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The Ethiopian Commodity Exchange and Spatial Price Dispersion

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Abstract

In this article, we study the impact of an institutional intervention on market efficiency in Ethiopia. More specifically, we study whether regional warehouses that are connected to a national commodity exchange reduce transaction costs and price dispersion between regions. In order to identify the causal effect, we take advantage of the fact that the warehouses that are connected to the Ethiopian Commodity Exchange were sequentially rolled out. Using retail price data and information about warehouse operation from 2007 to 2012, we find that the average price spread between market pairs is reduced by 0.86-1.775 ETB when both markets have an operating warehouse. This is a substantial reduction considering that the average price spread over the full period is 3.33 ETB.

Key Words: coffee, commodity exchanges, Ethiopia, price dispersion, warehouses

JEL Codes: C82, D47, Q13

Contents

The Ethiopian Coffee Exchange and Spatial Price Dispersion

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1. Introduction

This paper analyzes changes in the spread of coffee prices between regional markets following the recent introduction of a national commodity exchange and decentralized warehouse system in Ethiopia. We focus on the extent to which this introduction has contributed to increased market efficiency in terms of reducing price spreads between different regional markets in Ethiopia. However, our analysis contributes to answering broader questions of how exogenous institutional interventions can contribute to increased efficiency of output markets for smallholder farmers in developing countries.

In response to the failures of agricultural markets in developing countries,[1] there has been aggressive liberalization of agricultural systems since the late 1980s. However, in spite of liberalization reforms, the emergence of a common price and commercialization of subsistence farmers has been limited (Sadoulet and de Janvry 1995; Shiferaw et al. 2011), price volatility is still high, and investments remain constrained (Reinganum 1979; Stahl 1989; Dercon 1995; Negassa and Jayne 1997). In other words, historical liberalization efforts, with the explicit aim of eliminating market failures, do not seem to have reached the stated goals.

As a consequence of the failure of these previous liberalization strategies, more recent interventions have taken slightly different approaches. One such approach is the introduction of

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[1] Markets in developing countries are commonly characterized by small trading volumes, incomplete competition and high volatility in prices, which are firmly rooted in the presence of high transaction costs caused by poor transport and information infrastructure and lack of efficient market institutions (Kydd and Dorward 2004; Dorward et al. 2005). Such structural barriers are likely to lead to inefficiencies (Coase 1937; Faminow and Benson 1990) that prevent farmers from taking advantage of price differences between markets (Fafchamps and Hill 2005).

commodity exchanges with a specific focus on correcting fundamental shortcomings such as lack of physical and informational infrastructure, storage facilities and access to credit. A well-functioning agricultural exchange platform that disseminates relevant information to all decision makers and provides storage facilities as well as a legal framework for negotiating contracts has the potential to reduce such transaction costs, and thereby to improve resource allocation and to make the price discovery process more efficient[2] (Easwarana and Ramasundaram 2008; Shalini and Duraipandian 2014).

However, the literature on price discovery in agricultural commodity markets in developing countries provides mixed evidence concerning whether commodity exchange systems have contributed to improved efficiency (Mattos and Garcia 2004; Shakeel and Purankar 2014).[3] Research on price discovery in the context of commodity exchange markets in Africa, where markets are notoriously thin, is very scant (Gabre-Madhin and Goggin 2005).[4] Exceptions include Abdurezack (2010), Francesconi and Heerink (2011) and Katengeza (2012), but their results do not draw a completely clear picture of the effect of commodity exchanges. While Katengeza (2012) finds a significantly positive effect of the Malawi Agricultural Commodity Exchange (MACE) on spatial integration (i.e., that the exchange promotes a tendency of prices to move together in spatially separated markets), Francesconi and Heerink (2011) do not find significant effects of the Ethiopian Commodity Exchange (ECX) on commercialization levels of smallholder farmers in Ethiopia, and Abdurezack (2010) finds that traders can earn excess profits using the predictability in price series even after the introduction of the Ethiopian Commodity Exchange (ECX). Further analysis of the conditions under which commodity exchange institutions lead to market efficiency is therefore needed.

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[2] In inefficient markets, different prices for the same commodities may exist, which biases decision-making and thereby resource allocation. In contrast, an efficient market is characterized by a marketing system that generates prices that fully reflect the available information; such a system also transmits price information throughout the marketing system in a timely manner (Tomek 1980; Mattos and Garcia 2004; Kaur and Rao 2010).

[3] Previous research on the developed world has generally shown that commodity markets play an effective role in price discovery, and that such institutions thereby improve market efficiency (e.g., Yang et al. 2001). The picture for the developing world is less clear, with efficiency-increasing effects in some cases (Roy and Kumar 2007; Shakeel and Purankar 2014; Azizan et al. 2007) and negative effects in others (Thomas and Karande 2001; Kumar and Sunil 2004; Karande 2006; Praveen and Sudhakar 2006; Shihabudheen and Padhi 2010; Kaur and Rao 2010; Mattos and Garcia 2004).

[4] Section 2 discusses the nature of commodity exchange markets in Africa in more detail.

The purpose of this analysis is to provide a formal evaluation of the effect of the ECX on market efficiency. However, in contrast to previous research in the field, the focus of our analysis is on how physical infrastructure, in terms of local warehouses connected to a commodity exchange, affects market efficiency in terms of price dispersion between regions. The opening of the ECX was associated with an improved infrastructure for price information. However, high transaction costs and lack of secure storage imply that the effect on local markets of the ECX alone was probably limited. Our hypothesis is that the roll-out of local warehouses brought the ECX closer to local markets and that this, in turn, has contributed to a stronger link between local, national and international markets, thus improving the efficiency of local and national markets.

We evaluate market efficiency by comparing price dispersion between pairs of regional markets where both markets have access to warehouses with market pairs where at least one region lacks access to a warehouse. Our dataset consists of a sample of regional markets that all installed a warehouse during the study period, but where the timing of this installation varied. We thus use spatial price dispersion as a measure of market efficiency. Our focus on price spreads is based on the following arguments: 1) the price of commodities sold from a regional warehouse (at the ECX) is likely to function as a benchmark for the regional retail price of those commodities, and 2) the closer the warehouse is to a regional market, the lower the transaction costs between the two outlets. More specifically, shorter distances imply that transport costs are lower and that the price information transmitted from the ECX is more relevant to the regional market (lowering the cost of information search). Furthermore, shorter distances are most likely associated with fewer middlemen, less negation of contracts and lower transaction risks. Thus, the closer the warehouse, the more closely the retail and export prices are likely to be linked. At the same time, the trading platform at the exchange is likely to immediately exhaust arbitrage possibilities of products from different warehouses.

To identify the effect of the ECX on market efficiency, we analyze price dispersion between dyads of regional markets. The motivation for this approach is the idea that, if warehouses linked to the ECX do indeed improve efficiency, the price in markets with access to such warehouses should co-vary more closely with export prices than should the prices in markets without access to an ECX warehouse. As a consequence, the observed price spread between two markets with access to warehouses should be lower than the price spread between markets with no access to warehouses or where only one side of the market pair is connected to the ECX. Our identification strategy is therefore based on analyzing dyadic markets with and without access to ECX warehouses. Our overall strategy is based on the idea that price spreads may be used as an indicator of market efficiency.

As in Abdurezack (2010), our analysis is based on coffee prices. We use coffee prices as our main unit of analysis because (unprocessed) coffee was one of the first commodities traded at the ECX and because coffee is by far the most important export commodity in Ethiopia. However, our empirical analysis differs from that of Abdurezack (2010) in several important aspects. First and perhaps foremost, we have data on a longer time period since the introduction of the ECX and can therefore better estimate effects. Second, instead of analyzing closing prices on the ECX, we analyze how the spread in prices between different regions in Ethiopia has been affected by the presence of warehouses linked to the ECX.

Our work is related to a number of previous studies of the link between information infrastructure and market efficiency. It is most closely related to the work of Jensen (2007), Aker (2008, 2010) and Svensson and Yanagizawa (2009). Jensen (2007) utilizes a quasi-experimental setting – the gradual roll-out of mobile phones in the Kerala region of India –and shows that the introduction of this technology increased local fishermen's profits and reduced catch waste and price dispersion. Aker (2008, 2010) uses a similar method to evaluate the effect of mobile phones on market efficiency for the grain market in Niger. To identify the effect, Aker employs a difference-in-differences approach on a market and trader panel dataset.[5] The results of Aker's empirical analysis are in accordance with Jensen (2007), but the panel structure of Aker's dataset also allows her to identify effects on price dispersion both across markets and within years. Perhaps the most important result is that the magnitude of the effects of improved information increases with transportation costs (either due to poor road quality or long distance from markets). Finally, Svensson and Yanagizawa (2009) analyze how the introduction of a Market Information Service (MIS) project[6] in Uganda affected farm gate prices. Similarly to Aker (2008, 2010) and Jensen (2007), Svensson and Yanagizawa (2009) take advantage of the natural experiment characteristic of access to the MIS in Uganda, in this case in terms of exogenous differences in access to radio broadcasts. The results of the study suggest that improved access to

[5] The trader panel covers 415 traders located in 35 markets across six geographic regions in Niger and the agricultural price panel covers 37 domestic markets.

[6] An initiative by two agricultural research organizations, IITA and ASARECA, in association with the National (Ugandan) Ministry of Trade, Tourism and Industry, was initiated in 2000 and covered 21 of Uganda's 56 districts, reaching seven million of Uganda's 24 million population in eight languages.

information about prices is associated with a significant increase in farm gate prices; specifically, radio access in a MIS district was associated with a 15% increase in farm gate prices.

Similarly to the above-described studies, we utilize what may be seen as a quasi-experimental setting. Specifically, we use the fact that warehouses connected to the ECX were gradually implemented across regions in Ethiopia, and analyze differences between regions with and without access to these warehouses. Like Aker (2010) and Jensen (2007), we use price spreads between markets as a measure of market efficiency. However, in contrast to Jensen (2007), Aker (2008, 2010) and Svensson and Yanigizawa (2009), our focus is not solely on information but rather on the compound effect of warehouses and the presence of a centralized commodity exchange. To the best of our knowledge, this is the first paper that evaluates the effects of commodity exchanges in developing countries.

The rest of the paper is outlined as follows. In Section 2, we give a brief description of the Ethiopian coffee market, the ECX and the warehouse system. This is followed in Section 3 by a description of the conceptual framework used in the paper. In Section 4, the data and empirical methodology are presented. Section 5 presents the results of the empirical analysis, and Section 6 concludes.

2. Essential Features of Coffee Trading in Ethiopia, Commodity Markets, and the Ethiopian Commodity Exchange Market

2.1 Coffee Trading in Ethiopia

Ethiopia is often believed to be the origin of coffee Arabica and the country is probably also the oldest exporter of coffee in the world (Aregay 1988). In 2012, coffee accounted for about a quarter of Ethiopia’s export value, and over 4 million of Ethiopia’s smallholder-farming households were estimated to grow coffee (Central Statistical Agency Report, as cited in Minten et al. 2014). At the international level, Ethiopia is the fifth largest coffee producer in the world after Brazil, Vietnam, Indonesia and Colombia. However, coffee is not only an important export commodity; Ethiopia is one of the few coffee producing countries that also has large domestic consumption. About half of the coffee produced in Ethiopia is consumed locally (Central Statistical Agency Report, as cited in Minten et al. 2014) and coffee ceremonies are an important part of the cultural tradition.

Coffee is mainly produced in the regions of Oromia and Southern Nations, Nationalities and People's Republic (SNNPR). The taste and the quality of coffee differ depending on the geographical location of the production and vary in the dimensions of farming system (forest coffee, semi-forest coffee, garden coffee and semi-modern plantation) and processing method (dry and wet). During the past three decades, the Ethiopian coffee market has undergone a number of structural changes.[7] Many of these reforms have had a gradual effect on the market (Petit 2007) and a large share of the market structure characteristics still stem from the historical legacy (Love 2001). However, there are two significant milestones in the evolution of the Ethiopian coffee market. The first important mark in the country's history of coffee trading policy is the beginning of a more liberalized coffee market following the downfall of the Derg military regime in 1991, and the second was the introduction of the Ethiopian Commodity Exchange in 2008.

Throughout the Derg regime that started in 1975, the Ethiopian Coffee Market Corporation (ECMC) controlled about 80 percent of the internal and external marketing of coffee. During this era, domestic coffee prices were set by the Ministry of Coffee and Tea, while export minimum prices were set by the Central Bank (Petit 2007). Farmers were obliged to supply certain quotas of coffee to the government (Gemech and Stuthers 2007) and only licensed collectors (*sebsabies*), and suppliers (*agrabies*), were allowed to trade coffee at the auctions in Addis Ababa and Dire Dawa, where all coffee was priced. After the end of the Derg regime in 1991, the parastatal ECMC was closed down and export price controls, as well as farm gate price floors, were gradually removed. However, although license fees related to the trade of coffee were reduced, the supply chain through primary collectors, suppliers and auctions remained (Petit 2007). In addition, although the deregulation of the coffee market led to an improvement in the transmission of price signals from the world market to the domestic market, farmers' and traders' (*akrabies* and sesabies) insufficient access to market information and credit, along with high transaction costs and uncompetitive markets, substantially limited the effect (Love 2001; Worako et al. 2008).

2.2 The Ethiopian Commodity Exchange Market

The functioning of output markets in Ethiopia is fraught with many of the constraints discussed above. Specifically, markets in Ethiopia are characterized by low density and the high cost of transport (66% of the cost of marketing grain), inadequate market information about prices, supplies, and inter-regional grain flows in other markets, inadequacy of storage facilities, weak bargaining power of producers, imperfections in the marketing chain, inadequate

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[7] For an excellent review of structural changes at the international level, see Petit (2007).

enforcement of contracts and lack of universally applicable and enforceable product standards (RATES 2003; Assefa 1995; Osborne 2005; Jaleta 2007).

For the grain market in particular, traders have been found to engage in suboptimal searches due to insufficient access to brokers (Gabre-Madhin 2001). Therefore, innovations that facilitate market exchange by reducing transaction costs and imperfect information will benefit agricultural trade in Africa (Coulter and Onumah 2002).

The establishment of commodity exchange markets in Africa is a relatively recent phenomenon. Pioneers include the Uganda Commodity Exchange (UCE), the Kenya Agricultural Commodities Exchange (KACE), the Zimbabwe Agricultural Commodities Exchange (ZIMACE) and the South Africa Futures Exchange (SAFEX), all established in the 1990s. The ECX, which was launched in 2008, is the most recent spot/cash exchange in Africa.

Gabre-Madhin and Goggin (2005) argue that a commodity exchange in Ethiopia holds the potential to remedy some of the above-mentioned market inefficiencies and produce a more integrated agricultural market. Gabre-Madhin and Goggin (2005) further argue that the introduction of an exchange is justified from a bottom-up perspective: both farmers and traders have a demand for a better-organized domestic and regional market, and for improved agro-processing. In addition, a commodity exchange can potentially produce a more efficient and integrated agricultural market by providing actors with better information about market prices, quality controls and product standards as well as a legal framework to reduce the risk of default. However, the success of a commodity exchange depends critically on the economic order and the linking of institutions such as market information systems, quality certification, regulatory frameworks and legislation, arbitration mechanisms, and producer and trade associations.

Partly as a consequence of the work by Gabre-Madhin (2001) and Gabre-Madhin and Goggin (2005), the ECX was opened in 2008. The ECX is a modern auction for agricultural commodities located in Addis Ababa. The exchange is associated with a comprehensive system for disseminating information about market prices to more peripheral regional markets in the country. More specifically, traders in local markets can now receive market information via SMS, Interactive Voice Response, Internet, other media (radio, television and newspaper), or via electronic tickers placed in rural markets that display real-time prices of all commodities traded on the platform. ECX also has a comprehensive legal framework and an advanced system for clearing and settlement of contracts in order to guarantee payment and delivery, for example, by requiring all trading members to have prepaid credit accounts.

In an attempt to shorten the supply chain, primary transaction centers have been established as designated trading places where smallholder producers and cooperatives on the one hand and coffee suppliers (*agrabies*) on the other hand trade red cherry and sun-dried coffee (Council of Ministers 2008; Berhe 2010; Adinew 2011).[8]

Finally, a number of warehouses connected to the ECX have been established in surplus areas. The functioning of these warehouses is discussed next.

2.3 Warehouses of the ECX in Ethiopia

Warehouses linked to a commodity exchange can contribute to improved market efficiency. For example, warehouses bring secure storage and quality grading to the region. These services are crucial for seasonal smoothing of agricultural supply.

Fafchamps and Gabre-Madhin (2001) identify the lack of grading and quality certification, the lack of organization between brokers and agents through a commodity exchange, and the presence of search and transport costs as the main transaction costs and thus obstacles to improving efficiency in Malawi and Benin. In addition, Coulter and Onumah (2002) argue that regulated warehouse receipts reduce such transaction costs because warehouse operators have access to and can disseminate information on demand, supply, inventories and quality of the goods. The authors further propose that contracts between warehouse operators and local small-scale farmers (or traders) reduce the risks associated with deliveries and quality.

Ethiopia has a relatively long history of using decentralized warehouses for storage. However, with the liberalization of the economy, many warehouses fell into disuse because they were not profitable. The ones that remained active were located in a few urban areas.[9] Within the ECX, warehouses play a pivotal role, and the ECX has a mission to gradually re-open local warehouses. Within this new system, coffee is sold directly from the warehouses in the different regions instead of being transported to a central auction in Addis Ababa. The new system also implies that commodities in surplus areas across Ethiopia are stored in the nearest regional

[8] It should be noted that Adinew (2011) finds that, in the area of the study, the primary collectors still operate and perform their previous duties. It may also be noted that all coffee still has to pass through the auctions/ECX. Only coffee rejected for export due to poor quality can be sold on the domestic market. However, the mandatory pass-through concerns only coffee destined for non-growing areas; in coffee growing areas, licensed traders were allowed to sell directly to the market (Dercon and Ayalew 1995).

[9] Agricultural Growth Program (AGP) and USAID: http://ethioagp.org/agp-amde-ethiopia-warehouse-receipt-system-and-regulation-a-case-for-expansion/. Visited in 2015-08-05.

warehouse. Commodities are sampled and graded according to quality and quantity at the warehouses (Onumah 2010). This is done on a First-In-First-Out principle that is in line with international standards of inventory management (Ethiopian Commodity Exchange 2009). While all trade is conducted using Addis Ababa prices, a location differential is applied using a frequently updated, public table to reflect the variation in locations of the warehouses (Mezui et al. 2013).

Individuals who deposit goods at the warehouses are issued an Electronic Goods Received Note and a signed print copy as evidence of the deposit (Onumah 2010).[10] The ECX acts as the regulatory body of warehouses, with the jurisdiction over their licensing and regulation (Gabriel 2012). The public jurisdiction of the ECX is intended to ensure that warehouses are both credible and capable of providing fair and secure services (Gabriel 2012). Thus far, warehouses are rented from private owners and the Ethiopian Trade Enterprise (EGTE) by the ECX (Bacha 2014).

In effect, warehouses serve as the managers of the collateral of trading (Antonaci et al. 2015). Warehouses are required to insure against loss or damage of those goods stored within them at maximum coverage (ECX 2009). This implies that operators of warehouses are required to meet various criteria. These include minimum capital requirements and adequacy ratios; insurance and performance bonds so as to protect against fraud and mismanagement (Coulter and Onumah, 2002); either owning the physical infrastructure or holding a long-term lease; appropriate equipment that has been properly calibrated; and a bank reference (Gabriel 2012). Operators are further fully liable for the safe custody of the goods therein stored, regardless of fire or any other catastrophe (Onumah 2010).

Several limitations of Ethiopia's implementation of the warehouse component of the ECX system have been recognized. For example, although operators hold full liability for the goods in their storage, they themselves are not insured against loss (Onumah 2010). The system is also structured in a way that promotes relatively small wholesale quantities. However, the relatively high monthly fees for storage imply that small-scale traders are often unable to bear the costs of independent storage at required capacity (Onumah 2010; Quattri et al. 2011).

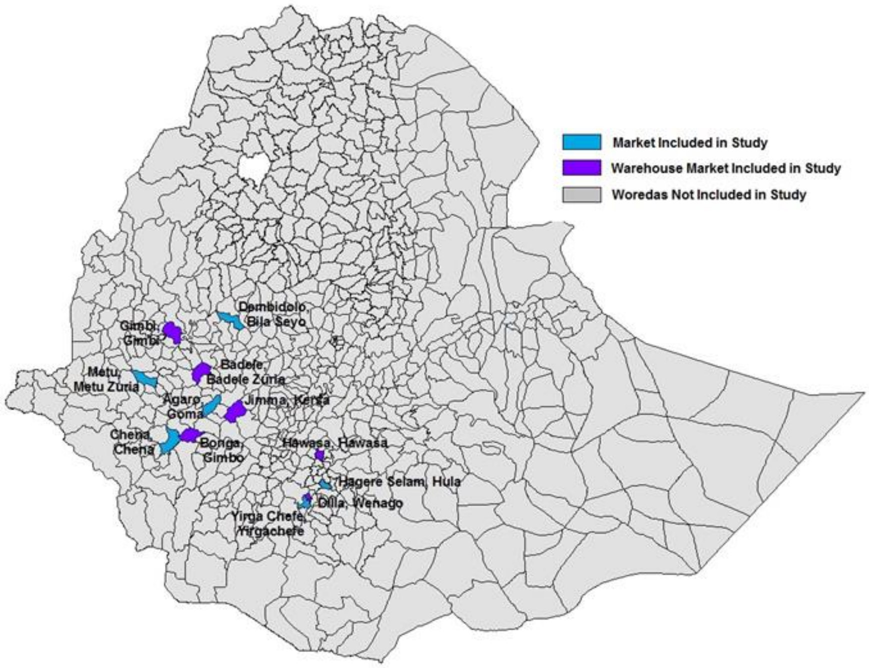
[10] This note does not constitute a transferable, negotiable or legal title to the commodity. Legal titles require an issue from the ECX Central Depository (Ethiopian Commodity Exchange 2009).

There have also been several instances of reported warehouse mismanagement, including a divergence between stated and actual quality, and replacement of higher-grade goods with lower grades (Bacha 2014). In response, the Ministry of Trade stated its intention to segment the warehousing operations into a separate entity in 2013 (Mezui et al. 2013). According to the Ministry, this new entity would be responsible and have the authority for the construction of new warehouses, as well as the management of the 60 existing warehouses, and of employing an Inventory Warehouse Management System to reflect lessons taken from the South African and Columbian experiences (Bacha 2014).

When the ECX was initiated in April 2008, just one warehouse was in use (Mezui et al. 2013).[11] However, this figure quickly rose to include ten warehouses (Francesconi and Herrink 2011). By 2010/2011, this figure had risen to 55 warehouses in 16 locations, growing to 57 in 2013 (Mezui et al. 2013) and 60 in 2014 (Bacha 2014*)*. While this figure is substantial, the concentration of warehouses in just 16 locations reflects an important lack of spatial dispersion (see Figure 1, below). It has been recommended that the warehouse system in Ethiopia be expanded not only in terms of number of warehouses, but more importantly to reach areas of the country not currently served, via areas, such as Dessie in the Amhara district, that act as the key transit points for the drought-prone areas of the North (Quattri et al. 2011). This recommendation is important for supporting crop movement from the moisture-reliable areas to the drought-prone areas so as to lessen the severity of droughts and prevent the onset of famines (Quattri et al. 2011). As of 2014, an Ethiopian reporter stated that warehouses would expand to include the regional towns of Adama, Hawassa, Jimma, Gonder and Humera (Bacha 2014).

[11] This warehouse was associated with coffee storage.

Figure 1. Locations of Warehouses under the ECX



Note: Jimma, Hawassa and Dilla are warehouse towns but are not included in our analysis due to lack of price observations.

It may be noted that, even after the introduction of the ECX, farmers still do not interact directly with warehouse managers. Instead, the produce is collected locally by primary collecting centers.

3. Conceptual Framework

In this paper, we use price dispersion as a measure of market efficiency. According to the Enke-Samuelson-Takayama-Judge (E-S-T-J) models, two markets are in a long run spatial equilibrium when the marginal return to arbitrage is equal to zero (Enke 1951; Samuelson 1952; Takayama and Judge 1971). Spatial arbitrage is defined as the opportunity to reap excess profit by transporting the good from one market to the other. This implies that the equilibrium condition for an efficient market is given by Equation (1) below.

$$P_{jt} \leq \tau_{jkt} + P_{kt} \tag{1}$$

where j and k indicate two spatially separated markets and t is a time index. $P$is the price of the traded good and τ is the cost of transfer between the markets. Transfer costs may include costs related to, e.g., transportation, information and transaction (Chowdhury et al. 2005). Transport costs may include, e.g., fuel cost, road tariffs and time cost associated with embarking and disembarking.[12] Information costs include searching for the most favorable price for a specific good or service, while transaction costs include the costs associated with drafting and negotiating contracts as well as monitoring and enforcing agreements.

In the absence of trade, the constraint in Equation (1) is not binding and, in such cases, there need not be any correlation between price differentials and transaction costs. However, when trade occurs, the constraint in Equation (1) is binding, causing transaction costs and price differentials to move in the same direction and with the same magnitude (Barrett and Li 2002).

The ECX has the potential to reduce many of the transfer costs described in the E-S-T-J-model. Specifically, an increase in the availability of adequate and timely market information should reduce search costs, while an improvement in the legal framework and reduced risk of defaults should reduce transaction costs.

But how does the introduction of ECX warehouses affect the price dispersion of coffee sold on the local markets?

To see this, we need to consider the relationship between the local retail price and the export price of coffee from that region, on the one hand, and the relationship between export coffee from different regions, on the other hand. Starting with the first link, the going price for exported coffee from a particular region is likely to function as a benchmark for coffee sold on local markets in that region. It should be noted that an increase (reduction) in export prices should increase (reduce) incentives to sell coffee via that channel (i.e., export), thus reducing (increasing) supply on the local market and thereby putting upward (downward) pressure on local retail prices. The strength of the relationship between the export and retail price is likely to depend on the distance between the ECX warehouse and local market. Long distances imply higher transport costs, presumably more middlemen, higher search costs and more uncertainty about selling coffee for export. In addition, long distances imply that the price signal that is transmitted from the warehouse is less relevant for the local market, as it also reflects other costs. Thus, with a longer distance, transfer costs are likely to create a wedge between the retail price and export price of coffee from a particular region.

[12] The original models were only specified in terms of transportation costs.

Concerning the second link, the ECX infrastructure connects export prices of coffee from different regions. This, in turn, implies that any arbitrage possibilities in exported coffee from different regions are immediately revealed and that they therefore should be exhausted. As a consequence, differences in export prices should only reflect differences in quality of coffee from the different regions. Thus, by reducing the dispersion of export prices between regions, and reducing the dispersion between export prices and local retail prices, a warehouse can reduce retail prices between coffee growing areas.

4. Data and Identification

4.1 Data

To estimate the effect of warehouses on price dispersion, we use three sources of data: 1) information regarding the location of each ECX warehouse and dates for when the warehouses became fully functional, 2) monthly coffee retail price data, and 3) time series of the world market price for coffee.

The information on location and opening date for ECX warehouses was retrieved via interviews with ECX officers. By October 2012, ECX had 56 warehouses operating at 17 different locations; nine of these locations had warehouses for coffee trade. The first ECX warehouses for coffee started to operate in July 2008, followed by three warehouses 2009, three warehouses in 2010 and two warehouses in 2011.

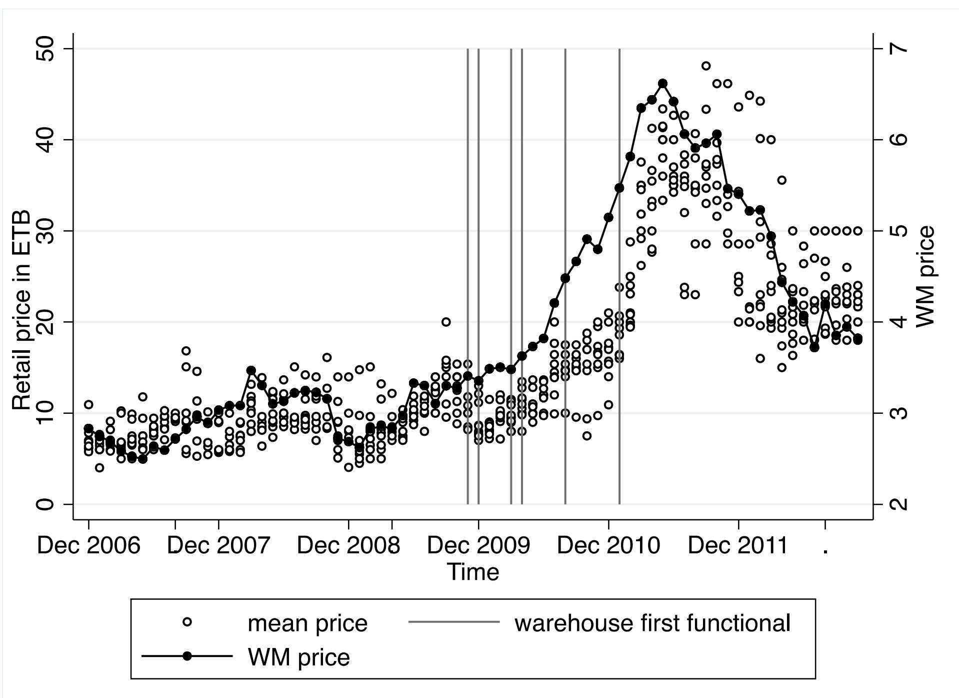
Monthly retail prices were retrieved from Central Statistical Agency (CSA) in Ethiopia. The main variable of interest from this data set is the average monthly price per kg for whole (unprocessed) coffee. The retail price data was collected by SCA from selected urban marketplaces such as open markets, kiosks and supermarkets. The data was mainly obtained through interviews with traders and contains a maximum of three price observations from different retailers during the same day for each month and location. Retail price data is available from all of the nine towns with an ECX warehouse. However, only three towns had a sufficient number of observations to be useful in the analysis. In order to increase the number of observations, we also include towns within the same zones as the warehouse towns. This leaves us with price information from nine different locations in total.

We limit our time frame to the period between January 2007 and December 2012, i.e., three years before and three years after the first ECX warehouse in our sample became fully functional.

Finally, our measure of the world market price of coffee is based on the Global Economic Monitor (GEM) commodities provided by the World Bank. More specifically, we use the International Coffee Organization indicator price (in nominal dollar price per kg) for Arabica coffee based on an average from the New York and Bremen/Hamburg markets.

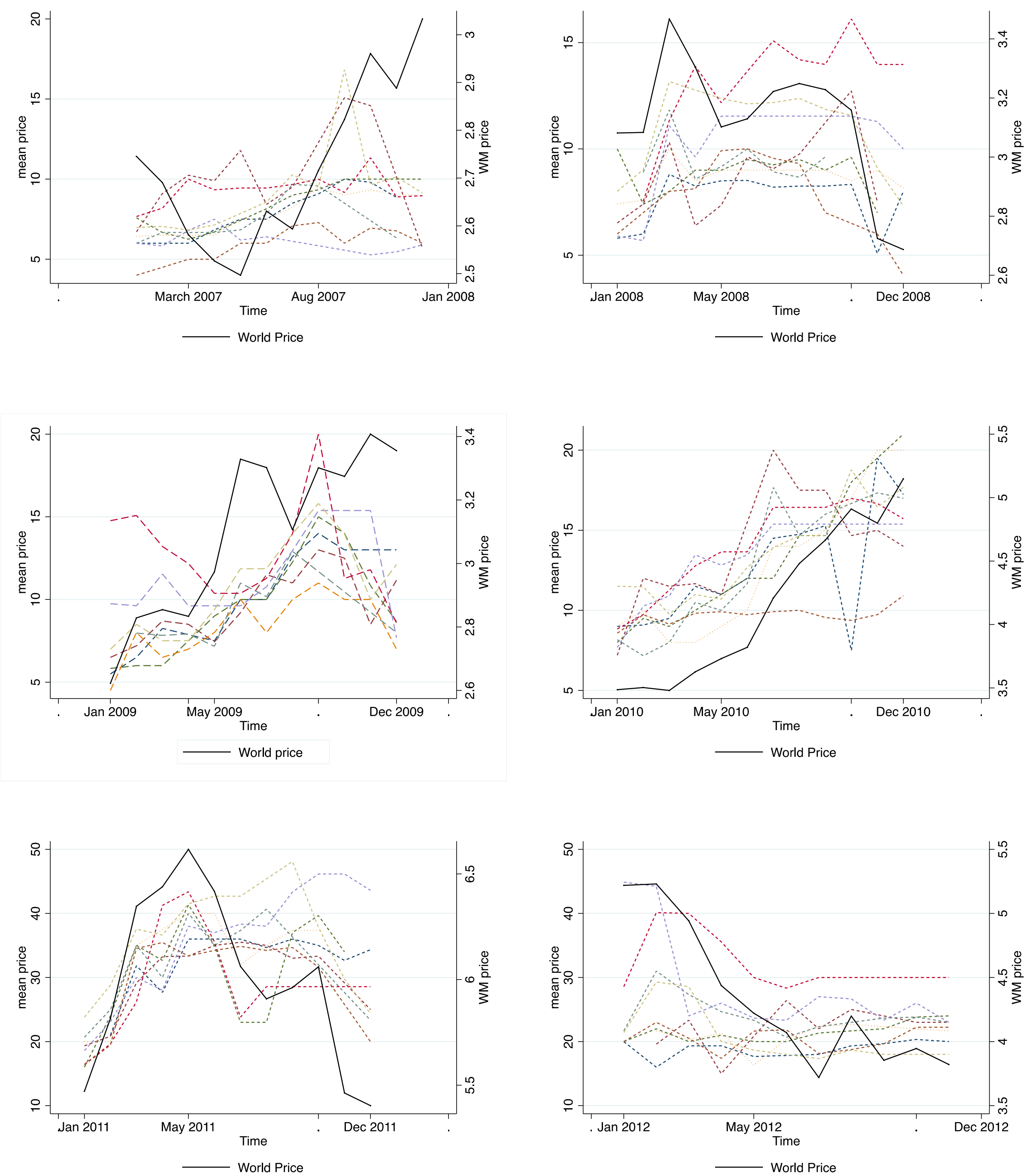
Figure 2 below describes the retail price, the world market price and the starting dates for the ECX warehouses considered in our sample. From the graph, we can see that the world market price was relatively stable in the period December 2006-December 2009. However, beginning in late 2009, we see a clear and strong trend in increasing coffee prices that lasts until the end of 2010, where we instead see a sharp reduction in the world market price. The individual dots in the graph represent local retail prices in Ethiopia. The trend in local prices seems to follow the world price relatively well. However, the graph also suggests that there are substantial differences in retail prices between local markets. The figure also displays the sequencing of the roll out of warehouses between the years 2009 and 2011.

Figure 2. Retail Prices in ETB and World Price in USD



As can be seen in Figure 2, local coffee prices tend to follow the world market price, at least in terms of trend. However, a closer look at the individual years shows that how well local prices follow the world price differs substantially between local markets and between time periods. Figure 3 depicts the price trend on local markets for each year (2007-2012), along with the world market price (each dashed line represents a local market).

Figure 3. Local Coffee Prices and World Market Price of Coffee 2007-2012



Although the picture is not completely clear, the graphs seem to suggest that coffee prices in local markets follow the world price more closely in the period from 2010 and onward. Figure 3 also suggests that there is a substantial variation in coffee prices between different local markets.

Figure 4a depicts the pair-wise difference in prices between local markets, calculated as the percentage of the highest price, and Figure 4b shows the average percentage difference between local markets for each year.

Figure 4a. Pair-wise Percentage Difference in Coffee Prices between Local Markets

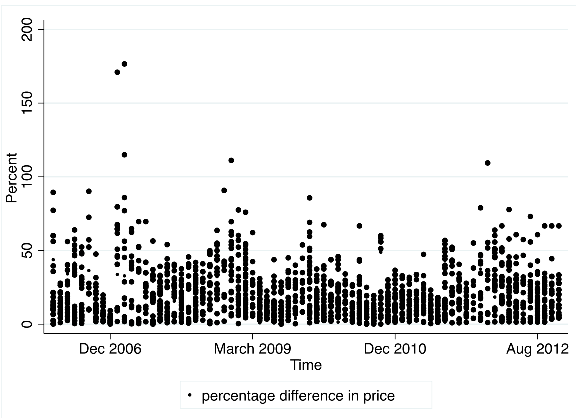


Figure 4b. Average Pair-wise Percentage Difference in Coffee Prices between Local Markets

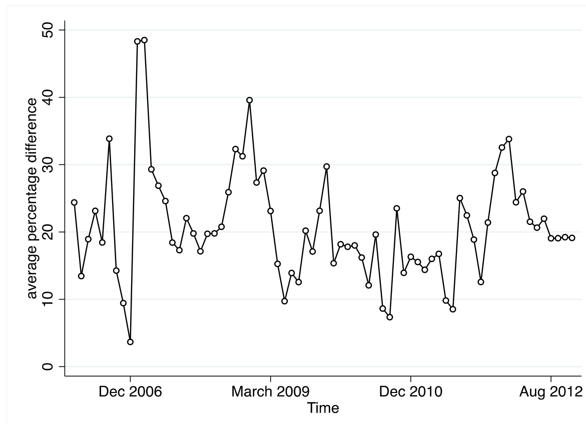


Figure 4a shows a significant variation in prices between local markets during the entire time period surveyed. However, Figure 4b suggests a slight trend toward stabilization of the spread between markets around 20 percent.

4.2 Method and Identification

In order to assess the impact of the warehouses on price dispersion, we follow an approach similar to Aker (2010) and estimate the following model:

$$|p_{jt} - p_{kt}| = \alpha + \beta_1 warehouse_{jk,t} + \beta_2 world\ market\ price_t + \alpha_{jk} + \theta_t + \mu_{jk,t} \qquad (2)$$

where $|p_{jt} - p_{kt}|$ is the difference in price between market *j* and market *k* in period *t*, $warehouse_{jk,t}$ is a dummy variable equal to one if both markets in the market pair had an ECX warehouse at time t and zero otherwise, α_{jk} is a pair fixed effect and θ_t is the trend variable.

Our identification strategy implies that we study price spreads between market pairs.[13] Our main motivation for this approach is that it gives us a measure of efficiency in terms of the ECX's effect on the link between different regional markets. Our hypothesis is that, if just one market has access to a warehouse and another does not, we should not see a large effect on the price spread. However, if both markets have access to storage facilities, information and organized transport, prices in these two markets should follow each other more closely.

Note that our estimations are based on data for local markets that opened up ECX warehouses during the study period. This means that all locations are eligible for an ECX warehouse and that our identification strategy is based on *differences in the opening date* (i.e., the date when each warehouse is defined as fully functional). To estimate the effect of warehouses on price dispersion, we compare the price differences between market pairs where both markets had a functional ECX warehouse at a particular point in time, to the price difference between markets pairs where at least one market did not yet have an operating ECX warehouse. To control for unobserved differences between market pairs and time effects, we include time-specific and market pair-specific effects. We further run a number of different specifications varying the specification of time-specific effects, time trends and lag structures of the explanatory variables to test our model specification. OLS estimates using various specifications are presented in Table 1, and time and pair fixed effects estimates are presented in the first two columns of Table 2.

When running an OLS regression, there is always a risk that the estimates are biased due to omitted variables. For example, as emphasized in the theoretical model, market pairs that are located closer to each other are likely to have a smaller price dispersion than market pairs that are located farther away from each other. In order to avoid such types of omitted variable bias, we include market pair specific fixed effects. There is also a risk that the price dispersion depends on the time period; it may vary between years and agricultural seasons, or exhibit some other type of time trend. We therefore test whether the main results are robust to various specifications of time-specific effects. Finally, full realization of the warehouse effect may take

[13] An alternative way to estimate the effect of the ECX on market efficiency is to use the spread in price between the local market and the world market price of coffee as the dependent variable and a dummy variable (taking the value one if the local market has a warehouse and zero otherwise) as our explanatory variable. As described in footnote 22, the results are qualitatively robust to this alternative identification strategy.

time. To allow for adjustment over time, we estimate a number of models with different lag and evaluate the robustness of the results.

Because a large share of Ethiopian coffee is exported, the world market price of coffee is most likely an important determinant of domestic coffee prices in Ethiopia. Intuitively then, domestic coffee prices should be positively correlated with price dispersion between market pairs. We therefore hypothesize a positive correlation between the world market price of coffee and price dispersion between market pairs. Again, we want to make sure that the main result is not affected by the choice of the lag structure of this variable and we therefore use a number of model specifications. The OLS estimates of these models are presented in Table 1, while time and pair fixed effects estimates are presented in the first two columns of Table 2.

Another set of complications will occur if the error terms have different variances across panels, if an exogenous shock affects all market pairs at a specific period in time, or if a shock that affects a certain market pair has lasting effects over several time periods. In order to correct for such heteroscedasticity across panels, contemporary correlation across panels and first order serial correlation in the disturbance term (which generally makes inferences about standard errors incorrect), we also use Panel Corrected Standard Errors (PCSE) and Prais-Winsten parameter estimates. With this estimation procedure, parameter estimates are conditional on estimates of the autocorrelation and the disturbance covariance matrix is estimated with FGLS.[14] Prais-Winsten (PCSE) estimates are presented in Table 2, Columns 3-6.

As the price difference may exhibit some dynamic structure, we also formulate a model with a lagged dependent variable on the right-hand side of the equation. However, the lagged dependent variable is by definition correlated with the error term and therefore produces biased estimates (shown in Nickell 1981). We therefore follow the approach as first suggested by Anderson and Hsiao (1982) and more generally described by Wooldridge (2010) and transform Equation (2) to a first difference equation. To instrument for the lagged dependent variable, we use further lags of the dependent and explanatory variables. If we define the change in the pair-wise difference in prices as $\Delta y_{it} = \left|p_{jt} - p_{kt}\right| - \left|p_{jt-1} - p_{kt-1}\right|$, and Δz as the change in the independent variables given above, the model can formally be described by Equation (3) below.

$$\Delta y_{it} = \alpha + \beta \Delta z_{it} + \beta_2 \Delta y_{it-1} + \mu_{jk,t} \tag{3}$$

[14] This is implemented in Stata with the xtpcse command.

where the instruments are coming from $(\Delta z_{t-3}, \Delta y_{t-3})$. Note that, because there may be some autocorrelation in the error term, y_{t-2} is not included as an instrument. Finally, we use heteroscedasticity and autocorrelation consistent (HAC) standard errors in the first differenced instrumental variable regression.[15] Estimations using this procedure are presented in Table 2, Columns 7-8.

One could argue that the roll-out of warehouses was not made in a random order; perhaps towns with more favorable characteristics were connected to the ECX earlier than other towns. In order to detect any "placebo effects," we test whether the price difference for a market pair is different from that of other market pairs six and 12 months before both of them have a fully functional ECX warehouse. The model can be described as

$$|p_{jt} - p_{kt}| = \alpha + \beta_1 warehouse_{jk,t+n} + \beta_2 world\ market\ price_t + \alpha_{jk} + \theta_t + \mu_{jk,t} \qquad (4)$$

where *n*=6, 12 months.

Estimations for these models are presented in Table 3.

5. Results

Our main estimation results are presented in Table 1 and 2, below. As can be seen in the tables, the joint presence of warehouses in two markets has a significantly negative impact on the price dispersion between these markets. Our OLS results are very robust to changes in specification and suggest that, if two markets have access to ECX warehouses, the average spread is reduced by 0.86-1.14 ETB, with all four OLS models significant at either the 1% or 5% levels. These findings are also robust to the use of lags, where lagging the effect of both markets having ECX access by one month is associated with a reduced spread of 0.97 ETB and the two-month lagged effect reduces the spread by 1.5 ETB, significant at the 5% and 1% levels, respectively. This is an interesting result, as it suggests that the impact of warehouses becomes stronger after some period of time.

[15] This is implemented in Stata using the xtivreg28 command developed by Schaffer (2012)

Table 1. OLS Estimates, Various Model Specifications

	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
	coef/se	coef/se	coef/se	coef/se	coef/se	coef/se
Both locations have a warehouse at time t	-0,861**	-1,142***	-1,097**	-1,024**		
	(0,338)	(0,340)	(0,341)	(0,341)		
Both locations have a warehouse at time t-1					-0,967**	
					(0,339)	
Both locations have a warehouse at time t-2						-1,495***
						(0,356)
World market price at time t	1,660***	0,901**	0,983**	0,748*		
	(0,172)	(0,409)	(0,413)	(0,419)		
World market price at time t-1					0,728*	
					(0,418)	
World market price at time t-2						0,907**
						(0,418)
Pair specific effects	yes	yes	yes	Yes	Yes	yes
Year specific effects	yes	no	no	No	No	no
Quarter specific effects	No	yes	yes	Yes	Yes	yes
Time trend			-0,119	1,141**	1,463**	1,615**
			(0,077)	(0,411)	(0,454)	(0,519)
Time squared				-0,006**	-0,008***	-0,008***
				(0,002)	(0,002)	(0,002)
Constant	yes	yes	yes	Yes	Yes	yes
Number of observations	2 191	2 191	2 191	2 191	1 885	1 612
Adjusted R2	0,282	0,360	0,361	0,363	0,378	0,415

Note. Dependent variable: absolute difference in retail prices between market pairs. Quarters are calculated as Jan-March-1st quarter; April-June-2nd quarter; July-September- 3rd quarter and October-December- 4th quarter (and main harvesting months). * p<0.05. ** p<0.01. ***p<0.001

Table 2. Fixed Effects, Prais-Winsten and First Difference Results

	Model 7	Model 8	Model 9	Model 10	Model 11	Model 12	Model 13	Model 14
	coef/se	**coef/se**	**coef/se**	**coef/se**	**coef/se**	**coef/se**	**coef/se**	**coef/se**
Both locations have warehouses at time t	-1,142***		-0,893*		-1,027**		0,451	
	(0,340)		(0,478)		(0,463)		(0,445)	
Both locations have warehouses at time (t-2)		-1,579***		-1,509**		-1,775***		-1,330**
		(0,358)		(0,461)		(0,523)		(0,626)
World market price at time t	0,901**		0,946*		1,130**		1,142**	
	(0,409)		(0,563)		(0,528)		(0,473)	
World market price at time (t-2)		1,237**		1,130**		1,112**		1,072**
		(0,398)		(0,531)		(0,477)		(0,468)
Difference in retail prices in period (t-1)							-0,309	-0,301
							(0,357)	(0,361)
Quarter specific effects	yes	yes	yes	yes	yes	Yes	Yes	yes
Pair specific fixed effect	yes	yes	no	no	no	No	No	no
Prais-Winsten (PCSE) estimates using general AR(1) disturbance	no	no	yes	yes	no	No	No	no
Prais-Winsten (PCSE) estimates using panel specific AR(1) disturbance	no	no	no	no	yes	Yes	No	no
First difference iv-regression	no	no	no	no	no	No	Yes	yes
Constant	-0,877	-1,543	-0,908	-1,195	-1,431	-1,125	-0,362***	-0,303***
	(1,131)	(1,202)	(1,628)	(1,652)	(1,523)	(1,498)	(0,095)	(0,090)
Number of observations	2 191	1 612	2 191	1 612	2 191	1 612	1 168	1 168
Adjusted R2	0,294	0,322					0,199	0,201

Note. In Models 13 and 14, the instruments used in this regression are the third lag of the dependent variable and the third lag of the world market price. Using the Hansen J statistic, we cannot reject that the instruments are valid and correctly excluded from the equation. Furthermore, using the Anderson (1984) canonical correlations test, we can reject the hypothesis that the equation is under-identified. * p<0.05. ** p<0.01. ***p<0.001.

Applying fixed effects and Prais-Winsten (PCSE) estimates, we find that, in three of the four additional models, there are statistically significant reductions in the average spread, by between 0.89 (significant at 10%) and 1.14 (significant at 1%). Then, applying a lag of two months, we find larger effects, ranging between 1.33 and 1.78 ETB, significant at either the 1% or 5% levels. Considering that the average spread over the full period is 3.33 ETB, this is a substantial reduction in price dispersion. The insignificant results for warehouse effects six and 12 months before their implementation, presented in Table 3, suggest that there are no problems with placebo effects. We do find evidence of time trends in our OLS estimates, which, in three of the four models, were significant at the 5% level for increases ranging between 1.41 ETB and 1.62 ETB; however, squaring the time effect, we found statistically significant, but extremely small, negative impacts on ETB, ranging from reductions of just 0.006 and 0.008 ETB.

Regarding the effect of world market price on the local price, we find market prices are significantly associated with an increase between 0.75 ETB and 1.66 ETB in the OLS Models 1 through 4. When lagged by one month, the effect of world price on these models is found to increase by ETB 0.73, significant at the 10% level; when lagged by two months, the effect increases to 0.91 ETB, significant at the 5% level. Using fixed effects and Prais-Winsten (PCSE) estimates, we find an increase in local price, ranging from 0.90 ETB and 1.42 ETB due to the world market price. Lagging these effects by two months, we still find significant results, as the world market price is shown to increase local price between 1.07 ETB and 1.23 ETB. We do, however, find potential issues of placebo effects regarding world market price, as shown by the significant results of Table 3.

Our sensitivity analysis suggests that the results are relatively robust. Note that our regression of first differences in Model 13, Table 2, produces a positive non-significant effect of ECX warehouses on price dispersion, while the result in Column 8 depicts a negative and significant coefficient. These results suggest that the effect of warehouse access on price dispersion may not be linear and that the downward pressure on dispersion may grow over time.[16]

16 We have also estimated Models 1-14 with an additional variable equal to one if only one of the markets in the pair has an ECX warehouse. In Models 1-8, the results suggest that having one warehouse has a negative and significant impact on price dispersion. In these models, the coefficient for both markets having a warehouse is still negative and significant, but the magnitude of the effect is somewhat lower. In Models 9-13, one warehouse has no significant effect.

Table 3.Test for Placebo Effects

	Model 15	Model 16	Model 17	Model 18	Model 19	Model 20
	coef/se	coef/se	coef/se	coef/se	coef/se	coef/se
Both locations have warehouses at time (t+6)	-0,276	-0,201	-0,164			
	(0,324)	(0,335)	(0,335)			
Both locations have warehouses at time (t+12)				-0,334	0,080	0,119
				(0,326)	(0,332)	(0,333)
WM price	1,575***	0,711*	0,813**	1,545***	0,704*	0,810**
	(0,174)	(0,406)	(0,410)	(0,165)	(0,406)	(0,410)
Pair specific effects	yes	yes	yes	yes	yes	yes
Year specific effects	yes			yes		
Quarter specific effects		yes	yes		yes	yes
Time trend			-0,138*			-0,142*
Constant	-3,582***	-1,686	8,253	-3,501***	-1,666	8,564
	(0,634)	(1,189)	(5,696)	(0,617)	(1,189)	(5,695)
Number of observations	2 191	2 191	2 191	2 191	2 191	2 191
Adjusted R2	0,281	0,357	0,358	0,281	0,357	0,358

* p<0.05. ** p<0.01. ***p<0.001.

6. Conclusions

The efficiency-enhancing feature of the ECX is based on its potential to reduce many of the transfer costs associated with the trade of coffee in Ethiopia. More specifically, an increase in the availability of adequate and timely market information should reduce search costs, while an improvement in the legal framework and reduced risk of defaults should reduce transaction costs. The reduced transfer costs are likely to reduce price dispersion between exported coffee originating in different regions, as well as price dispersion between the export price and local retail price within regions.

Exploiting the unique feature that the warehouses connected to the commodity exchange in Ethiopia were rolled out sequentially, this paper uses a number of models to explore the relationship between local warehouses and regional coffee price dispersion. Based on data on local and retail prices for coffee and starting dates of warehouse operations, we find that the average price spread between market pairs is reduced by 0.86 to 1.14 ETB when both markets have an operating warehouse, when using OLS estimates. These estimates hold up to both lags of one month and two months, with average price spread estimated to be reduced by 0.97 ETB for a lag of one month and by 1.5 ETB for a lag of two months. This is a substantial reduction, considering that the average price spread over the full period is 3.33 ETB. The result is stable between model specifications, in that the use of fixed effects and Prais-Winsten (PCSE) estimates is found to reduce the average price spread by between 0.89 and 1.14 ETB across the three models with statistically significant results. When redoing the analysis for two-month lags, the spread is found to reduce spread by 1.33-1.78 ETB at either the 10% and 5% levels. Furthermore, these reductions in average price spread are not found to be due to placebo effects.

While the evaluation exercise carried out in this paper is one of very few such studies and is particularly rare in its use of data from the developing world, the analysis of the impact of such interventions could be improved in many ways. First, as the commodity exchange has mainly been operating in a period when world market prices have been falling, longer time series are required for more generalizable results. Second, the current analysis does not delve into details of what types of costs the ECX actually contributes to reducing. Indeed, anecdotal evidence suggests that ECX operations are associated with large costs of testing the commodities, at ECX centers. These costs are mostly driven by long queues and issues with moisture testing, etc., rather than the transport costs to reach a warehouse. If this is the real cost, the possible changes in transport costs might be partially offset. Further examination of the nature of the costs possibly reduced by the ECX would support not only improved ECX operations, but also the evaluation of the corresponding welfare gains from reducing other cost components.

It should also be noted that we do not evaluate all the four functions stated in Section 2; we only evaluate the effect of warehouses on export prices. In other words, our analysis does not provide answers to the question of how the introduction of the ECX has affected the welfare of small-scale farmers. The results of our analysis suggest that local markets that are connected to the ECX via local warehouses experience less price dispersion. We can only speculate that this reduction in price volatility trickles down to local coffee producers. A proper poverty analysis would be an interesting addition to see which types of households benefit from such interventions, as it is based on consumption. An important task for future research is, therefore, to find and use information on local producer prices to evaluate the effect of warehouses and the ECX on the welfare of local farmers.

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