, and age and education level of the head of household) over space (Table 1).

To understand the extent to which variation in our well-being outcome variables is driven by soil quality, 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 the different levels of use of inputs by these households. To net out these confounding factors, we estimate separate production functions for each of the four main cereals produced in the survey area. We then estimate 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. We define this as the *adjusted* cereal yield and consider this a measure of intrinsic soil quality (for more details, see Stifel et al. 2016).

For each of the cereals under consideration, we relate the adjusted yields to remoteness from the market. As seen in Table 1, transport costs to the market do not have a significant link to the adjusted cereal yields. Thus, as Stifel et al. (2016) note, although there are potential biases that may arise from spatial sorting, out-migration, and differential land holdings, we can "cautiously interpret differences in our outcomes of interest as following from transport cost-induced household behavioral differences, not from differing geographic characteristics of the study area."[9]

[7] The household and community instruments that were fielded follow the format of typical household and community surveys as recommended by the World Bank (Grosh and Glewwe, 2000). They are available from the authors upon request.

[8] 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.

[9] Note that if land and soil characteristics (and variation in these characteristics) do not differ systematically across the study area, then outcomes such as household consumption, child health, and food security can follow from transport cost-induced choices and behaviors. As such, comparing choices and outcomes across the transport cost gradient is not an appropriate test for homogeneity.

Table 1. Household Summary Statistics

	Mean	Standard deviation	Transport cost effect† Coefficient	t-value / z-value††
Average travel time to Atsedemariam				
Dry season (hours)	4.5	2.1	-	-
Rainy season (hours)	5.2	2.2	-	-
Transport cost to Atsedemariam				
Birr per quintal (100kgs)	48.6	18.5	-	-
Household characteristics				
Household size	5.77	2.35	0.006	1.49
Male head	0.91	-	0.004	1.23
Schooling of head of household (years)	1.64	3.24	-0.002	-0.41
Age of the head of household	40.94	14.73	-0.002	-0.07
Adjusted cereal yields				
Maize (quintal/ha)	19.88	11.77	0.002	0.08
Millet (quintal/ha)	13.86	6.73	0.022	1.46
Sorghum (quintal/ha)	14.56	7.61	0.025	1.12
Teff (quintal/ha)	6.81	3.25	-0.011	-1.12
Total (quintal/ha)	14.63	7.63	-0.019	-1.29
Farm characteristics				
Total area owned by the household (ha)	1.11	1.05	-0.012	-5.78*
Total area of land cultivated by the household (ha)	1.52	1.10	-0.006	-2.63*
Number of plots cultivated by household	3.70	2.47	-0.003	-0.67
Shocks				
HH affected by serious shock in last 12 months	0.27	-	0.006	2.41*

Source: Ethiopia Rural Transport Survey 2011
Notes: † OLS regression on transportation cost to Atsedemariam variable. Intercept included, but not reported. †† OLS in the case of continuous variables as dependent variable, probit for dummies, and tobit for censored variables. *: significant at the 5% level.

Table 1 also shows that both access to land and effects from shocks vary significantly over space. This indicates the need to control for some of these characteristics in further analysis. In the remainder of the text, we therefore complement non-parametric regression analysis with multivariate regression analysis in which we control for landholdings, shocks, and altitude.

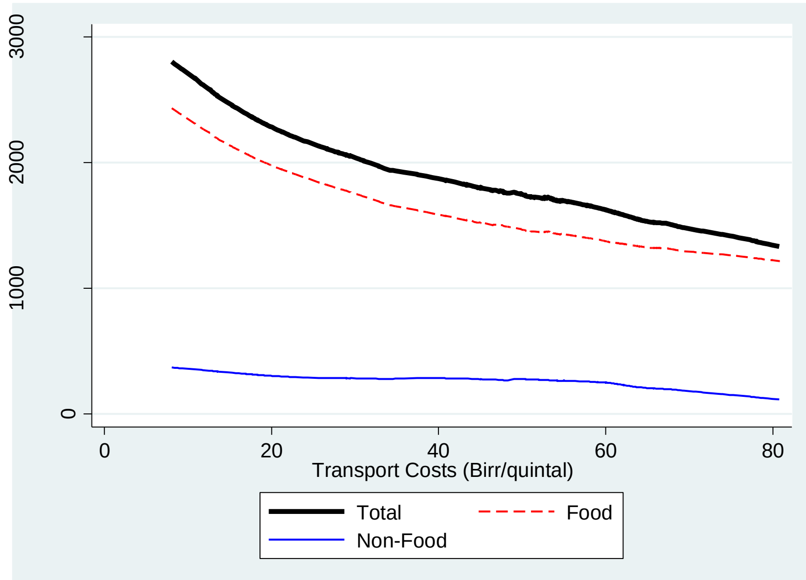
3. MARKET ACCESS AND HOUSEHOLD/INDIVIDUAL WELL-BEING

In this section, we establish the positive relationship between market access and household well-being that exists in the survey area. We begin with annual household per capita consumption expenditures, a variable which is constructed by valuing consumption of own production using median (over the whole sample) sale prices reported in the community questionnaire. In Figure 2, we present non-parametric regression[10] estimates of household consumption per capita as a function

[10] The benefit of nonparametric regression analysis is that there is no need to impose a functional form on the relationship between the *y* and *x* variables. We use locally weighted scatterplot smoothing (LOWESS) in this analysis. We prefer LOWESS to polynomial smoothing methods given that the latter are more affected by extreme values.

of transport costs. The thick solid line represents total household consumption, while the dashed line illustrates the levels of food consumption and the thin solid line represents non-food expenditures.

Figure 2. Household Per Capita Consumption by Remoteness



Source: Ethiopia Rural Transport Survey 2011
Note: Remoteness is defined by transportation costs from the location to the market in Atsedemariam. The Stata command "lowess" with a bandwidth of 0.8 is used to estimate these non-parametric regressions.

The striking feature of Figure 2 is the steep decline in household per capita consumption over the transport cost gradient. Although the mean per capita consumption level in the sample is 1,795 Birr (105 US Dollars), the least remote households have per capita consumption levels of over 2,335 Birr (135 US Dollars), which is 55 percent larger than for the most remote households (1,510 Birr, or 90 US Dollars). Conditioning on landholdings, shocks, and altitude, we estimate the marginal effect of one additional Birr of transport costs to be 16.2 less Birr of consumption per person. This estimate is statistically significant at the one percent level (see Appendix Table 1).[11] Further, given the low income levels, food consumption makes up over 85 percent of household consumption throughout the transport cost gradient, and, consequently, is the major driver of declining total consumption for more remote households. Given that non-food consumption is already very low, it declines with remoteness at a slower rate (marginal effect of -2.0) than does food consumption (-14.2).

In addition to lower household consumption levels, households in more remote areas suffer from more food insecurity. As illustrated in Table 2, households in more remote areas worried more that they would not have enough food to eat in the 30 days prior to the survey. The relationship is strong and statistically significant. The marginal effect translates into a 4 percent higher probability of worrying for each additional 10 Birr/quintal transport cost incurred. To put this in perspective a little further, 42 percent of households in the most remote quintile worried at least once that food would run short, compared to 26 percent in the least remote quintile. Further, the intensity of these concerns increases with remoteness. For example, 9 percent of households in the least remote quintile worried that food would run short for more than 10 days, compared to 15 percent of households in the most remote quintile. A similar picture emerges when investigating actions taken

[11] Note that the effects of landholdings, shocks and altitude on household consumption levels are not statistically significant.

by households in response to concerns about food insecurity. More remote households had smaller and fewer numbers of meals during the month prior to the survey than did less remote households because there was not enough food. In both cases, the most remote households were 25 percent more likely to make frequency and size adjustments to meals than did the least remote households.

Table 2. Nutrition and Remoteness

	Marginal effect		t-value / z-value†
Household Food Security (last month)			
Worry not enough food (3+ times)†	0.004	***	4.24
Had smaller meals (3+ times)†	0.004	***	5.09
Had fewer meals (3+ times)†	0.003	***	4.02
Household Dietary Diversity - Number of food groups			
All household members	-0.075	***	-25.91
Children (under age 5)	-0.007	**	-2.08
Mothers' Nutrition Outcomes			
Body-Mass Index (BMI)	0.007		1.44
Child Nutrition Outcomes (Under age 5 years)			
Height-for-Age z-score			
Boys	-0.003		-0.79
Girls	0.007		1.51
Weight-for-Height z-score			
Boys	0.006		1.69
Girls	0.004		1.06
Weight-for-Age z-score			
Boys	0.005		1.44
Girls	0.003		1.03

Source: Ethiopia Rural Transport Survey 2011

Note: OLS regression of the variable on transportation cost to Atsedemariam variable. Intercept and controls for landholdings, weather shocks and altitude included but not reported. † indicates probit model and corresponding z-value. *** (**) indicates significant at 1% (5%) level.

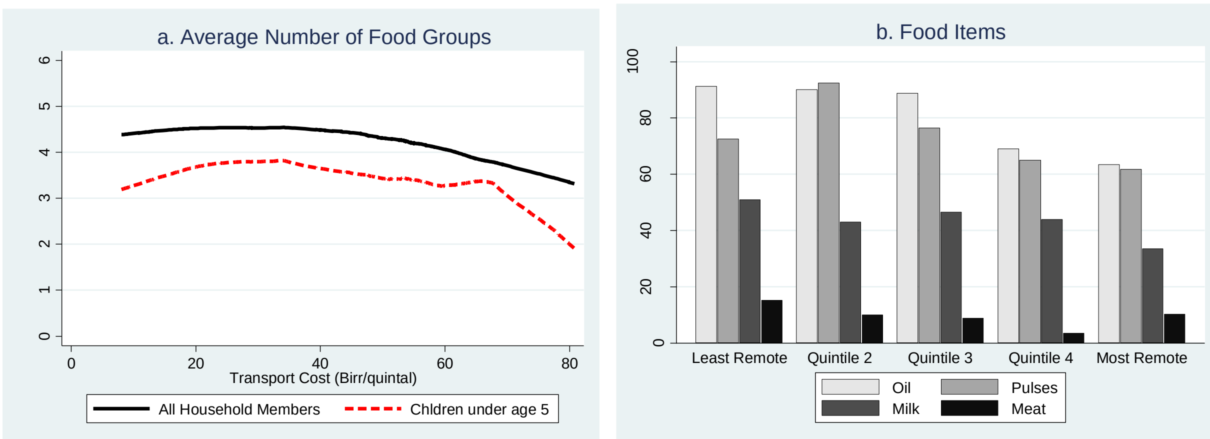
Dietary diversity, a measure of a high quality diet (Ruel 2003) and an important predictor of nutritional status[12], also is adversely affected by remoteness. Figure 3a illustrates that more remote households tend to have diets that include fewer food groups compared to the less remote households (4 versus 5). While children in the sample consume less diversified diets than adults (fewer than 4 food groups), the number of food groups consumed by children declines with remoteness at a rate that is slower than for adults (Table 2). [13] With respect to particular food items,

[12] Greater variety among and within food groups is recommended in most dietary guidelines (USDA 1992; WHO 1996).

[13] Standard errors cannot be estimated analytically for LOWESS. As such these differences cannot be tested. As an approximation, however, we used local polynomial smoothing (*lpolyci* in Stata) to construct confidence intervals around the nonparametric regressions. These 99 percent confidence intervals indicate that the differences between all household members and children under age 5 are statistically significant, as are the within-group gradients (as is consistent with Table 2).

more remote households are less likely to consume oils, pulses, dairy products, and meat (Figure 3b), though the differences are not monotonic throughout the region.

Figure 3. Dietary Diversity and Remoteness



Source: Ethiopia Rural Transport Survey 2011

Note: The Stata command “lowess” with a bandwidth of 0.8 is used to estimate these non-parametric regressions.

Given that more remote households are less food secure, consuming less food and fewer meals, it is surprising that there is no statistically significant relationship between nutrition outcomes and remoteness in the survey area. As illustrated in Table 2, mothers’ body mass indices (BMI) and child stunting (height-for-age z-scores) and wasting (weight-for-height z-scores) are not correlated with transport costs, suggesting that access to food alone may not be enough to affect these particular nutrition outcomes. For example, the pervasive low quality sanitation and health environment in the survey area (e.g. fewer than 40 percent of households have pit latrines) may negate positive effects that increased food consumption may have on nutrition outcomes in less remote areas.[14] Moreover, while the number of food groups consumed by children decreases with remoteness, it is low (below five) over the whole range. As Arimond and Ruel (2003) note, while four food groups is the minimum acceptable number of food groups for breastfed infants, it is higher (five) for older children. In other words, the diets of children in the sample are not diverse, even for those living in the least remote areas.

Finally, levels of education in the sample area are low (Table 3). Among adults between the ages of 15 and 30, only 38 percent have any formal schooling, resulting in an average of only 1.7 years of schooling overall. Further, among those who do have some schooling, the average number of years is only 4.5. In terms of geographical remoteness, however, there is no clear pattern between educational attainment and remoteness as none of the differences is statistically significant. This is not the case for children between the ages of 5 and 15, however, where we see that the enrollment rate in the most remote quintile is over 10 percentage points below those in the least remote quintile (t-statistic = 2.14).

[14] To illustrate the importance of this issue in the Ethiopian setting, Headey (2015) shows – using nationally representative data – that most of the improvement in maternal health in 2000-2010 – an important determinant for improved birth size and child nutritional outcomes – followed from better sanitation, rather than from diet, care, or other health factors.

Table 3. Schooling and Remoteness

	Enrollment rate (ages 5-15)	Adults (age 15-30)		
		Percent with some schooling	Average years of schooling	
			Full sample	Those with schooling
Transport Cost Quintiles				
Least Remote	42.9	43.5	2.0	4.5
Quintile 2	39.1	34.2	1.5	4.5
Quintile 3	46.5	36.7	1.6	4.9
Quintile 4	31.3	36.8	1.6	4.5
Most Remote	30.1	36.8	1.5	3.9
Total	**36.5**	**38.0**	**1.7**	**4.5**
Tests of differences between most and least remote				
z-statistic	2.14	1.11	1.26	1.59
p-value	0.03	0.26	0.21	0.15

Source: Ethiopia Rural Transport Survey 2011

It is discouraging to see that the enrollment rate among all children in the sample is only 36.5 percent, which is lower than the 38 percent of adults (15-30) who have had some schooling. This rate is pulled down by households in the two most remote quintiles where enrollment rates are roughly 31 percent, compared to the 39 percent and higher in the less remote quintiles. So while households in the least remote areas are developing more human capital than their earlier generations, the opposite is occurring in the two most remote quintiles.

The setting described here is one in which households living on similarly productive land, but which are differentiated from each other by remoteness from markets, have markedly different well-being outcomes. Indeed, more remote households consume less per person, are less food secure, have less diverse diets, and have fewer children enrolled in schools. The differences in these outcomes are indicators of the impacts of remoteness. We now explore the mechanisms by which remoteness results in these different outcomes.

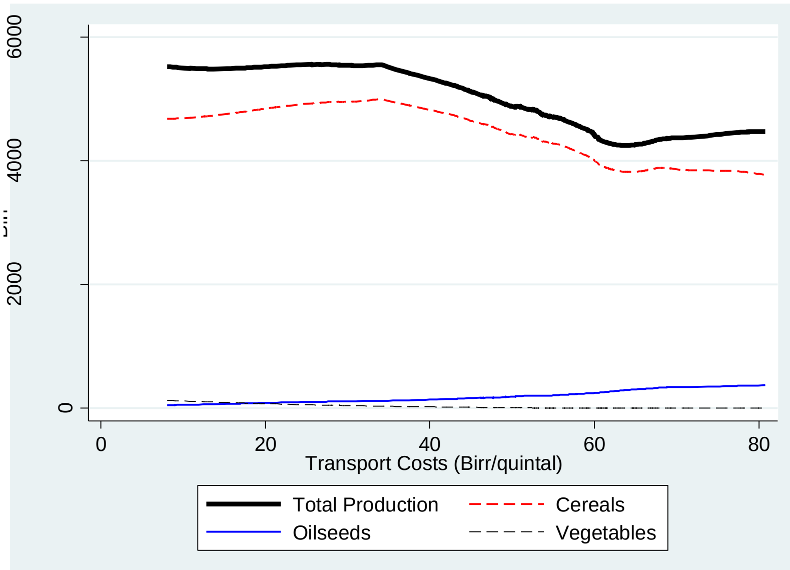
4. WHAT ACCOUNTS FOR THE RELATIONSHIP BETWEEN REMOTENESS FROM MARKETS AND WELL-BEING?

There are several potential mechanisms that can manifest in the negative relationship between remoteness and individual well-being in the survey area. First, agricultural production of households in more remote areas is less than for households closer to the market town due to issues of access to modern inputs and technologies. Second, larger transaction costs in more remote areas give rise to worsening terms of trade for farming households in such places. This is associated with less agricultural surplus marketed by these households and, consequently, less food and fewer food items purchased. Finally, although fewer non-agricultural income earning opportunities in more remote areas may result in less ability to acquire consumption items through the market, there is no evidence of this in the data. We address each of these potential mechanisms in turn.

4.1. Remoteness and Agricultural Production

Despite similarities in land productivity throughout the survey area, more remote households overall produce less agricultural output compared to households residing nearer to the local market. Figure 4 illustrates this with non-parametric regression estimates of the annual value of agricultural crop production by households as a function of transport costs. The thick solid line represents the value of total production across all crops, which clearly declines over the transport cost gradient.[15] After controlling for differences in landholdings, weather shocks and altitude, we estimate that a 1 Birr/quintal increase in transport costs is associated on average with a 30.9 Birr decrease in the value of annual production (Appendix Table 1). The average value of total production for households in the quintile closest to the market town (Birr 5,336 per household) was 25 percent higher than for households in the most remote quintile (Birr 4,277).

Figure 4. Value of Household Agricultural Production by Remoteness



Source: Ethiopia Rural Transport Survey 2011

Note: The Stata command "lowess" with a bandwidth of 0.8 is used to estimate these non-parametric regressions.

The decline in total production was dictated by cereal crops, which accounted for an average of 90 percent of household agricultural output throughout the survey area. As noted in other settings (e.g. Omamo 1998), remoteness influences crop choice. Households seemed to substitute some cereal and vegetable production for oilseed production in more remote areas (rising thin blue line in Figure 3). While regression estimates indicate that changes in oilseed production across the transport gradient are statistically significant (Appendix Table 1), and while the increase in oilseed production is enough to offset the decline in cereal production for households in the most remote areas compared to their somewhat less remote neighbors, the overall magnitude of these oilseed production changes (2.6 Birr) was small compared to cereals (-25.8 Birr). As such, we focus on cereal production and what the contributing factors are to lower output levels in more remote areas.

Access to and use of modern inputs may account for the systematic differences in agricultural production among households. Indeed, a common strand in the literature notes that improved roads reduce input costs, increase timely input availability, and, consequently, can result in higher agricultural productivity (Stifel and Minten 2008; Gollin and Rogerson 2010; Binswanger et al. 1993; Antle 1983). In our survey area, this is a plausible story as modern input use declines with transport costs (Table 4). Although chemical fertilizer use is reasonably high overall (81 percent of all households use chemical fertilizer), nearly all farming households in the least remote quintile use

[15] Output is valued using the median sale price reported in community questionnaire in a manner consistent with estimating the value of household consumption.

them (94 percent), while only seven out of ten in the most remote quintile do. The difference in improved maize seed use is even more remarkable, with 75 percent of households in the least remote quintile using them compared to less than 10 percent in the most remote quintile.[16]

Table 4. Modern Input Use by Remoteness

	Percent of households using…			
	Chemical Fertilizer			**Improved Seeds**
	Any	**DAP**	**Urea**	**(*maize only*)**
Transport Cost Quintile				
Least Remote	94.2	94.2	83.0	75.6
Quintile 2	86.2	86.2	61.4	31.2
Quintile 3	79.9	78.5	46.5	15.0
Quintile 4	73.2	73.5	49.3	12.4
Most Remote	71.1	71.7	37.5	9.4
Total	**81.2**	**81.1**	**56.3**	**33.3**
Tests of differences between most & least remote				
z-statistic	6.34	6.46	9.05	12.44
p-value	<0.01	<0.01	<0.01	<0.01

Source: Ethiopia Rural Transport Survey 2011

As is the case throughout Ethiopia, farmers in the survey area access modern inputs through cooperatives. With the distribution center located in the market town and with fixed prices set for all farmers, those who acquire modern inputs should theoretically pay the same per unit price. Using these same data, however, Minten et al. (2013) find that fertilizer prices reported in the survey were higher in more remote areas, which indicates 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." When implicit costs such as the opportunity cost of time and effective travel and storage costs are included, implicit costs rise even further for households located far from the market town. Indeed, the implicit price of fertilizer for the most remote households is roughly 30 percent higher than for the least remote households (Minten, et al. 2013).[17]

The combination of input prices that rise and output prices that fall with remoteness affects the profitability of chemical fertilizer use, and, consequently, affects households' adoption of such modern inputs and their subsequent levels of agricultural production. To explore the effect of remoteness on profitability, Minten et al. (2013) estimate value-cost ratios (VCR) for fertilizer with respect to the four most important cereal crops grown in the survey area. The VCR measures the additional value of output produced from one additional unit of input relative to the cost of that one unit of input. Higher VCRs indicate more profitability. Minten et al. (2013) find that transport costs have a large negative impact on the profitability of chemical fertilizer for teff, millet and sorghum, but not for maize, for which there is no discernable relationship. It is thus not surprising that households in more remote areas use fewer modern inputs and produce less agricultural output.

An additional factor that may differentially affect agricultural productivity of households in the survey area is access to agricultural extension services and knowledge of appropriate technologies. To illustrate this, we estimate a nonparametric regression of an indicator of households' interaction

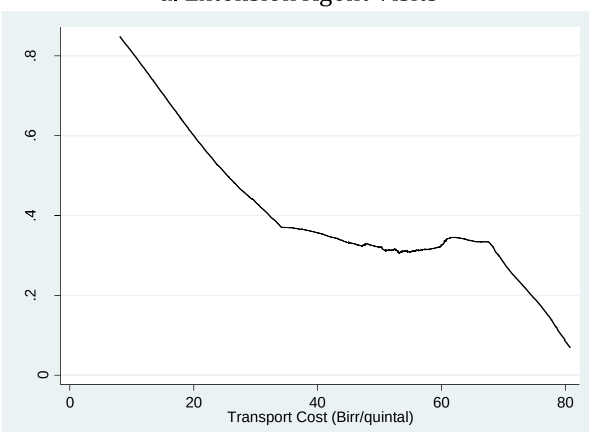
[16] These differences are all statistically significant when controlling for landholdings, weather shocks, and altitude (Appendix Table 1).

[17] Minten et al. (2013) conduct a similar analysis for improved seed prices and find a similar trajectory over the transport cost gradient. They note, however, that due to the limited number of observations in the most remote areas, the results must be interpreted with caution.

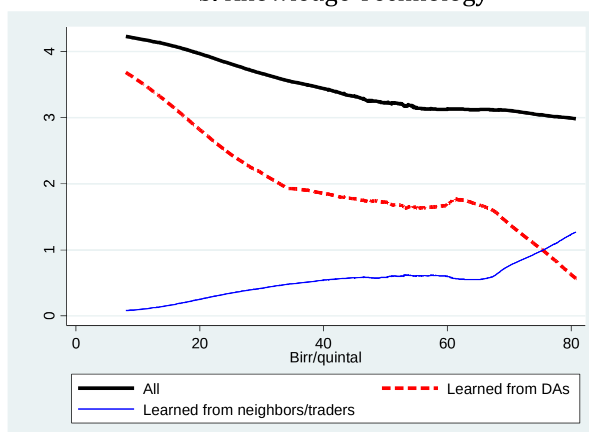
with agricultural extension agents on transport costs. Figure 5a shows that visits to less accessible communities are rare compared to those households closer to the market. Only 30 percent of households in the most remote quintile either received a visit from an extension agent or visited one themselves in the 5 years prior to the survey, compared to 64 percent of households in the least remote quintile. These visits appear to matter in terms of behavior and knowledge. Using these same data, Minten et al. (2013) find that such visits increase the probability of households in the sample adopting chemical fertilizers by 20 percent. Ragasa et al. (2013) arrive at a similar conclusion in other areas of Ethiopia. Further, Figure 5b suggests that extension agents do transmit knowledge of technological practices, such as soil conservation measures, chemical fertilizer application and dosage, chemical and mechanical weeding, compost preparation, and manure application. Consequently, a lack of direct information transmission from extension agents to farmers in more remote areas affects farmers' knowledge of these technologies, despite knowledge spillovers from neighbors and traders (Krishnan and Patnam 2012).[18] Thus, despite the government's substantive efforts to expand the agricultural extension system – by 2010, some 45,000 extension agents were placed in villages, such that there are now roughly three extension agents available per kebele (Davis et al. 2010) – there remains room for further expansion into remote areas.

Figure 5. Access to Extension Service and Knowledge of Technology by Remoteness

a. Extension Agent Visits



b. Knowledge Technology



Source: Ethiopia Rural Transport Survey 2011

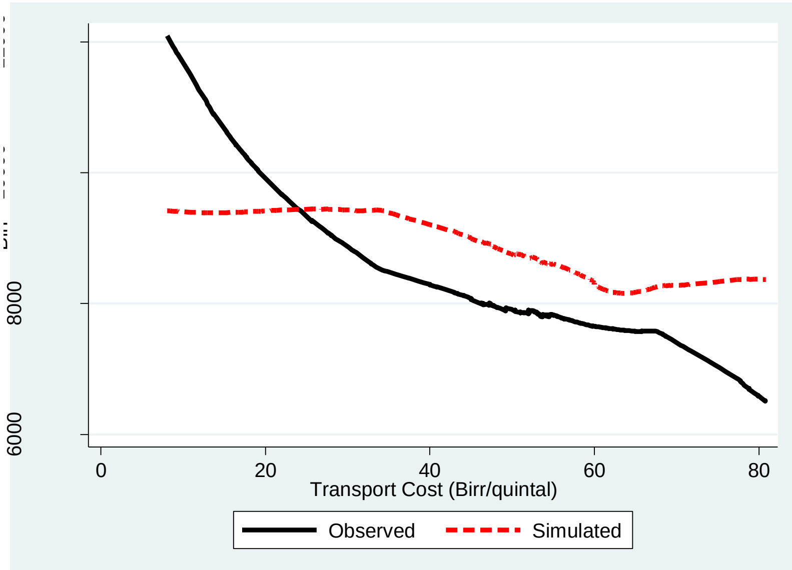
Note; Households were asked if they knew of 5 different technologies – soil conservation measures; chemical fertilizer application and dosage; chemical/mechanical weeding; compost preparation; and manure application. DA – Development Agent, the kebele-level agricultural extension agent. The Stata command "lowess" with a bandwidth of 0.8 is used to estimate these non-parametric regressions.

Having established the relationship between remoteness and agricultural production, we now need to assess the degree to which the decline in household consumption over the transport gradient can be attributed to decreases in crop production in more remote areas. To test this, we simulate how total household consumption would vary if only agricultural income[19] varied by regressing the former on the latter, and then plotting the predicted values. Nonparametric regressions of the simulated and observed household consumption appear in Figure 6.

[18] Interestingly, where extension visits drop precipitously in the most remote areas (dashed line), farmers learning from neighbors and traders increases substantially (thin solid line).

[19] Agricultural income is measured as value of production less input costs.

Figure 6. Simulated Effect of Agricultural Production on Household Consumption by Remoteness



Source: Ethiopia Rural Transport Survey 2011

Note: Simulated consumption are the predicted values from a regression of total household consumption on the value of total agricultural income. The Stata command "lowess" with a bandwidth of 0.8 is used to estimate these non-parametric regressions.

The flatter nonparametric regression line for simulated household consumption (elasticity of -0.11), compared to the steeper observed consumption (elasticity of -0.25), indicates that differences in household consumption cannot be attributed entirely to differences in agricultural production.[20] Indeed, differences in agricultural production explain only 45 percent of the observed gap in total household consumption between the least and most remote quintiles. The difference between simulated household consumption in the least and most remote quintiles is Birr 1,025, compared to Birr 2,240 for observed household consumption.

4.2. Remoteness, Terms of Trade and Marketed Agricultural Surplus

While the level of agricultural production on its own accounts for roughly half of the negative relationship between household consumption and remoteness, much of the remainder likely follows from changing terms of trade for more remote farming households. Remote households are hampered in their ability to transform their own production into food consumption by lower producer prices for their agricultural output combined with higher consumer prices for any food items they purchase. Since food makes up more than 85 percent of total household consumption for most households in the sample area (Figure 2), lower food consumption is the primary reason for lower total household consumption in more remote areas. As illustrated in Table 5, aside from maize, prices of cereals reported in the community questionnaire are negatively related to remoteness, while prices of consumer goods such as spices, cooking oil, and coffee are positively related to remoteness. Since households sell the cereals that they produce and use the marketed surplus to purchase consumer goods, the terms of trade for more remote households worsen as their producer prices fall and their consumer prices rise.

[20] Note that because the OLS estimator fits the regression line through the point of means, the simulated and observed average levels will be the same. Thus only a comparison of the slopes is appropriate for Figure 5.

Table 5. Prices and Remoteness

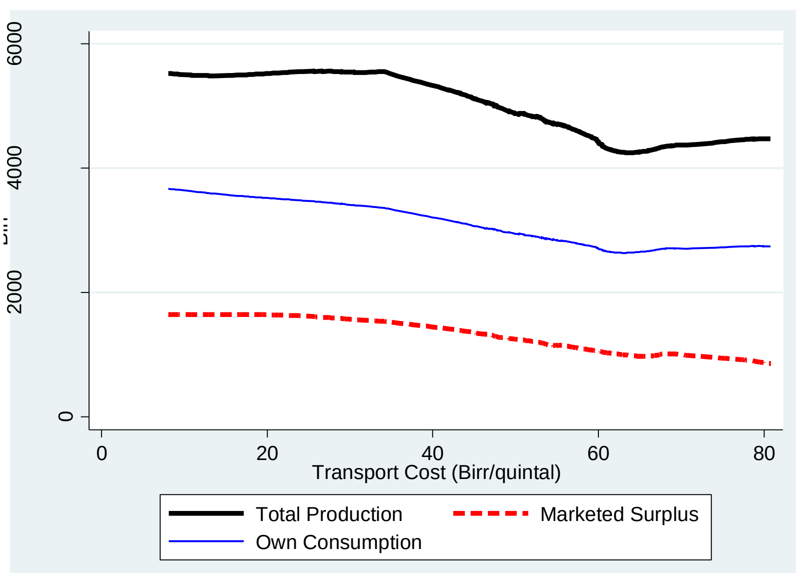
	Elasticity		Standard Error
Cereals			
Teff	-0.060	***	0.017
Maize	0.079	***	0.025
Sorghum	-0.125	***	0.017
Millet	-0.033	*	0.019
Consumer Goods			
Salt	0.026	*	0.015
Sugar	0.329	***	0.028
Cooking oil	0.115	***	0.036
Kerosene	-0.112	***	0.019
Coffee	0.124	***	0.031

Source: Community Questionnaire, Ethiopia Rural Transport Survey 2011

Note: Elasticity of prices with respect to transport costs.

In conjunction with falling producer prices, farming households in more remote areas sell less of their production than households that are less remote. Non-parametric regressions of total household agricultural production, own consumption, and marketed surplus of this production illustrate this in Figure 7. What is significant in Figure 7 is that, while the absolute magnitudes of both own consumption and marketed surplus are lower in more remote areas where production itself is lower, the portion of production that is marketed falls faster (conditional elasticity of -0.16) than own consumption (elasticity of -0.07).[21]

Figure 7. Household Marketed Crop Surplus and Own Consumption by Remoteness



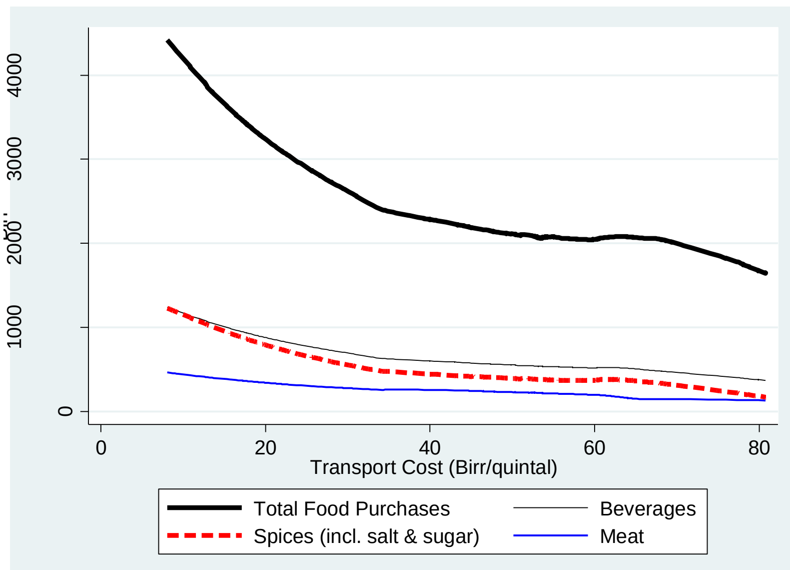
Source: Ethiopia Rural Transport Survey 2011

[21] This echoes the findings of Strauss (1986), who shows marketed surplus to be more responsive to market and price conditions than total production.

Note: The Stata command "lowess" with a bandwidth of 0.8 is used to estimate these non-parametric regressions.

Lower levels of income from marketed surpluses are compounded by rising consumer prices for remote households, resulting in fewer consumer goods purchased in remote areas. As demonstrated by the thick solid black line in Figure 8, food purchases are substantially lower in these remote areas. For example, the average value of food purchases in the least remote quintile (Birr 3,274) is 60 percent more than in the most remote quintile (Birr 2,058). In other words, food purchases are substantially lower in these remote areas. Controlling for landholding, shocks, and altitude, we estimate that for every 1 Birr/quintal increase in transportation costs, household food purchases fall significantly by 26.4 Birr (Appendix Table 1). The five food categories that account for most of the food items purchased by households are beverages, pulses, spices, cooking oil, and meat and meat products. While amounts spent on cooking oil and pulses do not vary significantly by remoteness, they did for spices (marginal effect of -9.6 Birr), beverages (-8.6 Birr) and meat (-3.8 Birr) in conjunction with rising prices for these items.[22]

Figure 8. Household Food Purchases by Remoteness



Source: Ethiopia Rural Transport Survey 2011

Note: The Stata command "lowess" with a bandwidth of 0.8 is used to estimate these non-parametric regressions.

These purchases are consistent with two observations about remoteness and household well-being made in Section 3. First, more remote households consume less. Households farther from the market town not only produce less agricultural output, but also market less agricultural surplus in the presence of higher transaction costs and lower producer prices. This, along with higher food prices, creates fewer market opportunities to purchase and consume more food.[23] Second, more remote households have less diverse diets. Since more remote households purchase less food, they are unable to acquire the variety of foods that households in close proximity to the market town obtain. Thus, the transaction costs associated with remoteness limit the viability of remote

[22] The community questionnaire did not include information on meat prices.

[23] Note in Figure 7 that purchases of cereals make up less than 5 percent of food purchases on average, and there is no statistically significant relationship between cereal purchases and remoteness (Appendix Table 1). As such, it is appropriate to treat cereal prices as producer prices that adversely affect terms of trade for farming households when they fall.

households from participating fully in the market. The consequence of this is that they not only have lower levels of consumption, but the lack of diversity of this consumption indicates that their diets are of lower quality (Ruel 2003).

4.3. Remoteness and Non-farm Earnings

A final consideration is whether opportunities for non-farm earnings contribute to higher well-being outcomes in less remote areas. Given evidence from other countries that greater non-agricultural labor activities are found nearer to towns (Fafchamps and Shilpi 2005; Stifel and Minten 2008; Jacoby and Minten 2009; Deichmann et al. 2009), we might intuitively suspect this to be the case in our sample as well. This, however, appears not to be the case for several reasons. First, only 12 percent of households in the sample have non-farm earnings from either non-farm labor or from household non-farm enterprises (Table 6). This is roughly half of the national average in rural areas of Ethiopia (World Bank 2009). Of these households, a greater number is actually found in the more remote communities. It is therefore not clear that there are greater non-agricultural activities nearer to the market town. Second, median annual non-farm earnings do not differ substantially across the transport cost gradient. Third, those households that do not have non-farm earnings have roughly 20 percent higher levels of household consumption expenditures compared to households with non-farm earnings. This suggests that there might be push factors that result in households engaging in non-farm activities, rather than pull factors (e.g. potential earnings premia due to lower transport costs) that draw them into such activities.[24] The absence of pull factors due to "urban" proximity is possibly explained by the small size of the market town in the survey area (approximately 1,000 households) compared to other settings that have been studied (e.g. Deichmann et al. 2009; Fafchamps and Shilpi 2005).

Table 6. Non-farm Earnings by Remoteness

	Pct. of HHs with non-farm earnings	Median non-farm earnings* (Birr)	Ratio of HH expenditures for HHs without to those with non-farm earnings
Least Remote	7	1,000	1.20
Quintile 2	12	1,300	1.26
Quintile 3	13	1,200	1.23
Quintile 4	14	1,180	1.22
Most Remote	17	1,102	1.18
Total	**12**	**1,102**	**1.22**

Source: Ethiopia Rural Transport Survey 2011

Note: * Median earnings among households with non-farm earnings.

[24] In certain instances there are incentives that *push* households with weak non-labor asset endowments and who live in risky agricultural zones into allocating household labor to non-farm activities. Although households frequently do turn to the non-farm sector as an ex ante risk reduction strategy, distress diversification into low-return non-farm activities is also observed as an ex post reaction to low farm income (Von Braun 1989; Haggblade 2007). This differs from such factors as earnings premia from high productivity or high income activities that may attract, or *pull*, some household labor into non-farm employment (Dercon and Krishnan 1996; Barrett et al. 2001; Lanjouw and Feder 2001; Reardon et al. 2001; Haggblade 2007). These high-return non-farm jobs may serve as a genuine source of upward mobility (Lanjouw 2001).

5. DISCUSSION AND CONCLUSIONS

Improving and maintaining road infrastructure is widely believed to be crucial for economic development. Indeed, there is growing pressure to assure that appropriate financing is available to alleviate the infrastructure deficit around the world, but especially in developing countries (World Bank 2012; The Economist 2014). Nonetheless, there is generally a lack of strong evidence of the relationship between lower transportation costs and improved market access on the one hand, and well-being outcomes on the other. Moreover, the pathways through which transportation costs and market access in low-income settings relate to economic performance of the agricultural and off-farm sectors is still a subject of debate (van de Walle 2009; Gollin and Rogerson 2010).

In this analysis, we used a unique data set to illustrate the link between improved market access and household well-being, and to explore the pathways through which remoteness is associated with well-being. We addressed the problem of causation by conducting a household survey in a region in northwestern Ethiopia that was selected purposefully in order that the only systematic differences between communities are the transport costs between the communities and the particular market to which community members travel. In our study area, these transportation costs differ substantially within the region, but they differ because of the geography of the region, not because of road placement. As such, we cautiously interpret the differences in our outcomes of interest across the study area as being due to transport cost-induced household behaviors.

We find that access to roads or markets indeed is positively associated with household well-being and diets. Households in remote areas consume 55 percent less (mostly food) than households nearer to the market, their diets are less diverse, they are more food insecure, and the school enrollment rates of their members are 25 percent lower. Part of these well-being differences can be attributed to lower household agricultural production in remote areas, which itself follows from declining use of modern inputs due to the higher transaction costs associated with acquiring modern inputs and with marketing output that they face. For example, chemical fertilizer value-cost ratios (VCRs) fall by over 25 percent for millet, sorghum, and teff for the most remote households in the survey area, which helps to explain the 30 percent reduction in fertilizer use for these households. Productivity in more remote areas may also be adversely affected by more limited access to agricultural extension services and knowledge of appropriate technologies.

But agricultural production differences alone do not account for all of the differences in household consumption levels for remote households. An additional contributing factor is the terms of trade for remote households that negatively affects both the size of the agricultural surplus that these households market and the quantity of food items that they purchase. Farmers in the most remote quintile market 50 percent less agricultural surplus than those in the least remote quintile, and their households acquire 60 percent less food in the market. Because more remote households purchase less food, they do not acquire the variety of foods obtained by households in close proximity to the market town. Thus, the transaction costs associated with remoteness limit the viability of remote households from participating fully in the market. They not only have lower levels of consumption, but the lack of diversity of this consumption indicates that their diets are of lower quality.

In short, we find that access to markets indeed is positively associated with household well-being through the link between agricultural production and marketing. However, there is room for additional agricultural investments, such as increased extension and modern input provision, in order to reach the most remote households. Further, to be fair, it is also possible that the observed gradients could follow from other mechanisms such as constraints in other markets. For example, households' inability to equalize opportunities across locations may also be due to limited migration and/or non-farm labor market opportunities. Although our data do not include information on emigration from the survey area, there are good reasons to believe that migration is limited given the degree to which land tenure policy in Ethiopia provides a disincentive to migrate (Dorosh et al., 2012). Farming households are liable to lose their use rights if they engage in nonfarm and off-farm activity and if they remain outside of the area for an extended period of time (Zewdu and Malek, 2010). Despite a land registration and certification program initiated in 2004, farming households continue to worry that they are not protected from government expropriation of their land and periodic land redistribution (Dorosh et al., 2012). Indeed, empirical evidence suggests that restrictive and uncertain land transfer rights inhibit migration behavior (de Brauw et al., 2010). Thus, some of the observed inequalities may persist even in the presence of improved infrastructure if households cannot equalize marginal products of labor by means of migration and/or land transactions.

Finally, it is worth emphasizing the role that rural markets play in the remoteness-well-being relationship. Reducing transaction costs associated with poor rural infrastructure can have important dividends. It can facilitate households' abilities to transform marketed surpluses into consumption goods through the market, and, consequently, to develop healthier, more diverse diets. Finally, while less remote households have healthier diets, these diets have not yet translated into improved anthropometric measures. This lack of a response in nutrition outcomes with better market access could follow from the overall low level of dietary diversity and from limited access to clean drinking water, sanitation, and health services and limited nutritional knowledge in the survey area (Headey, 2015; Hirvonen et al., 2016). Indeed, while market access is an important factor in household well-being, many other factors also influence heights, weights and other nutrition outcomes.

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APPENDIX

Appendix Table 1. Household Well-being/Production and Remoteness

	Marginal Effect		t-value / z-value†
Per Capita Household Consumption (Birr)			
Total	-16.2	***	-6.27
Food	-14.2	***	-6.65
Non-Food	-2.0	**	-2.16
Household Food Purchases			
Total	-26.4	***	-7.09
Beverages	-8.6	***	-5.94
Spices	-9.6	***	-6.15
Meat	-3.8	***	-3.66
Cereals	-0.005		-0.01
Value of Household Agricultural Production			
Total household production	-30.9	***	-6.40
Cereals	-25.8	***	-5.82
Oilseeds	2.6	**	2.34
Vegetables	-1.6	***	-9.31
Own consumption	-15.4	***	-6.61
Marketed Surplus	-18.1	***	-4.53
Modern Input Use			
Any chemical fertilizer†	-0.023	***	-6.70
DAP†	-0.023	***	-6.78
Urea†	-0.025	***	-9.08
Improved seeds (maize) †	-0.012	***	-12.40

Source: Authors' calculations from Ethiopia Rural Transport Survey 2011

Note: All estimates are based on regressions that include controls for landholdings, weather shocks, and altitude.

† indicates probit models with reported z-values.