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Nudging farmers in crop choice using price information: Evidence from Ethiopian Commodity Exchange

Dagim G. Belay* Hailemariam Ayalew†

Abstract

The lack of reference price information is often regarded as one of the most pervasive aspect of incomplete commodity markets in developing countries. Previous studies on the effects of price information emphasize the market participation and performance of rural households. This paper argues that access to reference price information influences farmers' crop choice decision, the most important decision in farming activity. The study exploits the variation in timing and spatial distance of the publicly run Ethiopian Commodity Exchange (ECX) price tickers as an indicator for variation in the intensity of access to reference price information among rural villages in Ethiopia. The paper finds that access to price information increases the average farm-gate prices for traded commodities and incentivizes farmers to allocate more land, fertilizer and improved seeds to commodities traded in the ECX. It also nudges farmers to produce more of the traded commodities, increasing the output share of ECX-traded commodities.

Keywords: Crop choice, Commodity exchange, Price information, Ethiopia

JEL Codes: D02, D83, Q02, Q12, Q13

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1 Introduction

Most rural households in developing countries make a large part of their livelihood from rain-fed crop production, which is susceptible to incidences of crop failure due to various agricultural shocks (drought, flooding, pest attack, etc.) and price volatility (Cooper et al. 2008; Kandulu et al. 2012; Bellemare et al. 2013; Milgroom and Giller 2013). Due to the absence of well-functioning insurance markets in rural areas of most developing countries (De Janvry et al. 1991; De Janvry and Sadoulet 2006), small-scale farmers often rely on crop choice decisions to internalize risks (Heady 1952; Dercon 2002; Kurukulasuriya et al. 2006; Salazar-Espinoza et al. 2015). In particular, diversifying the crop portfolio through the production of cash crops insures small-holder farmers against shocks and improves their welfare (e.g., Papademetriou and Dent 2001; Joshi et al. 2004). However, the decision to produce cash crops entails market-related risks (Bellemare et al. 2013), and ample evidence shows that the presence of these risks often inhibits the potential of households to benefit from growing high return-high risk cash crops in developing countries (e.g., Pellegrini and Luca 2014). Reducing uncertainty, the most pervasive aspect of market risk, by ensuring access to market price information is theoretically considered to be among the least costly methods of inducing farmers to plant risky but high-return cash crops.

Previous studies have attempted to document the effect of access to (price) information on sales prices and revenue (e.g., Svensson and Yanagizawa 2009; Goyal 2010; Fafchamps and Minten 2012; Nakasone 2013; Curtois and Subervie 2014), price dispersion (e.g., Jensen 2007; Aker 2010; Jensen 2007; Goyal 2010; Orlov 2011; Andersson et al. 2017), and price discovery (e.g., Figuerola-Ferretti and Gonzalo 2010; Peri et al. 2013; Inani 2017). These studies, however, overlook the effect of farm households' access to reference market price information on their crop choice decision even though it is the most important livelihood decision for a small-holder farmer to fulfill his household needs for subsistence and cash income generation. Therefore, Goyal (2010) is the only study that has examined the effect of access to information on farmers' output response, finding that access to price information through an internet kiosk increases the area covered under soy crops in India. However, the study considers (i) only a private source of price information that may not be reliable and accessible by most households, particularly the poor, and (ii) only one potential channel of output response (single crop adoption), which is not realistic given that farmers tend to choose between multiple cash crops.

This study, therefore, considers access to multi-crop reference price information through public price ticker boards run by the Ethiopian Commodity Exchange (ECX) as a unique quasi-experiment with the aim of assessing whether such access influences farmers' production behavior, obtained prices and incomes. Farmers have access to this information without exclusion. We exploit the variation in the timing and spatial distance of the price tickers to farmers' villages as an indicator of the variation in the intensity of access to reference price information among rural villages in Ethiopia. The study examines the effect of this variation on farmers' crop choice decision and short-term output responses in terms of changes in the output share across different crop items, using a combination of an Ethiopian agricultural sample survey dataset and geospatial data on the location of price display boards.

This paper contributes to the existing literature in the following dimensions. First, unlike the previous literature, this study uses price information from a 'trusted' public authority. We believe that the trust aspect of the information source, i.e., the ECX as a public agency, is key for the farmer-perceived reliability of the information and hence its influence on farmers' subsequent production decisions. Second, price information is public in the sense that there is no exclusivity in accessing the information among farmers located near a price display board. This aspect allows us to test the role of public price information on farmers' production behavior. Third, this study considers access to multi-crop real market reference price information. Fourth, this paper is the first to study the effect of ECX price information on farmers' crop choice. Although the ECX was launched in 2008 with a primary motive of weakening the recurrent drought-famine cycle by facilitating the distribution of agricultural commodities across space (Gabre-Madhin 2012), the price information disseminated by the commodity exchange has worked as reference prices for farmers and induced changes on the supply side by nudging crop choice. We believe that examining the effect of publicizing such a reference price on crop choice is very important for aspiring African countries on the move to institutionalize commodity exchanges. Finally, this paper adds to the scant existing literature on the link between market price information and crop choice, the most important decision in the farming activity in developing countries.

The remainder of the paper is organized as follows. Section two presents a brief context of agricultural commodity markets in Ethiopia. Section three provides the theoretical framework for the paper's analyses. Section four describes the data. Section five discusses the empirical strategy. Section six presents and discusses the main results, and the last section provides concluding remarks.

2 Commodity markets in Ethiopia

Agriculture is the backbone of the Ethiopian economy. The sector contributes 40%, 80% and 85% to GDP, exports and employment, respectively (MOFED 2016). According to the Ethiopian Rural Socioeconomic Survey (ERSS) (2013), approximately 93% of households who live in rural areas practice agriculture as their main economic activity. Although recurrent droughts and famines have characterized some parts of Ethiopia in the last few decades (Dercon 2004), the marketing of agricultural produce has also been a perplexing challenge in other parts of the country (Gabre-Madhin 2012). The agricultural commodity markets are characterized by high transportation costs, the absence of reliable market information, a lack of trust among actors with regard to products and transactions, asymmetric bargaining power among market actors, incomplete contract enforcement, inadequate storage facilities and the absence of product quality assurance (Gabre-Madhin 2001; Osborne 2005; Gabre-Madhin and Goggin 2006; Alemu and Meijerink 2010; Gabre-Madhin 2012; Andersson et al. 2017). Before the advent of the ECX, farmers relied exclusively on social networks and local buyers for market price information, and they traded produce in their nearest markets. Such a situation enables intermediaries, who have better access to price information, to exploit farmers by setting wedges between the market price and farm gate prices. In addition, the inability to access reference market information beyond their local area may lead risk-averse small-holder farmers to plant less of high-risk (high-return) crops.

The ECX was launched in April 2008 with the aim of helping curb the recurrent drought-famine cycle by facilitating the distribution of agricultural commodities across space, in line with the view that famines are not exclusively driven by the inadequacy of the food supply but are also due to a lack of distribution and access to the produced food (Sen 1981; Gabre-Madhin 2012). During the first year of its operation, the exchange traded only two commodities: coffee and sesame. By 2009, it included maize, wheat and haricot beans.

ECX is a modern and transparent commodity spot trading platform which works on a membership basis, i.e., buyers and sellers are required to buy transferable membership seats (own or via representative) to become eligible for trading at the central market in Addis Ababa, Ethiopia. Through conducting surveillance of market operations and trends, the ECX attempts to protect the market from manipulation, excessive speculation and fraud and assumes Central Counter Party (CCP) risk for all members' trades.

In advance of each trading, buyers are informed to put adequate money in a recognized bank whereas sellers are bound to transport their produce, get it graded and stored at a nearby warehouse run by ECX so that settlement of transactions happens at T+1 (the next day). In addition, it offers guarantees to farmers and traders to enable them access loan, provides ways to hedge against price risk, arbitration, and conciliation services whenever a dispute arises (Alemu and Meijerink 2010).

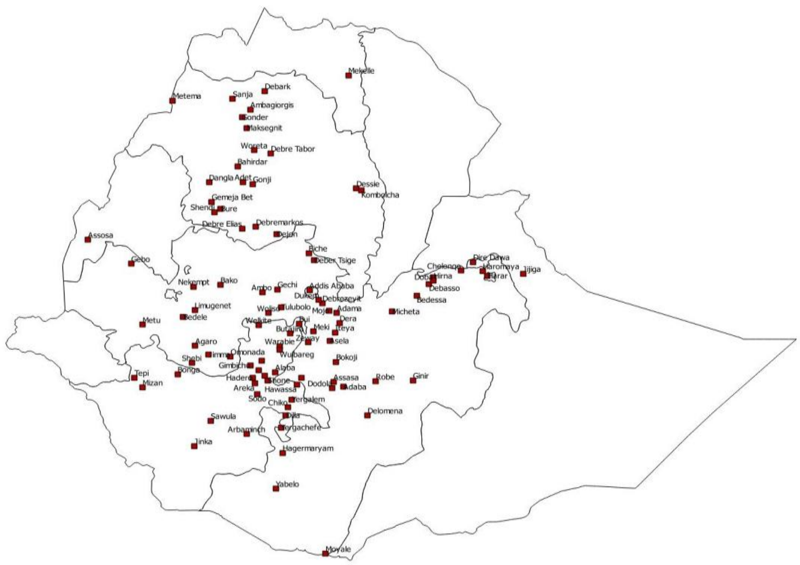

Figure 1: Geographic location of price ticker boards

In a few minutes after the transaction, ECX disseminates real-time market information to the public primarily through electronic price tickers, internet, interactive voice response, and various print and electronic media. Being a unique commodity market intervention in developing countries, the ECX currently runs 94 price tickers to disseminate real-time price information from the spot trading floor in the capital to different parts of the country. A typical price ticker automatically displays information about the volume and graded quality of the commodity, the real-time price, and the change in price between yesterday's closing price (T-1) and today's closing price (T). In addition to reducing market transaction costs on the demand side, the price information from the commodity exchange is expected to induce changes on the supply side in terms of nudging quality improvements in the commodities being traded, crop choice, etc. However, although the geographically dispersed price tickers disseminate the price information rapidly to most regions of the country, there are still differences in individual farmers' access to this information because they do not all live close to a price ticker board. In this study, we exploit the variation in the geospatial distance of villages to these price display boards as an indicator of the variation in the intensity of access to reference price information among rural villages in Ethiopia.

3 Theoretical Framework

To derive testable predictions that are relevant to our empirical estimations, we present a simplified model following the spirit of Rosenzweig and Binswanger (1993), Dercon (1996), Kurosaki and Fafchamps (2002) and Asad (2014) as follows. Although the model makes a number of specific assumptions on parameters and functional forms and is certainly not the only possible model that captures the main insights that we have in mind, it has the advantage of leading to a number of simple predictions, which have motivated our empirical design in section four. Suppose a representative farm household produces two types of crops: T traded at the ECX and NT non-traded at the ECX. The farmer allocates all of his land (which is assumed to be fixed and normalized to 1) to produce the two competing crops. The traded crop provides an income Y_T, and the non-traded commodity provides an income Y_{NT}. The risk-averse representative farmer follows a constant relative risk aversion (CRRA) utility function, given as $U(c) = c^{\lambda}$, where $\lambda < 1$ and c stands for consumption. The household decides to allocate land to different crop categories[3], with the share ϕ_T allocated to the traded crop T. To simplify, we assume that there is no access to credit and savings and, hence, consumption is equal to income; that is,

$$c = Y = \phi_T p_T Q_T + (1 - \phi_T) p_{NT} Q_{NT} \quad (1)$$

Where Q represents the crop yield. The farmer then chooses the optimal share of land to commit to the traded crop T to maximize his expected utility

$$Max \quad E(u(c)) = E\{\phi_T p_T Q_T + (1 - \phi_T) p_{NT} Q_{NT}\}^{\lambda} \quad (2)$$

We then take the first-order condition:

$$\frac{\partial E(u(c))}{\partial \phi_T} = Eu'(c)(p_T Q_T - p_{NT} Q_{NT})$$

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[3] The model can be simply extended to include other inputs such as labor in the production decision, but we focus on land here because it is the most important input in the production decision and the model closely resembles our empirical estimation in section 5.

$$= \lambda(p_T Q_T - p_{NT} Q_{NT})[\phi_T p_T Q_T + (1 - \phi_T) p_{NT} Q_{NT}]^{\lambda-1} = 0$$

$$\Rightarrow \phi_T p_T Q_T + (1 - \phi_T) p_{NT} Q_{NT} = 0$$

$$\Rightarrow \phi_T = \frac{p_{NT} Q_{NT}}{p_{NT} Q_{NT} - p_T Q_T} \quad (3)$$

Equation (3) states that the area share allocated to the ECX-traded crop increases if the price of the traded crop increases relative to the price of the non-traded crop. Increasing the bargaining power for farmers due to the price information (shown in Courtois and Julie Subervie 2015), if the price information from the price tickers leads to a change in the average price of traded commodities given by $\theta > 0$, then the share of land allocated to traded commodities without put price tickers is given by $\phi_T = \frac{p_{NT} Q_{NT}}{p_{NT} Q_{NT} - p_T(1+\theta) Q_T}$. Taking the first derivative of ϕ_T with respect to θ - $\phi'_T(\theta) = \frac{p_T p_{NT} Q_{NT} Q_T}{(p_T(1+\theta)Q_T - p_{NT} Q_{NT})^2} > 0$, it becomes clear that with an increase in the average price for traded crops at the ECX due to access to price information from price tickers, there is an increase in the share of land allocated to these traded commodities.

Suppose the farmer chooses the optimal share of land to commit to traded crop T to maximize his expected utility, taking into account the market price risk for the two commodities. $\sigma^2_{P_T}$ stands for the price risk of traded crops, $\sigma^2_{P_{NT}}$ represents the price risk for non-traded crops, and a reduction in the relative variance of the market price between traded crop T and non-traded NT is given by $\vartheta > 0$.

$$Max \quad E(u(c)) = E\left\{\phi_T (p_T - \sigma^2_{P_T}) Q_T + (1 - \phi_T)(p_{NT} - \sigma^2_{P_{NT}}) Q_{NT}\right\}^{\lambda}$$

$$\frac{\partial E(u(c))}{\partial \phi_T} = Eu'(c)[(p_T - \sigma^2_{P_T}) Q_T - (p_T - \sigma^2_{P_T}) Q_{NT}]$$

$$E\left\{\lambda((p_T - \sigma^2_{P_T}) Q_T - (p_{NT} - \sigma^2_{P_{NT}}) Q_{NT})\left[(\phi_T (p_T - \sigma^2_{P_T}) Q_T + (1 - \phi_T)(p_{NT} - \sigma^2_{P_{NT}}) Q_{NT})\right]^{\lambda-1}\right\} = 0$$

$$\phi_T (p_T - \sigma^2_{P_T}) Q_T + (1 - \phi_T)(p_{NT} - \sigma^2_{P_{NT}}) Q_{NT} = 0$$

$$\phi_T = \frac{(p_{NT} - \sigma^2_{P_{NT}}) Q_{NT}}{(p_{NT} - \sigma^2_{P_{NT}}) Q_{NT} - (p_T - \sigma^2_{P_T}) Q_T}$$

The share of land allocated to traded commodities without price tickers is given as:

$$\phi_T = \frac{(p_{NT} - \sigma^2_{P_{NT}})Q_{NT}}{(p_{NT} - \sigma^2_{P_{NT}})Q_{NT} - (p_T - \sigma^2_{P_T}(1-\vartheta))Q_T}$$

$$\phi'_T(\vartheta) = \frac{\sigma^2_{P_T} Q_{NT} Q_T (p_{NT} - \sigma^2_{P_{NT}})}{(\sigma^2_{P_{NT}} Q_{NT} - \sigma^2_{P_T} Q_T - P_{NT}Q_{NT} + P_T Q_T + \sigma^2_{P_T} Q_T \vartheta)^2} > 0$$

Hence, we hypothesize that if price tickers reduce farmers' price risk, then they will induce an increase in the area share allocated to the traded crop.

Assume that $\alpha > 1$ represents the number of sellers who show up in the market and that $0 \le \psi \le 1$ stands for the bargaining power of a given farmer, and assume that the probability η of selling the produce depends on only the number of suppliers in the market and their bargaining power, which, in turn, depends on having access to price information, i.e., define $\eta = \frac{\psi}{\alpha}$. If there is no price information displayed using price tickers, then the farmer chooses the optimal share of land to commit to traded crop T to maximize his expected utility.

$$Max \quad E(u(c)) = E\{\phi_T Y_T + (1 - \phi_T) Y_{NT}\}^{\lambda}$$

$$\frac{\partial E(u(c))}{\partial \phi} = Eu'(c)(Y_T - Y_{NT})$$

$$= \eta\lambda(Y_T - Y_{NT})\left[(\phi_T Y_T + (1 - \phi_T)Y_{NT})^{\lambda-1}\right] + (1-\eta)\lambda(Y_{NT})\left[\left((1 - \phi_T)Y_{NT}\right)^{\lambda-1}\right] = 0$$

$$\frac{\eta(Y_T - Y_{NT})}{(\eta-1)(Y_{NT})} = \frac{\left((1 - \phi_T)Y_{NT}\right)^{\lambda-1}}{(\phi_T Y_T + (1 - \phi_T)Y_{NT})^{\lambda-1}}$$

$$\phi_T = \frac{Y_{NT}}{\left[\left(\frac{\eta(Y_T - Y_{NT})}{(\eta-1)(Y_{NT})}\right)^{\frac{1}{1-\lambda}} - 1\right] Y_T^{-1} + Y_{NT}}$$

$$\phi_T = \frac{Y_{NT}}{\frac{Y_T}{B-1}+Y_{NT}} \quad \text{Where, } B = \left(\frac{\eta(Y_T-Y_{NT})}{(\eta-1)(Y_{NT})}\right)^{\frac{1}{1-\lambda}} > 1$$

Suppose the proportion γ ($0<\gamma<1$) of farmers receives real-time price information about the market (have access to the market), which increases their bargaining power (shown in Courtois and Subervie 2015), i.e., ψ to the highest level, 1. The implication is that farmers with access to price information through the price tickers will have a higher probability of selling $\eta = \frac{1}{\gamma\alpha}$ than those who do not have access to price information, with the probability of selling $\eta = \frac{\psi}{\alpha}$. Therefore, the share of land devoted to the traded crop T (ϕ_T) will be higher for farmers who have access to price information (price tickers). We thus hypothesize that increased bargaining power due to access to price tickers leads to an increase in the probability of sales, which increases the share of land allocated to the traded commodities.

Predictions from the theoretical framework indicate that access to price information through the price tickers is expected to affect farmers' crop choice decision towards ECX-traded commodities due to increased probability of sales, increased price and reduced variance in the average price (indicator of market risk), and more efficient input allocation.

4 Data

The data used in this paper are compiled from three sources: farm data from the Ethiopian Annual Agricultural Survey (AgSS), producer (farm gate) price data obtained from the Ethiopian Central Statistics Agency (CSA) for the 2007-2014 sample period, and geospatial data about the location of price ticker boards accessed from the Ethiopian Commodity Exchange.

The AgSS data contain information regarding the demographic characteristics of farm households and plot-level crop data (e.g., plot size, the amount and type of fertilizer used, and the yield per plot). The data were collected from all rural parts of Ethiopia, except three pastoral zones of Afar and Somali regions, using a stratified two-stage cluster sample design, in which enumeration areas (EAs) and agricultural households were considered as primary and secondary sampling units, respectively. The EAs were systematically selected based on the number of households in the Ethiopian Population and Housing

Census data, and subsequently, approximately 20 farm households were randomly selected from each sample EA. Since different households may appear in different years, we used the AgSS dataset to create an EA-level panel dataset. During the sample period, the data covered an average of 2120 EAs and 43,115 households each year. On average, the CSA covered more than 96 percent of EAs and households in each year with little variation across years.

To measure changes in the output shares and other production responses, we first constructed the EA-level of output, land, and use of fertilizer using the total quantity produced from different crops using the representative households living in each EA. We then calculated the quantity of shares of these variables for both ECX-traded and non-ECX-traded commodities. We used the changes in these shares as a proxy for a change in crop choice among Ethiopian farm households due to the access to price information from the ECX. The changes in crop shares reflect both an increased output of the traded crops among farmers who already plant the traded crops and an increased adoption of the traded crops among farmers who did not previously plant these crops. The monthly producer price (farm gate price) is used to establish the price and market risk channels.

Table 1 provides the EA-level summary statistics of our compiled dataset. All values, except the price information, indicate the average values of households at enumeration area level. Between 2007 and 2014, the average farm size was 1.02 hectares, the average EA-level crop output was found to be 4478 kg, and 29 percent of the households used fertilizer during the planting season. On average, the household size was approximately 5 persons, and the head of household was 43 years old and had 3.4 years of schooling as his or her educational background. The price data is reported at the crop level for enumeration areas for each year.

Table 1: Summary Statistics

Variable	Observations	Mean	Std. Dev.
Area per hectare	11289	1.02	1.09
Output per kg	11289	4478	12268
Age	11289	42.83	5.49
Household size	11289	5.22	0.85
Minimum distance to plasma screens (km)	11289	45.16	30.01
Maximum years of education	11289	3.39	5.17
Average use of fertilizer	11289	0.29	0.25
Improved seed	11289	0.01	0.03
Irrigation	11289	0.02	0.07
Price for all commodities	30812	13.99	47.01
Mean deviation for all commodities	30812	9.49	37.35
Price for only commodities traded at ECX	6309	7.62	10.49
Mean deviation for only commodities traded at ECX	6309	2.69	4.84

5 Empirical Strategy

This section describes the empirical strategy for estimating the effect of access to a reference price on farmers' decision on crop choice. We employ a generalized difference-in-differences (DID)[4] estimator for continuous treatments (in a dose-response setup) using the introduction of the Ethiopian Commodity Exchange as a quasi-experiment, exploiting the variation in the location of price ticker boards as an identification strategy. Located in 94 markets and public gathering places, price ticker boards are used to disseminate real-time price information at the exchange to all market actors across the country. The distance from the nearest plasma screens to each village is used to measure the intensity of access to the price information from the exchange (see also, e.g., Heintzelman and Tuttle 2012; Duijn et al. 2016). The identifying assumption is that in the absence of price ticker screens, there will be no differential change in the average output share of ECX-traded commodities across villages.

[4] A generalized DID is a difference-in-difference-type model in which there are multiple periods and the treatment variable is more flexible. For example, the treatment is continuous rather than binary, a different start time in each state is allowed, and switching (on and off) is allowed. Similar to the standard difference-in-difference model, it assumes that in the absence of the treatment, the outcomes in the treated and control units will follow a common path over time.

Our empirical approach to establish the relationship between output and land share of ECX commodities and distance to plasma screens (proxy for intensity of access to price information), is described by the following dose-response regression equation for continuous treatments :

$$y_{ijt} = f(D_i) + \delta\big(Post_t\ x\ f(D_i)\big) + \beta X_{ijt} + \epsilon_{ijt} \quad (4)$$

where y_{ijt} is the output share of ECX-traded commodities of enumeration area i located in district j at year t. The output share of ECX-traded commodities is considered as a proxy measure of the crop choice decision of farmers within the enumeration area.[5] $f(D_i)$ is the log distance from each enumeration area i to the nearest ECX price ticker (ranging from 0.5 to 235 km) as a treatment indicator for the intensity of access to the ECX price ticker. $Post_t$ is an indicator variable that takes the value of one if the period is after the establishment of ECX price tickers and zero otherwise, and X_{ijt} is a vector of control variables for enumeration area i located in district j at time t that may affect the output share of ECX commodities. In the main regression, the study controls for household size to capture the extent of farmers' reliance on their own labor. We also account for variations in the level of literacy among EAs, using the highest grade in the household, which could capture farmer households' ability to understand the information displayed on the price tickers. The age of the household head is also included to capture experience. ϵ_{ijt} is the error term, accounting for unobserved random factors not captured in the regressions. The effect of access to price information on changes in the output share of ECX commodities is captured by the δ parameter.

However, in our estimation, we include a rich set of dummy variables to control for both time-varying and time-specific fixed effects. The relevance of these fixed effects is also evident in the pretreatment graphics presented in the appendix. First, there could be concerns that plasma screens may be constructed in market places such that location might be correlated to the outcome variable. To address this issue, we include an EA-level time-invariant fixed effect variable α_i. We also include the year fixed effects, η_t, to account for any secular trends that affect all villages similarly (e.g., national regulations, credit constraints or technological progress similar to all villages). In addition, λ_{jt} stands for other fixed effects such as interaction of the time and district (region) fixed effects, which are included in order to capture

[5] Other measures of crop choice are also used in the literature, such as the number of crops and the labor allocated to different crops (e.g., Dercon 1996). However, we argue that the output shares approximate the actual changes in the crop choice decisions among farmers better than the mere allocation of inputs.

all district (region)-level time-varying factors that are correlated with the output (land) share, average price and variance of ECX commodities and the planting of price tickers. Doing so takes into account, for example, changes in the population in nearby urban areas (and, hence, changes in demand), changes in the rainfall pattern across districts (regions) and the expansion of new information communication technologies across districts (regions). Our preferred specification leads to the following fixed effects generalized DID model.

$$y_{ijt} = \alpha_i + \delta\big(Post_t \; x \; f(D_i)\big) + \beta X_{ijt} + \eta_t + \lambda_{jt} + \epsilon_{ijt} \qquad (5)$$

After estimating the effect of access to price information on different indicators of crop choice, we attempt to identify the potential mechanisms. Our main hypothesis is that farmers who receive the price information of the reference market will have an incentive to adjust their input allocation decision. As presented in our theoretical predictions, we expect that land allocation, price and reduction in market risk will be the main potential channels through which access to reference prices affects the crop choice. Additionally, the allocation of labor could be a relevant mechanism, but due to the lack of data on the type and amount of labor hours used during the production activity, we did not take into account this allocation channel.

In the empirical section, we could not estimate the probability of the sales channel due to data limitations. We thus assume that the probability of sales is the same for each household, meaning that farmers can sell their produce at a local market even though they may not have equal bargaining power due to differences in access to market price information. Hence, we mainly focus on changes in the unit price and the variance of farm gate prices and land allocation to ECX-traded commodities as potential channels.

6 Results and Discussion

This section presents the main findings of the study. First, we estimate the generalized DID main model outlined above. Then, several robustness checks are conducted to investigate the internal validity of this model. Finally, we examine some of the main mechanisms through which access to reference price information affects the crop choice, i.e., we decompose the effect of access to price information into different potential channels such as changes in land allocation, unit price, and variance in price (market risk).

6.1 Effects on output and land share

Table 2 presents the effects of access to price information in the generalized DID model. We considered three specifications. Column (1) presents a specification that estimates the effect of access to price information on the output share of commodities traded at the ECX, controlling only for EA fixed effects and year fixed effects. Columns (2) and (3) present specifications that additionally control for village, year fixed effects and 'socio-demographic' covariates. In particular, we controlled for the EA averages of farm households' highest grade in school to capture the differences in the level of literacy among EAs. Across all specifications, the results show that reducing the distance from the EA to the nearest plasma display screens increases the output share of ECX-traded commodities. The estimates show that if we reduce the distance from households to the nearest plasma display screen by half, then the output share of ECX-traded commodities increases by 6.8 percentage points.

Table 2: The effect of access to price information on the output and land share of ECX commodities

	Output share			Land share		
	(1)	(2)	(3)	(1)	(2)	(3)
Treatment * post	-0.137***	-0.136***	-0.136***	-0.059**	-0.060**	-0.058**
	(0.037)	(0.037)	(0.037)	(0.024)	(0.024)	(0.024)
Household Size		-0.004	-0.046		0.008	-0.070
		(0.015)	(0.091)		(0.010)	(0.059)
Education (Highest Grade)		0.000	0.006		-0.002	-0.001
		(0.002)	(0.008)		(0.001)	(0.005)
Age		-0.001	-0.023		0.000	-0.022
		(0.002)	(0.021)		(0.001)	(0.014)
Household Size Square			0.004			0.007
			(0.008)			(0.005)
Education (Highest Grade) Square			-0.000			-0.000
			(0.000)			(0.000)
Age Square			0.000			0.000
			(0.000)			(0.000)
Number of Obs	11289	11289	11289	11289	11289	11289

Notes: The dependent variable is the log of the output and land share of ECX-traded commodities. In all estimations, we control for EA and year fixed effects. Standard errors in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

We find that, on average, farmers in areas that receive reference price information about ECX-traded crops (sesame, coffee, maize, wheat and haricot beans) produce more of these commodities than farmers in areas that do not receive this information. This finding is in line with the positive output response documented in Goyal (2010)

The right-hand part of Table 2 reveals that farmers were nudged to allocate more land to ECX-traded commodities due to the increased access to price information through the prices displayed on plasma screens. The results show that reducing the distance from the EA to the nearest plasma display screen by half increases the share of land allocated to ECX-traded commodities by 2.9 percentage points.

Similarly, we estimated the effect of access to price information on the allocation of other inputs to ECX commodities (Table 3). We found that the share of fertilizer use increased with access to price information. The results show that reducing the distance from the EA to the nearest plasma display screen by half increases the average fertilizer share of ECX-traded commodities by 1.15 percentage points. Similarly, the share of improved seeds and irrigation use for ECX commodities increase by 0.15 and 0.3 percentage points respectively if we reduce the distance to plasma screens by half. These findings are in line with our theoretical predications that increased access to price information through the plasma screens encourages allocation of productive inputs towards traded commodities, although (in our theoretical model) we showed only land allocation to proxy allocation of productive inputs.

Table 3: Effects on the allocation of other inputs

	Fertilizer	Improved seed	Irrigation
Treatment x post	-0.023***	-0.003***	-0.006***
	(0.007)	(0.001)	(0.002)
EA Fixed Effect	Yes	Yes	Yes
Year Fixed Effect	Yes	Yes	Yes
Number of Obs.	11289	11289	11289

Notes: The dependent variable is the log of the share of fertilizer use, the share of improved seeds, and share of irrigation use for columns (1), (2) and (3), respectively. In all estimations, we control for other covariates. Standard errors in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

6.2 Internal Validity Checks

Table 4 presents the robustness checks of our identification strategy. We paid particular attention to the major assumption of the generalized DID model, that is, in the absence of the treatment, the average change in the output share would have been the same for households located close to and far from the price tickers. In other words, in the absence of the treatment, the spatial variation in distance from the nearest price ticker board to each village would not have any effect on the average output share of ECX-traded commodities. A simple graphic depiction (given in appendix) of the pretreatment period (2007-2009) indicates absence of significant correlation between distance to plasma screens, and land and output shares of ECX commodities, especially when controlling for fixed effects such as district fixed effects. However, we formally tested this point based on data from the pretreatment periods of 2007 and 2009, using 2008 as a placebo treatment year. The results in Table 4 show that the variation in distance from a given village to the nearest towns where price tickers were subsequently established did not have any significant effect on the output share of ECX-traded commodities in the pre-establishment period. Second, using the same period before the introduction of price tickers, we also examined whether the variation in distance to the nearest price tickers had an impact on the share of land allocated to ECX-traded commodities, and the results are presented in the right-hand part of Table 4. The results reveal that the geographical variation in distance from the villages to the nearest town where price tickers were subsequently established did not have any significant effect on the share of land allocated to ECX-traded commodities. The results from the two analyses provide evidence that the parallel trend assumption for land allocation and crop choice decisions is valid. The results from the two analyses suggest that the use of a generalized DID model for analyzing both the main result and the main potential channels is appropriate.

Table 4: Test for parallel trends on the ECX output and land shares

	Output share			Land share		
	(1)	(2)	(3)	(1)	(2)	(3)
Treatment * post	0.125	0.152	0.120	0.035	0.033	0.034
	(0.249)	(0.250)	(0.251)	(0.024)	(0.023)	(0.024)
Household Size		0.048	0.066		0.030*	-0.057
		(0.033)	(0.191)		(0.018)	(0.105)
Education (Highest		0.006	-0.057		-0.032*	-0.024
Grade)		(0.032)	(0.097)		(0.018)	(0.053)
Age		-0.010*	-0.095**		-0.009***	-0.015
		(0.005)	(0.048)		(0.003)	(0.026)
Household Size			-0.002			0.008
Square			(0.017)			(0.009)
Education (Highest			0.010			-0.001
Grade) Square			(0.014)			(0.008)
Age Square			0.001*			0.000
			(0.001)			(0.000)
Number of Obs.	3157	3157	3157	3157	3157	3157

Notes: The dependent variable is the log of the output and land share of ECX-traded commodities. In all estimations, we control for EA and year fixed effects. Standard errors in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$.

The validity tests across the different models broadly support our main identification strategy of adopting a generalized DID model. The results are also found to be robust across all specifications considered including the control of various covariates and fixed effects. For both the main model and its corresponding test for parallel trends, the results based on alternative specifications controlling for additional covariates are given in the appendices.

6.3 Mechanisms

Our findings indicate that providing the price information in the reference market, Addis Ababa, increases the output shares of ECX-traded commodities among rural farmers. This could be due to the productive or marketing behavioral changes of farmers that follow from having access to price information. We presume that access to price information in the reference market (i) will increase the bargaining power of farmers, leading to an increased (farm gate) price for farmers and (ii) reduced price expectation errors, price volatility and spatial dispersion, which, in turn, will also have an effect on households' input allocation decisions. Consequently, farm households may be incentivized to adjust their input allocation, depending on the price information that they receive though price tickers.

Table 5 presents the mechanisms through which access to price information from price tickers affects farmers' decisions on crop choice. Columns (1) and (2) provide the changes in the average price and standard deviation of prices for all crop commodities, respectively, whereas columns (3) and (4) present the results for the changes in the average price and standard deviation of prices for ECX-traded commodities, respectively. The table shows that access to price information increased the average price of ECX-traded commodities. The results from column (3) show that reducing the distance from the EA to the nearest plasma display screen by half increases the average price of ECX-traded commodities by 3.05 percent. This result supports the findings in Goyal (2010). Similarly, our findings suggest that the variance of the unit price of ECX-traded commodities declined as we are closer to the price display boards. Thus, the results from column (4) reveal that reducing the distance from the EA to the nearest plasma display screen by half decreases the variance of the average price of ECX-traded commodities by 0.6 percent. This result is consistent with studies such as Jensen (2007) and Aker (2010), who found a reduction in price dispersion due to increased access to mobile telephone coverage in fish markets in India and millet markets in Niger, respectively. This could be because access to the price information from plasma screens amplifies the spatial integration of crop prices (Abdulahi 2000; Gabre-Madhin 2012).

Table 5: Effects on the unit price and variance

	(1)	(2)	(3)	(4)
Treatment*post	0.023	0.040	-0.061***	0.012**
	(0.020)	(0.041)	(0.022)	(0.006)
Log(price)		0.725***		0.578***
		(0.054)		(0.013)
Number of Obs.	26241	26238	5633	5633

Notes: The dependent variables are the log of the average price and the standard deviation of price for all crop commodities for columns (1) and (2), respectively, and the log of the average price and the standard deviation of price for ECX-traded commodities in columns (3) and (4), respectively. In all estimations, we control for EA-Crop fixed effects and the interaction of region and year fixed effects. Robust standard errors, clustered at the Kebele level in parentheses. * $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

This study does not claim to have addressed all possible channels that link access to price information with changes in the output share (crop choice). However, we found suggestive evidence that the main mechanisms are increased land allocation, increased price and reduced price variance (indicative of a reduction in market risk). This evidence supports the predictions in the theoretical model presented in section 3. The results indicate that the land allocation, average price, fertilizer use and price variance reduce the average effect of the price information ranging between 0.15 and 2.9 percentage points. We find that land allocation toward crops traded at the commodity exchange is one of the main channels through which the reference price affects the output shares of ECX-traded commodities.

7 Concluding Remarks

This paper argues that access to reference market price information influences the decision of crop choice, the most important decision in the farming activity. Existing studies regarding the role of access to price information exclusively focus on the market performance of rural households. For example, it has been well documented that asymmetric information reduces competition, increases price dispersion, increases market risk and creates inefficiency in the allocation of goods across markets. The study adds to the literature by examining the effect of access to price information on farmers' crop choice decision focusing on short-term output responses in terms of changes in the output shares among commodities traded at the ECX.

Although the ECX was launched with a primary motive of abating the recurrent drought-famine cycle by facilitating the distribution of agricultural commodities across space (Gabre-Madhin 2012), the price information disseminated by the commodity exchange has induced changes on the supply side by nudging crop choice. It is found that providing price information increases the output share of ECX-traded commodities by approximately 6.8 percent. The results also suggest that increased land allocation, increased price and reduced variance of price are the potential channels through which price information increases the output share of ECX-traded commodities.

Understanding the effect of providing market price information and general information on crop choice in particular and output response in general is key for policy making in developing countries, where a large percentage of the population lives in rural areas with missing commodity markets. Our findings suggest that policy makers should appreciate the role of providing price information in nudging small-holder farmers toward more profitable production behavior by planting high-return, high-risk crops to enhance rural development and poverty reduction in a low-cost manner. Further research on how the price information from the ECX has influenced quality improvements in the grains being traded must be conducted.

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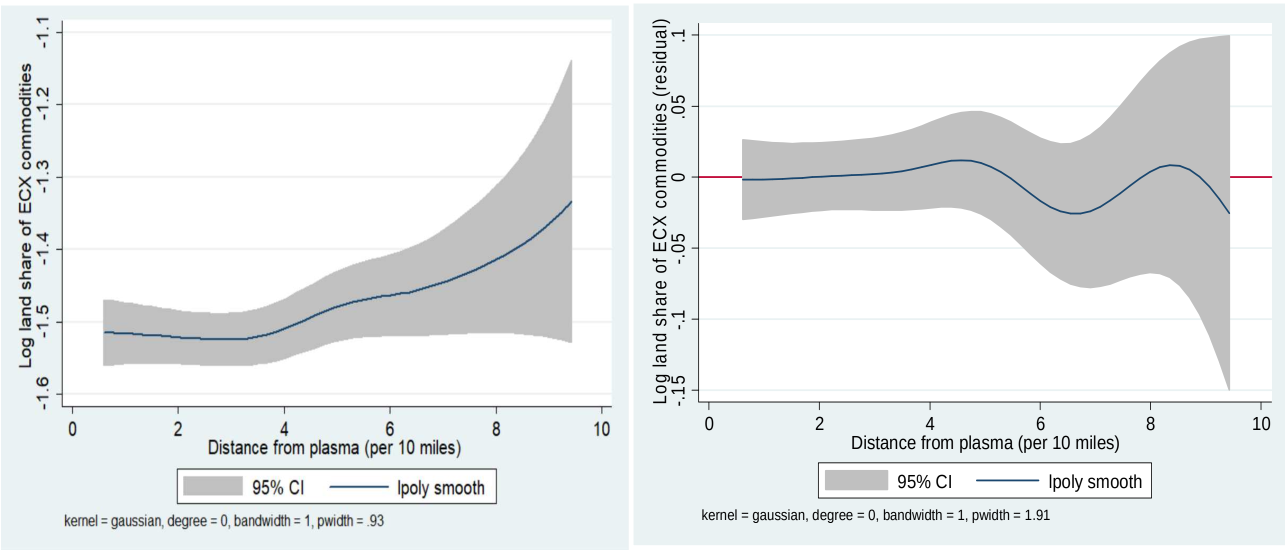
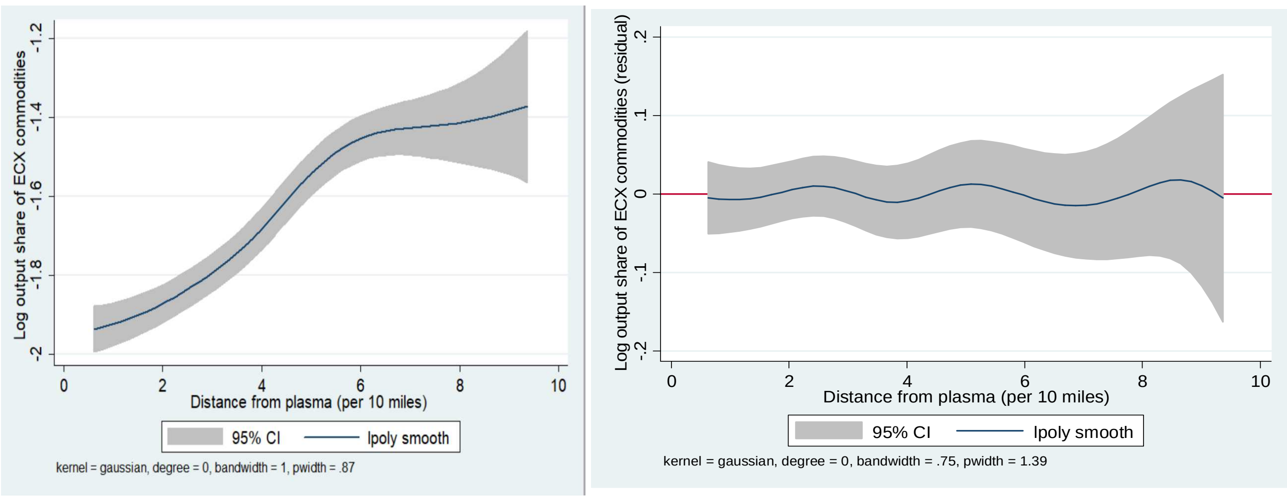
Appendix



A) Before controlling fixed effect B) After controlling district fixed effect

Figure 2. ECX Land share and distance to plasma screens (pretreatment)



A) Before controlling fixed effect B) After controlling district fixed effect

Figure 3. ECX Output share and distance to plasma screens (pretreatment)