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The Role of Agricultural Market Information on Farmers' Agricultural Outcomes: Evidence from Smallholder Coffee Producers in Ethiopia[*]

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Guenwoo Lee[†], Aya Suzuki[‡], Yu Ri Kim[§]

Abstract

Using data from 466 smallholder coffee farmers in Ethiopia, this paper examines the effect of a public agricultural market information system (AMIS) on the farmers' agricultural outcomes. Our findings confirm that providing market price information via the AMIS is positively related to coffee sales, the ratio of sales to production, and coffee income. In addition, we consider market heterogeneity by comparing two zones with different market characteristics. We find that the AMIS is positively associated with increasing coffee sales, the ratio of sales to production, and coffee income in only one zone with relatively lower market participation. On the contrary, the sales and income of AMIS users in the other zone with higher market participation did not increase although their selling price increased. While public information provision via ICT is more beneficial to underdeveloped markets, we suggest correcting other market imperfections is important to maximize the utility of AMISs.

Key words: Agricultural Market Information System; Coffee Farmer; Ethiopia; ICT4D; IPWRA

JEL code: D80; Q12

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1 Introduction

The information asymmetry between farmers and buyers is a classic source of market inefficiency (Stigler, 1961) and is more important in rural areas in developing countries than in developed countries because of high transportation costs, poor infrastructure, and a limited number of buyers (Fafchamps & Hill, 2008; Mérel et al., 2009; Osborne, 2005). To reduce this asymmetry, after the abolishment of marketing boards in the 1980s, many Sub-Saharan African governments introduced agricultural market information systems (AMISs), which publish price information on the commodities in various markets (Tollens, 2006; USAID, 2013). Although these donor-funded first-generation AMISs did not function effectively because of operational difficulties, the development of information and communication technology (ICT) and penetration of mobile technologies in the 2000s led to second-generation AMISs (Courtois & Subervie, 2015; USAID, 2013). The new AMISs were offered in various forms such as through radios, televisions, short messaging services (SMS), and websites, and private AMIS providers also emerged. The types of information were also expanded to include not only agricultural prices but also technical advice, input information, and weather forecasts.

Following the rapid penetration of mobile phones in developing countries in the 2000s, the number of studies of the effects of mobile phones, which are considered to reduce information asymmetry, on agricultural markets expanded (Aker & Mbiti, 2010; Nakasone et al., 2014). The earlier studies by Jensen (2007) and Aker & Mbiti (2010) showed that the introduction of mobile phones narrows price dispersions across the markets in India and Niger, respectively. Since then, the impact of mobile phones on agricultural outcomes has been analyzed, including agricultural prices (Fafchamps & Minten, 2012; Shimamoto et al., 2015; Svensson & Yanagizawa, 2009), market participation (Aker & Ksoll, 2016; Muto & Yamano, 2009), farmers' income (Fafchamps & Minten, 2012; Muto & Yamano, 2009), technology adoption (Aker, 2011; Cole & Fernando, 2012), and crop diversification (Aker & Ksoll, 2016). While most find that the introduction of mobile technology leads to a decline in price dispersion across markets and thus greater market integration, the findings on the impact on agricultural outcomes are mixed (Nakasone et al., 2014). Positive effects on selling prices have been found in Cambodia (Shimamoto et al., 2015) and on input use and agricultural productivity in Kenya (Ogutu et al., 2014). However, heterogeneous effects due to age, farm size, and types of crops are also found (Fafchamps & Minten, 2012; Mitra et al., 2018; Muto & Yamano, 2009). This heterogeneity suggests the need for more studies to clarify what drives the results. In addition, the AMISs analyzed in existing studies are mostly privately managed ones that charge fees, with the notable exception of Svensson & Yanagizawa (2009). As a public AMIS has different features than a private AMIS in terms of distribution and user fees for farmers, its effects on agricultural outcomes must be separately evaluated.

Given this background, we evaluate the effects of a public AMIS on farmers' agricultural outcomes using primary data collected from 466 coffee farmers in Ethiopia in 2014. We collect data from two zones that differ in market structure to examine the possible heterogeneity in the effects of the AMIS. We find that while there is no difference in selling price per kilogram between AMIS users and non-AMIS users, there is a difference in sales volume, the ratio of sales to production, and farm income. Moreover, the difference in farm income between AMIS users and non-AMIS users is attributed to an increase in sales volume by AMIS users rather than an increase in their selling prices. As we expected the major benefit of having more information to be observed in the form of a selling price increase, this finding was contrary to our expectations.

We further test for the presence of the heterogeneous effects of AMISs and find consistent regional heterogeneity in the impact of AMISs across market structures but find no systematic difference in the effects of AMIS use on outcomes due to educational background. Such regional heterogeneity is likely driven by the different degrees of market competition in these areas, which may be determined by both demand- and supply-side conditions, namely, the number of buyers accessible and level of farmers' market participation. Indeed, we find that AMIS use is positively associated with a price increase in Sidama, where market competition is higher than that in Jimma. In Jimma, on the contrary, the price is unaffected by AMIS use. However, AMIS use is positively associated with higher sales volume, the ratio of sales to production, and farm income in Jimma, which suggests that although farmers cannot obtain higher prices using the AMIS, they can increase production and sales volume. The results are robust to different estimation methods, including inverse probability weighting (IPW) in quasi-experimental designs for evaluating the causal treatment effect of AMIS use.

Our study contributes to the emerging literature on the effect of ICT on the information asymmetry in agricultural markets in developing countries in two ways. First, we evaluate the effects of using a public AMIS on farmers' outcomes, while most existing studies analyze the impacts of privately managed AMISs or the ownership (or use) of mobile phones. A public AMIS is freely available to a large pool of farmers through radios, televisions, SMS, and mobile phones, and therefore it is important to understand whether the implementation of AMISs actually yields positive results for them. Our findings confirm that providing market price information via the AMIS is positively related to coffee sales, the ratio of sales to production, and coffee income. In addition, we consider market heterogeneity by comparing two zones with different market characteristics. We find that the AMIS is positively associated with increasing coffee sales, the ratio of sales to production, and coffee income in only one zone with relatively lower market participation. On the contrary, the sales and income of AMIS users in the other zone with higher market participation did not increase although their selling price increased. These findings indicate the need to improve on other market imperfections in addition to information asymmetry, consistent with the findings of Aker & Ksoll (2016).

The remainder of this paper is organized as follows. In Section 2, we develop our hypotheses to be tested based on the relevant literature. Section 3 describes Ethiopia's coffee industry and its AMIS. In Section 4, we explain the data used and present summary statistics. Section 5 describes our empirical strategy, and the results are presented in Section 6. Finally, Section 7 concludes.

2 Hypothesis Development

With the rapid development of ICT allowing farmers in developing countries to obtain market price information more easily than before, there has been growing interest in the impact of providing market information on farmers' bargaining power and market participation. First, we focus on the relationship between market information and farmers' bargaining power. Theoretically, it is straightforward to predict that removing information asymmetry by providing farmers with more market information raises their bargaining power compared with traders (Stigler, 1961). Many empirical studies have also provided evidence for this. For example, Jensen (2007) found that the use of market information through mobile phones helps fishers choose the fish market with the highest price. Svensson & Yanagizawa (2009) also found that farmers who are better informed about agricultural prices have higher bargaining power over traders. Courtois & Subervie (2015) evaluate the impact of a private AMIS-based program in Ghana on farmers' marketing performances. They found that AMIS users sell maize at a price 10% higher than those of non-AMIS users. This implies that the use of AMIS increases farmers' bargaining power. However, their target program was privately operated so that the effect of public AMIS on farmers' bargaining power remains unknown. Thus, we first test the following:

Hypothesis 1. *Providing market information to farmers through a public AMIS increases farmers' bargaining power so that they can sell at a higher price.*

Next, we turn to sales volume. Several studies examine the effect of farmers' use of market information on market participation. Muto & Yamano (2009) suggested that as information flow increases, the cost of crop marketing decreases, which raises the market participation of farmers in remote areas. They interpreted the result as follows: farmers and traders bear the cost and risk of traveling if both parties are aware of the volume and price of what they can trade in advance. Courtois & Subervie (2015) claimed that asymmetric information about market prices may collapse negotiations between farmers and traders. In particular, when the market price falls sharply due to external factors, uninformed farmers may refuse to sell their products to traders because the payoff by selling products is lower than expected, even if traders offer prices that minimize their gains. To deal with this problem, they propose the use of AMISs by farmers and expect transaction success rates to improve when farmers subscribe to an AMIS—even when the market price fluctuates largely due to unexpected external factors. Hence,

Hypothesis 2. *Providing market information through a public AMIS to farmers reduces* sales price and travel cost uncertainty so that farmers can sell in larger quantity or at a higher the ratio of sales to production.

To provide evidence on the potential benefit of the Ethiopian AMIS, Getnet et al. (2011) used a quasi-rational expectation formation and found that the AMIS helps farmers make unbiased price forecasts. The positive impact of the AMIS on farmers' price predictions may improve their decision-making and market behavior related to coffee production and marketing; thus, the AMIS can increase farmers' income. However, the study does not estimate the AMIS's effect on farmers' income. Hence, empirical evidence of the positive effect of the AMIS on farmers' income is still lacking. Thus, we test the following:

Hypothesis 3. *Providing market information to farmers through a public AMIS improve farmers' decision-making and market behavior related to coffee production and marketing so that they can sell at a higher price.*

We further assume that depending on the market structure, the impact of AMISs may differ due to different elasticities of demand and supply. For instance, when the market structure is close to an oligopsony, it may be difficult for farmers to negotiate with traders. Even if farmers are aware of the prevailing market price, they may not benefit from such information if they lack access to other buyers. Farmers can only choose from selling their products at below the market price or not selling them at all. By contrast, if there are many buyers in the market, farmers can search for other buyers willing to pay a price closer to the market price. In such a market, providing market information to farmers is expected to induce them to sell more in the market. Thus,

Hypothesis 4. *The effects of providing market price information to farmers depend on the market structure.*

In addition to examining the impact of ICT-based AMISs on farmers' bargaining power and market participation, we examine two types of heterogeneity in this impact, namely, farmers' individual ability and location. While many previous studies have found that AMISs are effective at changing farmers' behavior, it remains unclear if the majority of smallholder farms, especially with less educated farmers, benefit from using such new technologies. In other words, because an individual's ability to interpret information depends on his/her cognitive skills, the benefits of receiving information are expected to be larger for those with higher levels of education than those with lower levels of education. Thus,

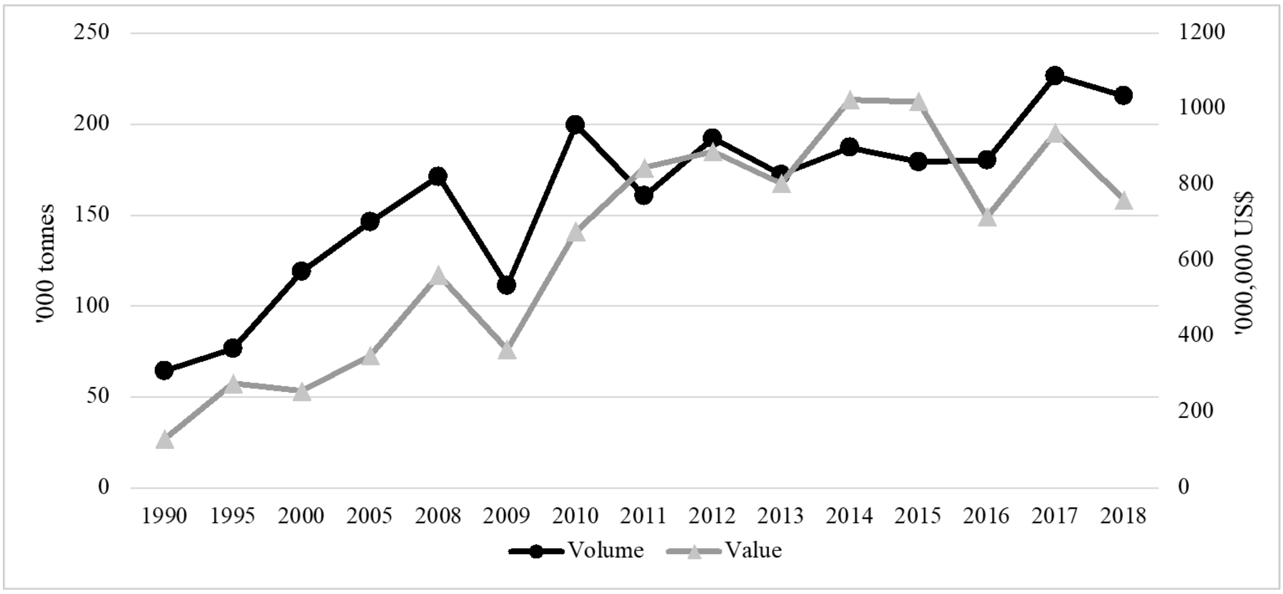
Hypothesis 5. *The effects of providing market price information to farmers depend on their ability to interpret information.*

We test these five hypotheses using primary data on coffee farmers collected in Ethiopia to verify whether the AMIS is a valid tool for enhancing farmers' bargaining power and market participation and how its effects depend on the individual's level of education and market structure.

3 AMIS in Ethiopia

3.1 Coffee industry

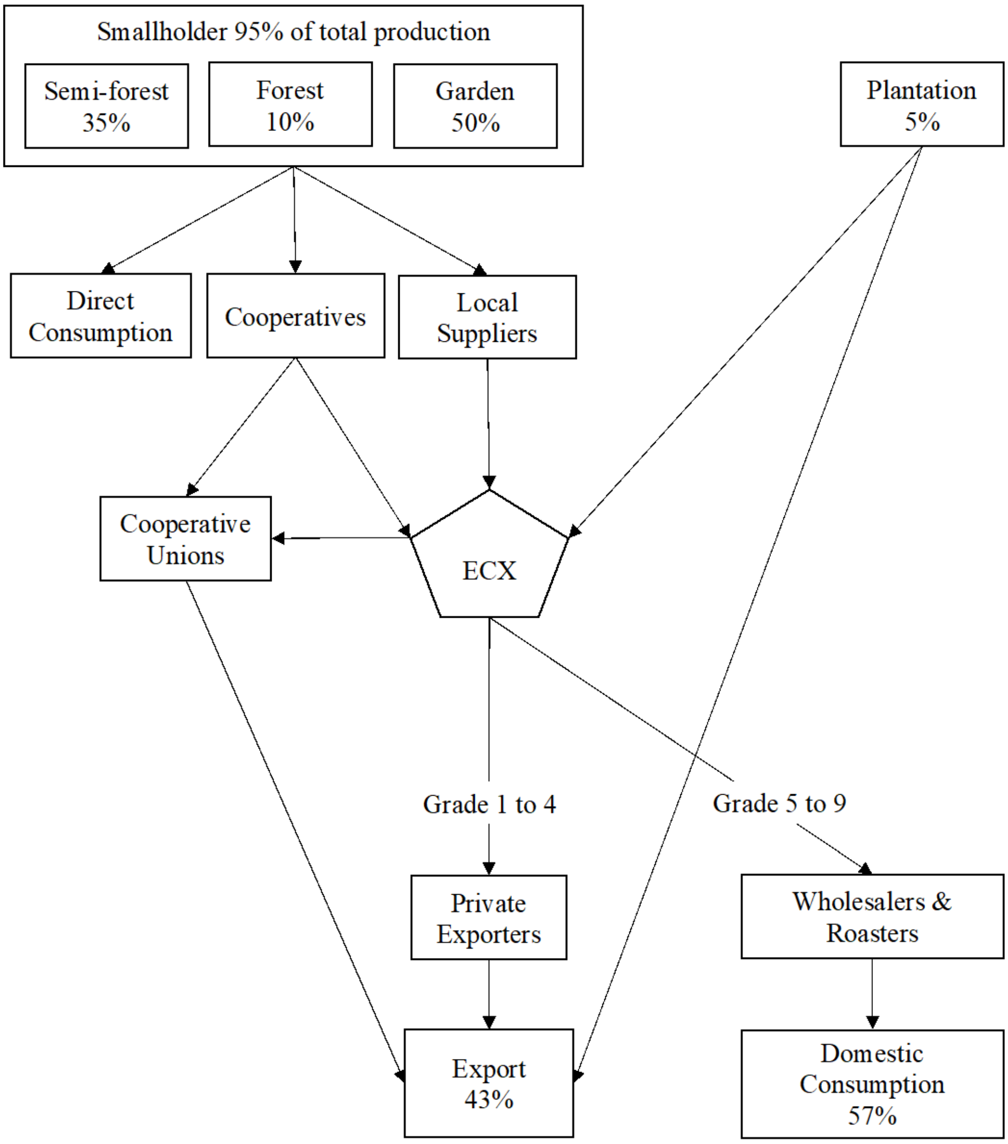
In Ethiopia, there are more than one million coffee-growing households, and the livelihoods of over 15 million people directly and indirectly depend on the coffee industry (Labouisse et al., 2008; Lmc, 2000; Petit, 2007). Since liberalizing its agricultural market in 1990, the Ethiopian government has striven to improve the productivity, quality, and market efficiency of domestic coffee crops (Petit, 2007). Consequently, in 2018, Ethiopia was ranked the largest coffee exporter in Africa and 10th largest exporter in the world (ICO, 2020; Minten et al., 2019). Figure 1 shows Ethiopia's coffee export volume and value between 1990 and 2018. During this period, Ethiopian coffee exports increased from 64 thousand tons to 215 thousand tons; in terms of the U.S. dollar value, it rose from $129 million to $759 million. This represents a 340% increase in volume and a 590% increase in value (FAO, 2020).



Source: FAO (2020)

Figure 1. Ethiopian coffee export volume and value

In May 2008, to ensure the development of an efficient and modern trading system, the Ethiopian government established the Ethiopian Commodity Exchange (ECX) in Addis Ababa with $29 million of funding from international institutes and official development assistance; it also changed the hub of its coffee distribution from auction centers to the ECX (Gabre-Madhin, 2012). Most of the coffee produced by smallholder farms is traded on the ECX because the government has revised the laws on coffee trading for export or domestic distribution to ban coffee transactions outside the ECX (Gelaw et al., 2017). In 2009, the year after its establishment, Ethiopia's coffee exports decreased by 60 thousand tons compared with 2008, but they began to recover in 2010 and nearly doubled in 2018, as shown in Figure 1. This increasing trend may be partially due to growing demand for coffee, as coffee exports from coffee-producing countries rose by nearly 130% from 5.7 million tons to 7.4 million tons between 2009 and 2018 (FAO, 2020). At the same time, the modernized trading system under the ECX has also contributed to the remarkable growth achieved by the Ethiopian coffee industry.



Source: Based on Tamirat (2013) and Duguma & Van deer Meer (2018)

Figure 2. Ethiopian coffee supply chain after the establishment of the ECX

Figure 2 depicts the Ethiopian coffee supply chain after the ECX system was introduced in 2008. Most of the coffee produced by smallholder farms is traded on the ECX because the government has revised the laws on coffee trading for export or domestic distribution to ban coffee transactions outside the ECX (Gelaw et al., 2017). Since the Ethiopian government banned unauthorized collectors and brokers' business activities with the establishment of the ECX, most smallholder coffee farms sell their products directly to cooperatives or licensed local suppliers rather than to brokers (Minten et al., 2019). According to ECX (2020), the coffee collected by cooperatives and suppliers is sent to the ECX's warehouses nationally and graded by experts. Coffee with grades 1 to 4 is exported overseas, while coffee with grade 5 or lower is distributed to domestic markets (Duguma & Van deer Meer, 2018; ECX, 2020; Tamirat, 2013).

3.2 Market information provided by the ECX

Smallholder coffee farms in Ethiopia produce about 95% of the country's coffee output. However, they have difficulty accessing information on wholesale prices since most are geographically isolated from central markets (Getnet et al., 2011; Labouisse et al., 2008). Hence, many obtain market information from unofficial sources such as neighbors, friends, and traders and generally make marketing decisions such as selling prices and sales volume based on sometimes incorrect and outdated information (Getnet et al., 2011). Such an environment in which producers rely on unofficial market price information causes information asymmetries between producers and traders that try to lower selling prices. Since neighbors also obtain market information from traders and other unofficial sources, the information asymmetry problem persists despite an active exchange among producers (Osborne, 2005).

Since 2008, the ECX has adopted an AMIS and disseminated price information on wholesale prices to all market actors including smallholder farms through its website, electronic tickers in 250 rural markets, SMS, interactive voice response services, radio broadcasts (three times a day), television programs (twice a day), newspapers, and newsletters (daily, monthly, and half-yearly) (ECX, 2020). Given the Ethiopian coffee industry's supply chain structure in which most coffee is traded at the ECX, the AMIS is expected to provide more accurate price information than other channels.

4 Data and Summary Statistics

To assess the impact of the AMIS on coffee producers' bargaining power and market participation, we interviewed the farmers of 466 smallholder coffee farms in 19 kebeles (wards) in the Jimma and Sidama zones in 2014. We collected recall data on coffee production and sales in 2012 and 2013 and restricted respondents to household heads. The kebeles and respondents were chosen randomly using lists obtained from the Oromia Coffee Farmers Cooperative Union and Sidama Coffee Farmers Cooperative Union.[**] These two zones were chosen, as they are the largest coffee producers and exporters in Ethiopia. In 2013, the Jimma zone exported about 20% of Ethiopia's coffee exports, while the Sidama zone exported about 40% (Minten et al., 2014). Another reason for choosing the two zones was to compare the effects of the AMIS under different market structures. According to Minten et al. (2015), 80% of farmers in the Sidama zone can choose to whom to sell from multiple traders. On the contrary, only 63% of farmers in the Jimma zone can select their trading partners.

[**] Cooperatives have all smallholder coffee farmers in the Oromia region and the SNNPR region including both members and non-members.

While only 2.2% of farmers in the Sidama zone stated that they had no choice, 11.2% in the Jimma zone did so. These survey results suggest that there are more traders in the Sidama zone than in the Jimma zone. Owing to the differences in the market structure of the two zones, we thus expect the benefits of the price information obtained from the AMIS to differ.

Table 1. Number of sample households and AMIS users in each kebele

Zone	Woreda	Kebele	House holds	AMIS Users			
				2012		2013	
			#	#	%	#	%
Jimma			245	50	20.41	50	20.41
	Gera	A	29	10	34.48	10	34.48
		B	19	2	10.53	2	10.53
		C	37	7	18.92	7	18.92
	Limu Seka	D	24	13	54.17	13	54.17
		E	23	1	4.35	1	4.35
		F	39	1	2.56	1	2.56
	Kersa	G	36	2	5.56	2	5.56
		H	26	7	26.92	7	26.92
		I	12	7	58.33	7	58.33
Sidama			221	88	39.82	91	41.18
	Dale	J	25	17	68.00	17	68.00
		K	34	28	82.35	30	88.24
		L	8	3	37.50	3	37.50
	Aleta Wendo	M	27	3	11.11	3	11.11
		N	27	18	66.67	18	66.67
		O	26	8	30.77	9	34.62
	Shebedino	P	29	4	13.79	4	13.79
		Q	23	5	21.74	5	21.74
		R	22	2	9.09	2	9.09
N			466	138	29.61	141	30.26

Notes: "AMIS" is an abbreviation for agricultural market information system.
% of AMIS users in each year = # of AMIS users in each year / # of observations in each village

Source: Authors' survey (2014)

Table 1 presents the number of sample households and AMIS users in each kebele in the two sample years. Between 2012 and 2013, the number of AMIS users remains the same in all kebeles except for kebeles K and O, which show increases by two and one, respectively. In the full sample, the share of AMIS users increases marginally from 29.61% in 2012 to 30.26% in 2013. This stagnant adoption trend may be attributed to the low awareness of the system among farmers. Farmers might also be reluctant to use the AMIS, as its benefits at the time of the survey might not have been visible.

Table 2. Types of price information sources

(Multiple answers are allowed)

	Jimma (n=245)		Sidama (n=221)		Total (n=466)	
	#	%	#	%	#	%
From unofficial channels						
Family member	163	66.53	27	12.22	190	40.77
Friends and neighbors	226	92.24	109	49.32	335	71.89
Relative	187	76.33	15	6.79	202	43.35
From buyers						
Broker	24	9.80	2	0.90	26	5.58
Private trader	179	73.06	8	3.62	187	40.13
Collector	46	18.78	23	10.41	69	14.81
Exporter	38	15.51	1	0.45	39	8.37
From official channels						
Cooperative	21	8.57	193	87.33	214	45.92
Extension agent	25	10.20	5	2.26	30	6.44
AMIS	50	20.41	91	41.18	141	30.26

Notes: % of users in each channel = # of users in each channel / # of observations in each zone

Source: Authors' survey (2014)

Table 2 shows the types of information sources used by smallholder coffee farms to obtain price information in 2013. Altogether, 72% of respondents answered that they obtain information from friends or neighbors, 43% from relatives, and 46% from cooperatives. Only 30% of respondents, or 141 of the 466 farmers, use the AMIS provided by the ECX. Overall, farmers in the Jimma zone tend to rely on informal information such as from family members, friends, and private traders, while most farmers in the Sidama zone obtain price information from formal information sources such as cooperatives. In addition, the AMIS is the third most popular information source in Sidama after cooperatives and friends and neighbors (41.18% of the sample). In turn, the user ratio of the AMIS in the Jimma zone is only half that of Sidama and the AMIS is only the fifth most popular information source among the 10 types surveyed.

Table 3. Types of AMIS channels

(Multiple answers are allowed)

	Jimma (n=50)		Sidama (n=91)		Total (n=141)	
	#	%	#	%	#	%
Radio	49	98.00	91	100.00	140	99.29
SMS	9	18.00	14	15.38	23	16.31
TV	3	6.00	12	13.19	15	10.64
Electronic ticker	0	0.00	7	7.69	7	4.96
IVR	1	2.00	0	0.00	1	0.71
Newspaper	1	2.00	0	0.00	1	0.71
Website	0	0.00	0	0.00	0	0.00

Notes: % of users in each channel = # of users in each channel / # of observations in each zone

Source: Authors' survey (2014)

Table 3 describes the types of AMIS channels used by coffee farmers in 2013. Virtually all respondents (157 of 158) who use the AMIS obtain their information from radio broadcasts. Although 85% of farmers in the sample own mobile phones, the usage rates of the costly SMS subscription and interactive voice response systems are relatively low. Instead, farmers use the radio features on their mobile phones in addition to a radio receiver, which is owned by 73% of farmers, making radio the most popular AMIS channel. Nobody accessed the ECX website to check price information for two main reasons: the website targets foreign buyers rather than local coffee farmers and most smallholder farms do not have a device or network to view the website. Seven farmers in the Sidama zone answered that they obtain price information through electronic tickers, whereas the number of users in Jimma is zero.

Table 4. Socioeconomic characteristics of respondents

Variables		Jimma AMIS Mean	Jimma Non-AMIS Mean	Jimma Dif.	Sidama AMIS Mean	Sidama Non-AMIS Mean	Sidama Dif.	Total AMIS Mean	Total Non-AMIS Mean	Total Dif.
HH's age	years	44.88	45.55	-0.67	47.31	46.72	0.58	46.45	46.02	0.43
		[12.81]	[11.53]	(1.87)	[9.18]	[11.21]	(1.43)	[10.63]	[11.40]	(1.13)
HH's gender	=1 male	0.98	0.97	0.01	0.98	1.00	-0.02*	0.98	0.98	-0.00
		[0.14]	[0.17]	(0.03)	[0.15]	[0.00]	(0.01)	[0.14]	[0.13]	(0.01)
HH's schooling	years	2.84	3.09	-0.25	5.38	4.78	0.61	4.48	3.77	0.72**
		[2.97]	[2.88]	(0.46)	[3.06]	[3.33]	(0.44)	[3.25]	[3.18]	(0.32)
Household size	#	5.68	5.96	-0.28	5.76	5.81	-0.05	5.73	5.90	-0.17
		[2.04]	[1.61]	(0.27)	[2.08]	[2.05]	(0.28)	[2.06]	[1.80]	(0.19)
Adults in the household	#	2.84	3.05	-0.21	4.29	4.13	0.15	3.77	3.48	0.29
		[1.18]	[1.22]	(0.19)	[2.11]	[2.17]	(0.29)	[1.96]	[1.74]	(0.18)
Total assets	birr	55373.72	31317.94	24055.78**	31276.02	31724.18	-448.16	39821.30	31480.44	8340.87*
		[76614.28]	[56204.60]	(9649.59)	[26948.34]	[28917.38]	(3844.10)	[51527.78]	[47164.09]	(4893.07)
AMIS informants	#	0.48	0.02	0.46***	2.03	1.70	0.33*	1.48	0.69	0.79***
		[1.16]	[0.14]	(0.09)	[1.28]	[1.46]	(0.19)	[1.44]	[1.24]	(0.13)
N		50	195		91	130		141	325	

Notes: Standard deviations are in brackets. Standard errors are in parentheses. * p<0.05, ** p<0.01, *** p<0.001.
"HH" and "AMIS" are abbreviations for the head of household and agricultural market information system, respectively.
Total assets = fixed assets + saving - loan

Table 4 outlines respondents' socioeconomic characteristics from the 2013 data. The AMIS user and non-AMIS user groups were divided according to the answer of the household head who participated in the interview. This grouping does not reflect the usage of other household members, as household heads have the strongest bargaining power in the household. Thus, we only consider the household head's characteristics in the following analysis. The average age of the household head is 46 years old and 98% are men. There is no significant difference between AMIS and non-AMIS users. Significant differences are found in the years of schooling, total assets, and number of AMIS informants (i.e., the number of people to whom respondents mainly talk about market prices, but only those who use the AMIS), which are higher for AMIS users than non-users. The number of AMIS informants is the only characteristic that is significantly different between the user and non-user groups in both Jimma and Sidama as well as for the total sample. The AMIS user groups in both zones have more informants who use the AMIS around them than the non-user group.

Table 5. Coffee production and sales performance of farms

		Jimma			Sidama			Total		
Variables	Unit	AMIS Mean	Non-AMIS Mean	Dif.	AMIS Mean	Non-AMIS Mean	Dif.	AMIS Mean	Non-AMIS Mean	Dif.
Coffee farm size	Ha	0.83	0.94	-0.11	0.69	0.61	0.08	0.74	0.81	-0.07
		[0.57]	[0.63]	(0.10)	[0.39]	[0.36]	(0.05)	[0.46]	[0.56]	(0.05)
Harvest volume	kg	795.00	554.10	240.90***	1114.18	1011.15	103.02	1000.99	736.92	264.07***
		[470.37]	[404.12]	(66.31)	[544.83]	[665.58]	(84.58)	[540.14]	[569.61]	(56.56)
Sales volume	kg	725.00	434.74	290.26***	960.11	804.23	155.88**	876.74	582.54	294.20***
		[514.11]	[360.97]	(62.87)	[532.87]	[461.00]	(67.22)	[536.46]	[442.15]	(47.66)
Ratio of sales to production	%	86.81	74.72	12.09***	83.33	82.66	0.67	84.56	77.89	6.67***
		[17.43]	[18.11]	(2.85)	[12.49]	[17.72]	(2.16)	[14.47]	[18.35]	(1.74)
Sales price/kg	birr	10.39	12.80	-2.41***	14.71	13.10	1.61***	13.18	12.92	0.26
		[4.17]	[4.46]	(0.70)	[4.16]	[4.45]	(0.59)	[4.63]	[4.45]	(0.45)
Total coffee income	birr	6399.90	5307.80	1092.10	13848.90	10300.05	3548.85***	11207.41	7304.70	3902.71***
		[3639.65]	[4853.12]	(734.59)	[8071.70]	[6448.60]	(978.67)	[7701.29]	[6054.69]	(665.05)
Total coffee cost	birr	368.58	460.01	-91.43	2230.14	966.53	1263.61***	1570.01	662.62	907.40***
		[1476.41]	[1480.65]	(234.58)	[1979.71]	[2492.08]	(313.73)	[2020.20]	[1961.41]	(199.60)
Fertilizer	birr	22.58	41.44	-18.86	8.79	0.00	8.79***	13.68	24.86	-11.18
		[116.35]	[506.82]	(72.26)	[32.14]	[0.00]	(2.82)	[73.80]	[392.70]	(33.34)
Pesticide	birr	0.00	0.00	0.00	0.66	0.00	0.66	0.43	0.00	0.43
		[0.00]	[0.00]	(0.00)	[6.29]	[0.00]	(0.55)	[5.05]	[0.00]	(0.28)
Herbicide	birr	0.00	14.70	-14.70*	1.47	0.00	1.47**	0.95	8.82	-7.87**
		[0.00]	[56.59]	(8.01)	[8.25]	[0.00]	(0.72)	[6.65]	[44.38]	(3.76)
Labor	birr	346	403.87	-57.87	2219.22	966.53	1252.69***	1554.96	628.94	926.02***
		[1419.30]	[1393.43]	(221.72)	[1968.16]	[2492.08]	(313.18)	[2001.01]	[1926.53]	(196.57)
N		50	195	245	91	130	221	141	325	466

Notes: Standard deviations are in brackets. Standard errors are in parentheses. * p<0.05, ** p<0.01, *** p<0.001.
"AMIS" is an abbreviation for agricultural market information system.
Total coffee income = sales volume × sales price/kg
Total coffee cost = fertilizer + pesticide + herbicide + labor

Table 5 shows coffee production, cost, and sales in 2013. The AMIS user group has a statistically higher harvest volume, sales volume, ratio of sales to production, coffee cost, and labor cost than non-AMIS users. The difference in coffee cost between the two groups is because the AMIS user group's labor cost is 926 birr ($24.75) more than that of the non-AMIS group. Since AMIS users can reduce market price uncertainty by using the AMIS, AMIS users in Sidama appear to have actively hired workers as an investment strategy to increase revenue. However, in Jimma, the difference in the labor cost between the groups is not statistically significant. In addition, the AMIS group harvests about 264 kilograms more and sells about 294 kilograms more than the non-AMIS group despite the land size differences not reaching statistical significance. Owing to the higher sales volume among AMIS users, they earn 3,903 birr ($104.29) more coffee income than non-AMIS users. Such higher income may not result from the higher selling price because the price difference between the two groups is not statistically significant. We can thus infer that the effect of the AMIS may differ in the two zones since the difference in the average prices between users and non-users in Jimma indicates a negative sign, while that in Sidama shows a positive sign. Further, sample farmers in Sidama harvest more, sell more, sell at a higher price, earn more, and invest more even though they have less farmland than farmers in Jimma.

5 Econometric Strategies

Using the novel data set of 466 farmers from the household survey mentioned in Section 4, we empirically examine the impact of the AMIS on farmers' bargaining power and market participation. Although we collected two-year panel data from each farmer, the main analysis of the study is cross-sectional because the number of AMIS users was almost the same in 2012 and 2013, as shown in Table 1. As an alternative, we employ a pooled regression model, a fixed effect model, and a random effect model using panel data as a robustness check. The following econometric model is estimated:

$$Y_{ik13} = \alpha + \beta_1 MIS_{ik13} + \beta_2 MIS\ informant_{ik13} + X_{ik13}\beta_k + \gamma Y_{ik12} + \delta_k + \varepsilon_{ik} \quad (1)$$

where Y_{ik13} is the outcome (log selling price per kilogram, log sales volume, the ratio of sales to production, and log farm income) for farmer i in zone or woreda k in 2013; MIS_{ik13} is a dummy variable that indicates whether farmer i is an AMIS user in 2013; and $MIS\ informant_{ik13}$ is the number of informants who use the AMIS and exchange price information with farmer i in 2013. This variable controls for potential treatment spillover effects because, as the price information obtained from the AMIS can easily spill over to other farmers who do not use the AMIS. X_i accounts for farmer i's age and years of schooling, farm size, total coffee costs, and types of coffee price information sources in 2013. A lagged dependent variable Y_{ik12} is included to estimates to what extent MIS usage is associated with higher growth of the outcomes. δ_k refers to zone or woreda dummies, and ε is an error term. As mentioned in sub-section 3.1, most of the coffee harvested by smallholders is traded on the regional trading centers managed by the ECX. Since the centers are located at the woreda level and the coffee cultivation method varies by zone, the heterogeneity across woredas or zones is likely to be greater than that across villages. Thus, to capture unobserved heterogeneity across zones or woreda, the regression model includes zone or woreda dummies instead of village dummies.

To test Hypothesis 4, this study employs an interaction term between AMIS usage and residential area is estimated to test Hypothesis 4. The benefit of the price information obtained from the AMIS is expected to differ in the two zones due to differences in their markets, as described in Section 4.

Another interaction effect between AMIS usage and years of schooling. This interaction term is a proxy for revealing the differences in the outcomes among AMIS users depending on their ability to interpret market price information. If the impact of the AMIS on the outcome variables is higher for more educated farmers than less educated ones, Hypothesis 5 is supported. In other words, the effects of the AMIS can be amplified when price information is provided to individuals with a better understanding and higher cognitive skills.

Because our sample farmers have freely chosen whether to use the AMIS, self-selection bias may arise in the analyses. Thus, as a quasi-experimental method, this study adopts the inverse probability-weighted regression adjustment (IPWRA) estimator and estimates the average treatment effect (ATE) to measure the differences in the average outcomes between the AMIS user and non-AMIS user groups. Since the estimator is a doubly robust estimator that combines a logistic model for the treatment (i.e., the IPW component) and a linear model for the outcome (i.e., the RA component), it provides asymptotically unbiased estimates even if one of the models is mis-specified (Bourguignon et al., 2007; Robins et al., 2007; Wooldridge, 2007):

$$\widehat{ATE_{IPWRA}} = \frac{1}{n}\sum_{i=1}^{n}\left[\frac{MIS_iY_i}{\hat{\pi}(Z_i)} - \frac{(1-MIS_i)Y_i}{1-\hat{\pi}(Z_i)}\right] \tag{2}$$

where n is the number of individuals in our sample and $\hat{\pi}(Z_i)$ is the estimated propensity score, which is the estimated conditional probability of using the AMIS given Z_i. Appendices 2 to 4 show the variables used to estimate the probability.

6 Results

6.1 Effects of the AMIS on farmers' agricultural outcomes

We first analyze the effect of the AMIS on farmers' agricultural outcomes using the full sample. In addition to ordinary least squares (OLS), which may be biased because of the endogenous nature of AMIS adoption, the IPWRA results are presented. For the matching, we use the household and farm characteristics. The matching passes the covariate balance tests (Appendix 1) and overidentification tests (Table 6).

As shown in Table 6, the effects of the AMIS are consistent under both the OLS and the IPWRA specifications for all four dependent variables, except for the ratio of sales to production. First, the AMIS user dummy does not show statistically significant effects on the selling price per kilogram in both OLS and IPWRA. However, the AMIS dummy shows the positive and statistically significant effects on the user's sales volume, ratio of sales to production, and farm income in either the OLS or the IPWRA columns. The sales volume of AMIS users is 10% higher (column (iv)) than that of non-AMIS users. The ratio of sales to production is about 3% higher for AMIS users, inferring that AMIS users increase their sales both in absolute and in relative terms. Consequently, AMIS users also have statistically higher farm income, as presented in columns (vii) and (viii). In sum, farmers who use the AMIS enjoy higher income from coffee because of more active market participation, but not higher selling prices.

Table 6. Effects of the AMIS on farmers' agricultural outcomes

	ln(sales price/kg)		ln(sales volume)		Ratio of sales to production		ln(coffee farm income)	
	OLS	IPWRA	OLS	IPWRA	OLS	IPWRA	OLS	IPWRA
	(i)	(ii)	(iii)	(iv)	(v)	(vi)	(vii)	(viii)
= 1 AMIS user	0.002	0.01	0.08**	0.10***	2.17	3.44**	0.12***	0.16***
	(0.03)	(0.02)	(0.04)	(0.04)	(1.33)	(1.58)	(0.05)	(0.04)
= 1 info. from	-0.06	-0.10**	0.14*	0.09	1.12	-0.49	0.01	-0.12
unofficial channels	(0.04)	(0.05)	(0.07)	(0.08)	(2.15)	(2.12)	(0.09)	(0.08)
= 1 info. from	0.003	0.07	-0.03	-0.17	0.27	-6.00	-0.04	-0.23
buyers	(0.04)	(0.09)	(0.06)	(0.18)	(2.16)	(3.68)	(0.07)	(0.22)
= 1 info. from	-0.09**	-0.09*	0.19***	0.06	1.85	-4.21	0.17**	0.04
extension agents	(0.04)	(0.05)	(0.05)	(0.07)	(1.49)	(2.88)	(0.07)	(0.09)
= 1 info. from coop.	-0.0003	0.15**	-0.01	-0.10	-3.97**	-1.66	0.02	0.08
	(0.04)	(0.08)	(0.06)	(0.10)	(1.82)	(3.35)	(0.08)	(0.14)
# of AMIS informants	-0.02*	-0.02	0.06**	0.04**	1.55**	-0.18	0.04	0.01
	(0.01)	(0.02)	(0.02)	(0.02)	(0.70)	(0.89)	(0.03)	(0.03)
Y_{t-1}	0.67***	0.63***	0.88***	0.93***	0.78***	0.79***	0.74***	0.75***
	(0.05)	(0.06)	(0.05)	(0.05)	(0.06)	(0.07)	(0.07)	(0.07)
Jimma dummy	-0.03	-0.002	-0.07	0.19	-3.42	7.70*	-0.13	0.28
(=1 live in Jimma)	(0.06)	(0.13)	(0.07)	(0.19)	(2.40)	(4.63)	(0.10)	(0.21)
Constant	1.11***	1.36***	0.62*	0.09	29.96***	23.91	2.24***	1.99***
	(0.20)	(0.35)	(0.35)	(0.44)	(9.16)	(18.50)	(0.62)	(0.75)
Over. (Prob>F)		0.33		0.33		0.33		0.33
R^2	0.55		0.79		0.48		0.72	
N	466	466	466	466	466	466	466	466

Notes: Robust standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1.
All regressions include control variables for the household head's age, age^2, schooling, and coffee farm size.

6.2 *Heterogeneous effects of the AMIS on farmers' agricultural outcomes*

We investigate the regional heterogeneity between the Jimma and Sidama zones. Based on the differences in Table 4, we assume that farmers are situated differently in the two zones in terms of both coffee production and marketing. Table 7 captures the difference in the effect of the AMIS between the Jimma and Sidama zones by including the Jimma dummy as well as the interaction term. While farmers in Jimma sell 5.12% points lower from their production and earn 19% less farm income than farmers in Sidama on average, the effects of using the AMIS are much greater for farmers in Jimma. If farmers in Jimma use the AMIS, the ratio of sales to production and farm income increase by 0.8% points and 0.05%, respectively compared with users in Sidama. The larger effects of the AMIS among users in Jimma may be attributed to the lower sales volume, ratio of sales to production, and farm income than farmers in Sidama. The effects of the AMIS on selling price remain insignificant even in Jimma, where selling price per kilogram is lower than that in Sidama.

Table 7. Regional heterogeneity of the AMIS effects: OLS

	ln(sales price/kg)	ln(sales volume)	Ratio of sales to production	ln(coffee farm income)
	(i)	(ii)	(iii)	(iv)
= 1 AMIS user	0.02	-0.01	-0.40	0.01
	(0.04)	(0.05)	(1.38)	(0.06)
= 1 info. from unofficial channels	-0.06	0.16**	1.74	0.04
	(0.04)	(0.07)	(2.10)	(0.09)
= 1 info. from buyers	0.01	-0.04	-0.19	-0.06
	(0.04)	(0.06)	(2.16)	(0.07)
= 1 info. from extension agents	-0.08**	0.16***	1.03	0.13**
	(0.04)	(0.05)	(1.63)	(0.06)
= 1 info. from coop.	0.003	-0.01	-4.15**	0.01
	(0.04)	(0.06)	(1.79)	(0.08)
# of AMIS informants	-0.02*	0.06**	1.61**	0.04
	(0.01)	(0.02)	(0.71)	(0.03)
Y_{t-1}	0.67***	0.87***	0.77***	0.75***
	(0.05)	(0.05)	(0.06)	(0.07)
Jimma dummy (=1 live in Jimma)	-0.02	-0.14*	-5.12**	-0.19*
	(0.06)	(0.08)	(2.55)	(0.10)
AMIS × Jimma dummy	-0.04	0.22***	5.94**	0.24***
	(0.05)	(0.08)	(2.88)	(0.09)
Constant	1.12***	0.65	30.58***	2.20***
	(0.20)	(0.35)	(9.27)	(0.61)
Joint. (Prob>F)	0.38	0.004***	0.04**	0.007***
R^2	0.55	0.80	0.48	0.71
N	466	466	466	466

Notes: Robust standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1.
All regressions include control variables for the household head's age, age^2, schooling, and coffee farm size.

To further distinguish the difference between the effects of the AMIS in Jimma and Sidama, we divide the sample in half and run separate regressions. Tables 8 summarize the results using OLS and IPWRA, respectively. For the matching, we use the household and farm characteristics. The matching passes all the covariate balance tests (Appendices 3 and 4) and overidentification tests. We find, under both OLS and IPWRA, that the significance level of the four dependent variables varies by region. The AMIS variable shows the positive and statistically significant effect on the selling price of farmers in Sidama, but the effects on the other three dependent variables are insignificant. The opposite case is true for the Jimma zone. The coefficients of the AMIS dummy are positive and statistically significant for sales volume, the ratio of sales to production, and farm income, but not selling price (OLS). The results using IPWRA show similar trends to the OLS results, except for the effect on the selling price of farmers in Jimma. This contradictory trend between the two zones is likely due to differences in market structure. As explained in Section 4, farmers in Sidama have relatively more choices of buyers than farmers in Jimma, meaning that additional access to the official price information through the AMIS could increase their price. Nonetheless, a higher selling price does not contribute to a statistically significant increase in farm income. In Jimma, the AMIS encourages farmers in Jimma to sell more coffee to the market, leading to higher farm income.

Table 8. Effects of the AMIS by region

	OLS		IPWRA	
	Jimma	Sidama	Jimma	Sidama
	(i)	(ii)	(iii)	(iv)
ln(sales price/kg)	0.03	0.11***	0.08*	0.10***
	(0.03)	(0.04)	(0.04)	(0.04)
ln(sales volume)	0.22***	0.05	0.21***	0.03
	(0.07)	(0.07)	(0.07)	(0.07)
Ratio of sales to production	8.03***	0.07	8.20***	0.30
	(2.65)	(1.94)	(2.73)	(1.71)
ln(coffee farm income)	0.29***	0.11	0.34***	0.10
	(0.07)	(0.10)	(0.08)	(0.08)
N	245	221	245	221

Notes: Robust standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1.
All regressions include woreda dummies and same control variables as in Table 6, except for Jimma dummy.

Next, we examine whether the effect of the AMIS differs depending on the user's education level using OLS. Table 9 shows that neither the AMIS dummy nor the interaction term is statistically significant. Hence, the education level of AMIS users does not affect users' performance, perhaps because the price information that farmers obtain from the AMIS is sufficiently simple that even those with an elementary education can understand and process it without much difficulty. Since all the models in this table fail the joint significance test, those without interaction terms seem to be more appropriate for measuring the effects of the AMIS.

Table 9. Educational heterogeneity of the AMIS effects: OLS

	ln(sales price/kg)	ln(sales volume)	Ratio of sales to production	ln(coffee farm income)
	(i)	(ii)	(iii)	(iv)
= 1 AMIS user	-0.01	0.08	2.05	0.12
	(0.04)	(0.06)	(2.24)	(0.08)
= 1 info. from unofficial channels	-0.06	0.14*	1.13	0.01
	(0.04)	(0.07)	(2.16)	(0.09)
= 1 info. from buyers	0.004	-0.03	0.27	-0.04
	(0.04)	(0.06)	(2.16)	(0.07)
= 1 info. from extension agents	-0.09**	0.19***	1.86	0.17**
	(0.04)	(0.05)	(1.53)	(0.07)
= 1 info. from coop.	-0.00004	-0.01	-3.97**	0.02
	(0.04)	(0.06)	(1.83)	(0.08)
# of AMIS informants	-0.02*	0.06**	1.55**	0.04
	(0.01)	(0.03)	(0.71)	(0.03)
Y_{t-1}	0.67***	0.88***	0.78***	0.74***
	(0.05)	(0.05)	(0.06)	(0.07)
HH's schooling	0.01**	-0.01	-0.50**	0.005
	(0.01)	(0.01)	(0.24)	(0.01)
AMIS × schooling	0.003	0.0001	0.03	0.0001
	(0.01)	(0.01)	(0.37)	(0.01)
Jimma dummy	-0.03	-0.07	-3.42	-0.13
(=1 live in Jimma)	(0.06)	(0.07)	(2.41)	(0.10)
Constant	1.11***	0.62*	29.99***	2.24***
	(0.20)	(0.35)	(9.16)	(0.62)
Joint. (Prob>F)	0.42	0.57	0.70	0.47
R^2	0.66	0.99	0.94	0.99
N	466	466	466	466

Notes: Robust standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1.
All regressions include control variables such as the household head's age, age^2, and coffee farm size.

6.3 Robustness check

As a robustness check, we run a fixed effect model, random effect model, and pooled model using the two-year panel data from 2012 and 2013. The results in Table 10 are consistent with those using OLS and IPWRA. The coefficients of the AMIS dummy are insignificant for selling price in all the columns, but statistically significant and positive for sales volume, the ratio of sales to production, and farm income.

Table 10. Robustness check

	FE	RE	Pooled
	(i)	(ii)	(iii)
ln(sales price/kg)	0.01	0.03	0.03
	(0.05)	(0.03)	(0.03)
ln(sales volume)	0.16**	0.28***	0.29***
	(0.08)	(0.06)	(0.05)
Ratio of sales to production	2.31**	3.71***	3.76***
	(1.04)	(1.37)	(1.11)
ln(coffee farm income)	0.18***	0.30***	0.31***
	(0.05)	(0.06)	(0.05)
# of observations	932	932	932
# of groups	466	466	466

7 Policy Implications and Conclusions

7.1 Policy implications

This study evaluates the impact of the AMIS in Ethiopia on smallholder farms' agricultural outcomes using novel data collected from 446 coffee farmers. Moreover, we examine whether the AMIS's effect differs depending on the market structure and farmer's level of education. Based on our results, we conclude that AMIS users indeed obtain higher farm income than non-AMIS users on average. Such differences in farm income between AMIS and non-AMIS users may be attributed to an increase in sales volume by AMIS users rather than a rise in their selling prices. Moreover, the ratio of sales to production is about 3% higher for AMIS users, suggesting that the Ethiopian AMIS may enhance farmers' market participation; this finding is consistent with those of existing studies (Courtois & Subervie, 2015; Mabota et al., 2003; Muto & Yamano, 2009).

However, unlike many studies (Courtois & Subervie, 2015; Jensen, 2007; Muto & Yamano, 2009), the AMIS user dummy does not show statistically significant effects on farmers' selling price per kilogram.

One reason for not having an overall impact on selling price is the regional heterogeneity in our data. By region, the AMIS dummy shows a positive and significant effect on farmers' selling price per kilogram in Sidama, whereas the other dependent variables are statistically insignificant. On the contrary, the AMIS dummy shows the positive and statistically significant effects on farmers' sales volume, the ratio of sales to production, and farm income in Jimma, perhaps because of the difference in market structure between it and Sidama. According to Minten et al. (2015), coffee farmers in Sidama have more choices of traders and more options to sell to cooperatives than those in Jimma. We therefore conclude that in a market dominated by a small number of traders, the AMIS may not affect farmers' selling price. In addition, in a market in which farmers sell less actively, the AMIS may enhance their sales-to-production ratio, as shown in Table 5. These findings together suggest that unless other market imperfections such as high transportation costs that discourage more traders from entering the market and more farmers from participating are addressed, farmers may not benefit fully from the AMIS.

In addition, we find no difference in outcomes among AMIS users depending on their years of schooling. There are two possible reasons for this. First, because the average education level is only four years and variance across farmers is minor, the benefits of using the AMIS do not differ markedly. Second, the type of information that farmers can obtain from the AMIS is only simple market prices. These require little knowledge to process and do not lead to a statistically significant difference in how farmers use such information in their decision-making processes. Nonetheless, if the information provided by the AMIS becomes more complex, the difference in AMIS benefits will widen depending on the individual's ability to interpret such price data.

7.2 Conclusions

In conclusion, this paper presents the findings relevant to the Ethiopian AMIS will help to influence policies for public AMISs in developing countries to improve smallholder farms' agricultural outcomes. While this study contributes to the literature by examining the impact of the AMIS on farmers' agricultural outcomes as well as by considering the heterogeneity among farmers, we acknowledge several limitations. One is that the data used in this study are not obtained from a random assignment of the treatment. Second, our sample size is only 466, and we estimate heterogeneous effects across regions using data collected in only two zones.

Furthermore, it is beyond the scope of our data to observe the effect of the AMIS on farmers' long-term profit maximization decisions. Farmers may use the information from the AMIS to decide on such inputs as farm size, the number of coffee trees, and fertilizers, which may affect the performance of the next cropping year. If farmers use the AMIS to obtain information on market trends, it may positively and significantly affect users' profits in the long run. Therefore, future studies could use data obtained from a random assignment and from a longer time-span.

Our study contributes to the discussion on the effect of ICT on mitigating information asymmetry in agricultural markets by providing empirical evidence on the effects of using a public AMIS on smallholder farms' agricultural outcomes, while most existing studies analyze the impacts of privately managed AMISs or ownership. Our findings that the effect of AMIS varies depending on the competitiveness of market structure suggest the importance of correcting other market imperfections in addition to information asymmetry to benefit fully from the use of AMISs.

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Appendix 1. Covariate balance test: the full sample

	Standardized differences		Variance ratio	
	Raw	Weighted	Raw	Weighted
HH's age	0.04	-0.01	0.87	0.93
HH's schooling	0.22	-0.01	1.05	1.02
Adults in the household	0.16	-0.01	1.27	1.02
Coffee farm size	-0.13	-0.04	0.69	0.87
Total assets	0.26	0.02	0.98	1.01
Info. from traders	-0.38	0.01	1.01	1.00
Info. from extension agents	0.19	0.01	1.92	1.03
Village dummies	0.17	0.06	0.71	0.89

Appendix 2. Covariate balance test: Jimma

	Standardized differences		Variance ratio	
	Raw	Weighted	Raw	Weighted
Coffee farm size	-0.19	0.00	0.83	1.05
Total assets	0.37	0.01	1.58	1.22
Info. from unofficial channels	-0.05	0.03	1.31	0.87
Info. from traders	0.36	0.06	0.21	0.83
Info. from extension agents	0.49	0.01	2.98	1.03

Appendix 3. Covariate balance test: Sidama

	Standardized differences		Variance ratio	
	Raw	Weighted	Raw	Weighted
Coffee farm size	0.22	0.01	1.14	0.90
Total assets	0.07	0.01	0.70	0.75
Info. from unofficial channels	0.49	-0.01	0.92	1.00
Info. from traders	-0.19	0.04	0.66	1.08
Info. from extension agents	-0.01	0.00	0.96	0.99