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IMPACT OF INFORMATION TECHNOLOGY ON AGRICULTURAL COMMODITY AUCTIONS IN INDIA

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Abstract

Empirical research on the value of information technology investments in the information systems literature has primarily focused on the use of IT by businesses and multinational firms. The impact of IT on the global agricultural supply chain has largely been ignored in the IS literature. Auctions to buy and sell large volumes of agricultural commodities are widely prevalent in diverse regions of the world and are an important part of the agricultural supply chain. In an effort to increase efficiency, commodity auctions have been experimenting with online formats in recent years. Such online auctions have generated significant interest in the trade press because of their potential to generate higher commodity prices for producers, reduce unfair trading practices by middlemen, and bridge the digital divide. We analyze transaction data from a recently set up online auction in India that trades in various grades of coffee. We model the impact of lower transaction costs, daily operations, less collusive behavior among buyers, and learning curve effects on the selling price of coffee in the online auction. We estimate the parameters of the model by comparing the prices in the electronic auction with those of the same grade of coffee at physical auctions held weekly. We find that electronic auction prices are 4 percent higher and the difference is statistically significant. Further, we find that the price differential is higher for coffee grades that have higher price volatility and that are traded less frequently in the physical exchange. We also find that the price differential increases over time as buyers become more familiar with the benefits of the electronic trading format.

Keywords: Online auctions, digital divide, global information technology, agricultural auctions

Introduction

During the last few years, several innovative applications have emerged around the world that promise to bridge the proverbial “digital divide.” The e-choupal project in India is one such example of an information technology based platform that is used by farmers in India to sell their agricultural produce, look up weather information, and obtain expert crop advice (Upton and Fuller 2004). Other examples include online cooperatives of trades people in South America to directly sell products to end consumers (Anonymous 2000), trading Web sites for cattle ranchers in the United States (Bearden 2004), and online coffee auctions in Brazil (Scholer 2003). The common purpose of these initiatives is to link the rural communities to the Internet, provide timely price information and disseminate farming knowledge, allow producers to execute trades and transactions, eliminate intermediaries, reduce unscrupulous trading, and consequently transform the global agricultural supply chain that supports the livelihood of billions of people around the world.

The impact of IT on the agricultural supply chain has largely been ignored in the information systems empirical literature. However, two factors make this an important and fruitful research area. First, while such initiatives have the potential to affect the lives of billions of people that live on the other side of the digital divide, their effectiveness is often unclear and many are skeptical that the benefits actually reach the rural communities (Anonymous 2005). Second, several unanswered research questions arise in this context that are important for policy formulation, such as the nature and magnitude of the benefits from online platforms, who appropriates the benefits, types of products that are suitable, and other factors that affect the benefits obtained.

Auctions to buy and sell large volumes of agricultural commodities such as wheat, rice, tea, coffee, and soybeans are an important part of the global agricultural supply chain in diverse regions of the world. In an effort to improve efficiency, agricultural auctions have been experimenting with online formats, where the physical auction environment is simulated almost exactly in an online setting. The projected benefits of the online environment include lower transaction costs for buyers and sellers, 7 days-a-week operations, better price and product information, better visibility of the price formation process, less collusion among buyers, less exploitation by intermediaries, and a more streamlined agricultural supply chain. In spite of these benefits, online commodity auctions are in their infancy and governments have been cautious in granting permission without adequate protection for the producers. A major concern is whether the benefits of the online platform will actually translate to higher commodity prices for the producers.

In this paper, we compare prices of various grades of coffee sold through a recently commissioned online auction in India with similar prices from the regulated physical auction held weekly by the Indian Coffee Traders Association (ICTA).¹ The online auction is operated by the International Business Division (IBD) of ITC Limited, a large conglomerate in India with annual revenues in excess of \$3 billion.

We answer two basic questions in this research. First, is there a price difference between sales executed at the online and physical ICTA auctions? As similar online commodity auctions become more prevalent in other regions of the world, empirical evidence on whether buyers or sellers appropriate the benefits of online trading is of interest to governmental agencies charged with protecting the interests of producers. The second research issue we investigate is the set of factors that drive the difference in price between the two trading formats. Coffee grades vary based on their price volatility, availability, and the need to physically verify quality. Through regression analysis, we investigate how these and other factors affect the price difference. The analysis provides insights on the type of commodities that will most benefit from the online auction format.

Literature Review and Contributions

There is a vast theoretical literature on auctions and bidding in Economics that applies game-theoretic concepts to the study of auctions (McAfee and McMillan 1987; Milgrom 1989). It is well-known that under certain assumptions, the four common types of auctions (English, Dutch, first price sealed bid, and second price sealed bid) yield the same revenue for the seller (Vickrey 1961). The economics literature has examined in detail the implications of relaxing some of the assumptions underlying the model used by Vickrey (1961) on the basic results, such as incorporating risk averse buyers (Matthews 1987), common value assumptions (McAfee et al. 1989), correlated bidder valuations (Milgrom and Weber 1982), and collusion among buyers (McAfee and McMillan 1992). A recent survey of this literature appears in Klemperer (1999).

The IS literature has extensively examined analytical models of online auctions, mainly in the consumer-to-consumer (C2C) and business-to-consumer (B2C) contexts (for a recent survey, see Pinker et al. 2003). Typical research issues include trust building in electronic markets in the business-to-consumer setting (Dewan and Hsu 2004; Hu et al. 2004), reputation mechanism design in online environments (Dellarocas 2005), and optimal design of online auction mechanisms (Bapna et al. 2003a). Empirical research on B2C online auctions has focused on price differences (Lee et al. 1999), consumer surplus and product variety (Brynjolfsson et al. 2003), trust building (Ba and Pavlou 2002; Pavlou and Gefen 2004), and the frictional costs of submitting new bids (Hann and Terweisch 2003).

Recent research on online auctions has also examined the optimal design of combinatorial and multiunit auctions that are common in business-to-business (B2B) and governmental auction environments (Pekec and Rothkopf 2002; Rothkopf and Harstadt 1998). Typical issues addressed in this research include algorithms for winner determination (Sandholm 2002), real time bidder support strategies (Adomavicius and Gupta 2005), and simulation based approaches for analyzing alternative bidder strategies (Bapna et al. 2003b). A recent survey of this literature appears in Anandalingam et al. (2005).

Several analytical models have also been proposed in the IS literature on the use of online auctions in the B2B application area to support integrated supply chains. A model for decentralized information systems design in the online auction and supply chain contexts appears in Fan et al. (2003). Other models in the literature include the effect of competition among sellers (Bandopadhyay et al. 2005) and the role of information transparency (Zhu 2004) in an online B2B auction.

¹See the ICTA Web site at www.indiacoffee.org for more information.

Empirical research on B2B online auctions has been relatively sparse, perhaps due to the difficulty in obtaining data. Snir and Hitt (2003) empirically evaluate the procurement of IT services by U.S. businesses through online auctions. Their findings suggest that when bidding and bid evaluations are costly, firms that are willing to pay more for higher quality will receive more bids, often from low quality vendors. The type of service evaluated by the authors is orthogonal to the commodities analyzed here because the bidding process requires significant data exchange to specify requirements.

We contribute to the empirical literature on B2B online auctions in several ways. First, the nascent electronic auctions studied here that trade in standardized agricultural commodities provide an excellent and unique opportunity to study the differences between the electronic and physical trading formats. Such electronic auctions often coexist with their physical counterparts. Further, they trade in well-defined and standardized commodities, which make it easier to isolate the impact of the electronic trading format on prices, transaction costs, and other parameters of interest. They represent an important research area that has been inadequately analyzed in the IS literature. Second, we evaluate the impact of commodity characteristics such as price volatility and product availability on the value that participants derive from the daily format of the online exchange, an issue that has not been addressed in the empirical literature. We also evaluate learning curve effects on the commodity price in nascent online exchanges as buyers become more familiar with the online format.

We contribute to the growing literature that focuses on the use of IT in the global context (Jarvenpaa et al. 2004; Tractinsky and Jarvenpaa 1995; Zhu et al. 2004). A recent article in *The Economist* (Anonymous 2005) underscores the importance and difficulty in bringing the benefits of computerization to the impoverished masses of India and other parts of the developing world. Our research provides preliminary evidence that price of commodities can be higher in the online exchange format, an issue that is of vital interest to those entrusted with protecting the interests of farmers. Further, Indian coffee auctions are an important element of the global coffee supply chain that begins with the farmer in the developing world and ends at the coffee houses in the West. Similar global supply chains also exist for other agricultural commodities. Online auctions have the potential to transform the global supply chains of many such commodities. Our analysis of the impact of commodity characteristics on the price difference provides insights on the type of commodities that governments can target as they contemplate expansion of online auctions to cover a large number of such commodities.

Hypotheses Development

The Coffee Supply Chain in India

Like in many other agricultural commodities, the coffee supply chain in India consists of four major players: (1) *planters* who are the coffee growers and plantation owners, (2) *exporters* who contract with international trading houses and international roasters, (3) *domestic roasters* who produce coffee for the domestic market, and (4) *intermediaries* such as agents, brokers, and traders who perform several roles like financing the planters, arranging transportation, searching for buyers and sellers, and negotiating deals on behalf of other participants.

Coffee Grades

Coffee as a commodity item is traded in the form of coffee beans. The berries of the coffee plant, both the Arabica and Robusta varieties, are harvested and subjected to on-farm processing to extract the bean in its raw form. Based on the type of on-farm processing, four types of raw coffee beans are traded in the market: (1) washed Arabica or *Arabica Parchment*, (2) unwashed Arabica or *Arabica Cherry*, (3) washed Robusta or *Robusta Parchment*, and (4) unwashed Robusta or *Robusta Cherry*. Each of these four types of coffee beans is further graded using international standards into several subgrades (PB, AA, A, B, C, and BBB), based on the bean size (measured through standard sieves) and the percentage and type of imperfections present.

ICTA and Online Auctions

The Indian Coffee Traders Association (ICTA) holds a coffee auction every Thursday in Bangalore. Planters, brokers, and agents carry a sample of the coffee to the auction where the lots are sold through oral, ascending bid, English auctions in the presence of all the buyers. The online coffee auction is operated by ITC Limited and is designed to mimic the ICTA auction. However, unlike the ICTA auction, it is open for business 5 days a week. Between 9 a.m. and 11 a.m. every day, sellers submit information about the lots for sale on that day, such as the coffee type and grade, lot size, reserve price, and details of the seller. Beginning

at 11 a.m., lots are auctioned sequentially. Each bid submitted is open for 3 minutes after which the lot is sold to the highest bidder. The auction concludes when all of the lots have been processed, although some lots may remain unsold because no acceptable bids were received. Lots that remain unsold may be offered again on following days.

Price Difference between the Two Formats

It is well recognized in the literature that transaction costs are lower in the electronic format for several reasons (Pinker et al. 2003). Participation in the electronic auction requires no travel to the auction site and participants do not incur the travel-related and other costs associated with the physical ICTA auctions. In addition, the time commitment on the part of the participants is lower in the electronic auction. These transaction cost advantages of the electronic trading format apply to both buyers and sellers. It is, therefore, unclear whether buyers or sellers will appropriate the benefits accruing from the electronic format.

The auctions literature sidesteps this issue by assuming that sellers are monopolists selling a unique product. Thus, any transaction cost benefit of the electronic auction format would be entirely appropriated by the seller. However, agricultural commodities are not unique goods and the ability of the seller to behave as a monopolist is limited because the buyer has several other options available to procure the same commodity.

The marketing literature on two-party channel negotiations between manufacturers and retailers provides additional insight (Iyer and Villas-Boas 2003; Srivastava et al. 2000). The basic premise is that bargaining power is an important determinant of the outcome of the negotiations (Iyer and Villas-Boas 2003). There are two factors identified in this literature that increase the bargaining power of the seller in the electronic format. The first is the availability of information about buyer valuations. In experiments reported by Cason and Sharma (2001) involving buyer-seller negotiations, the negotiated price is higher when sellers are better informed about buyer valuations: the information allows the seller to extract a larger portion of the surplus. A distinctive feature of the electronic auction format is the constant updating and easy reporting of international coffee prices at the auction Web site. Since buyers typically sell the coffee on the international markets, this information provides the sellers with additional insights into buyer valuations of the coffee. The second factor is the opportunity cost of delay for buyers and sellers. Negotiating parties that have a lower opportunity cost of delay are in a position to negotiate a better price because they can afford to wait (Srivastava et al. 2000). The variance of coffee prices is consistently higher on the international markets than in the ICTA auctions.² Since buyers typically sell to the international markets, they are under greater pressure to complete a transaction at the daily electronic auction rather than wait for the weekly ICTA auction, to take advantage of any changes in international coffee prices. On the other hand, the seller is more willing to wait for the weekly auction if the price at the electronic auction is not up to his expectations. The increased bargaining power of the seller in the electronic format leads to the seller appropriating a larger portion of the benefits of the electronic format. The above arguments lead to our first hypothesis.

Hypothesis H1: *The price for the same grade of coffee will be higher at the electronic auction than at the physical ICTA auction.*

Commodity Characteristics that Affect the Difference in Price

In this section, we investigate how certain characteristics of a commodity (coffee grade) affect the price difference between the electronic and physical auction formats. An important difference between the electronic and physical ICTA formats is the daily (as opposed to weekly) operations of the electronic auction. This allows the buyer to take advantage of price fluctuations in the international markets by booking a trade in the daily electronic auction, rather than waiting for the weekly physical ICTA auction. However, the advantage of daily operations will not apply equally to all coffee grades. Coffee grades differ based on two dimensions: price volatility and availability. Price volatility is measured by the variance of price for a specific coffee grade in the ICTA auction. Not all coffee grades are traded at each ICTA auction. Availability is measured by the percentage of weeks that a specific coffee grade is traded at the weekly ICTA auctions.

The relationship between risk and expected return is well documented in the Finance literature on the capital asset pricing model (Sharpe 1964). The fundamental relationship in the CAPM is that under equilibrium conditions, capital assets with higher

²Based on price data from the London (Robusta) and New York (Arabica) coffee exchanges, the price variance in the international markets were two to four times higher than in the Indian coffee auctions.

expected return also have more variable returns. This correspondence suggests that the higher expected return is a compensation for the higher perceived risk associated with the return (Jagannathan and McGrattan 1995). This intuitive concept, applied to our scenario, implies that coffee grades that have relatively stable prices (low volatility) and are frequently traded (high availability) will benefit the least from the daily operations of the electronic auction format. A risk-averse buyer should be willing to pay a higher premium at the current electronic auction for coffee grades that have high price variance (σ_g) to account for the increased price risk of waiting for the physical ICTA auction. Similarly, the buyer should be willing to pay a price premium for coffee grades that are traded less frequently at the physical ICTA auctions (low availability) to account for the increased risk of incurring additional search costs if the buyer waits for the next physical ICTA auction and the coffee grade is not traded at that auction. The above arguments form the basis for the following two hypotheses:

Hypothesis H2: *The difference in price between the electronic and physical ICTA auction formats will be higher for coffee grades that have high price volatility.*

Hypothesis H3: *The difference in price between the electronic and physical ICTA auction formats will be higher for coffee grades that are traded less frequently at the ICTA physical auctions.*

Learning Curve Effects

Numerous studies document the positive relationship between organizational experience and performance (Argote 1999; Wright 1936). Firms also learn from the experience of others and there is evidence in the literature on the transfer of experience within groups of firms (Ingram and Simons 2002). This is particularly relevant in our context because the online auction is available for all participants to observe even without actually conducting transactions. Word-of-mouth effects can also be a factor in strengthening perceptions of value. The online coffee auction is a novelty in the agricultural commodity markets in India and our analysis period covered the first year of its operations. Learning curve effects imply that buyers will be willing to pay a higher price differential at the electronic auction as they become more comfortable and perceive greater value from the new auction format. Thus, the price differential between the electronic and physical ICTA auction formats should increase over time. Hypothesis H4 captures this relationship.

Hypothesis H4: *The difference in price between the electronic and physical ICTA auction formats for the same grade of coffee will increase over time.*

Control Variables

To ensure that the results of our data analysis to test hypotheses H1 through H4 are not driven by extraneous factors, we incorporate three additional control variables in the model.

Number of Bidders in the Two Formats

Collusion among buyers in the agricultural commodity markets in India and other parts of the world is a widely recognized phenomenon (Banerji and Meenakshi 2004). In a standard ascending-bid English auction, the auction price should equal the second highest valuation (it is optimal for each bidder to bid his valuation) of the good among the set of bidders (McAfee and McMillan 1987). If buyers collude (such as by rotating bids among themselves and not bidding against each other) they are able to drive the selling price lower than the second highest valuation by reducing the number of active bidders.

In an electronic auction, collusion is more difficult to achieve for several reasons. Buyers do not see all of the lots to be auctioned or the set of other bidders present online. Lack of physical proximity may also inhibit collusive behavior. Further, automatic records are kept in an electronic auction of bids submitted that can be used for later analysis of collusive behavior. Thus, the number of active bidders may be higher in an electronic auction and must be controlled for in our data analysis to test hypotheses H1 through H4.

Our data does not provide the number of active bidders in each auction or for each transaction. However, we use an indirect method to capture the impact of a difference in the number of bidders in the two formats on the selling price differential. Let r_g be the range of buyer valuations for a specific grade of coffee at an auction. For coffee grades where the range of buyer valuations (r_g) is large, the impact of fewer buyers on the second highest buyer valuation (the selling price) will be more pronounced. Thus,

if there are more active buyers in the online auction, its impact will be more for coffee grades that have a greater range (r_g) of buyer valuations. Note that there is an important but subtle difference between σ_g and the range r_g . The first, σ_g , is the standard deviation of bidder valuations over time. It is a measure of how much a bidder's valuation changes over time. The second, r_g , is the range of valuations among the set of bidders in a specific auction. We use r_g as a control variable to capture the impact of a difference in the number of active bidders on the selling price differential.

Premium Coffee Grades

The higher priced subgrades of coffee (PB, AA, AB, and A) within each of the four major bean classifications (Arabica Parchment, Arabica Cherry, Robusta Parchment, and Robusta Cherry) are considered premier grades of coffee. Determination of the subgrade is dependent on the bean size and percentage of imperfections present. While the four major bean classifications are unambiguous, it is reasonable to expect that the higher subgrades will have a greater need for the touch and feel associated with the physical exchange. To control for this in our regression, we introduce a 0/1 control variable (HIGH) which is set to 1 for the higher subgrades, 0 otherwise.

Lot Size

Conversations with ITC-IBD personnel indicated that buyers might be willing to pay higher prices for larger lot sizes because of the higher transaction costs and inconvenience associated with buying in small lots. To consider this, we introduce a control variable Q in the model that represents the lot size (kilograms) of a transaction.

Data and Results

The Data Set

We obtained data for the empirical analysis from two sources. In March of 2002, ITC Limited started operating the online coffee auction platform described earlier in the paper. The company provided us with 1 year of transaction data for all transactions completed on the online coffee auction platform between March 2002 and February 2003. There were a total of 127 completed transactions in that period of time. Volumes were concentrated between July and October of 2002, with 87 of the 127 completed transactions concentrated in these four months. The data provided to us contained (among other items) the buyer and seller names, the coffee grade, the unit price (INR/Kg), the lot size (Kg), and the commission paid by the seller for the transaction (INR).

We also obtained data on each weekly ICTA physical auction held between March 2002 and February 2003 from the Karnataka State Coffee Board. This data contained the average closing price for each coffee grade (INR/Kg) traded at that auction. In addition, since multiple lots of the same coffee grade may be sold at the auction, the data also provided the maximum and the minimum auction prices for each coffee grade. Obviously, when only one lot of a coffee grade was traded at the auction, all three (minimum, maximum, and average) prices would be the same for that coffee grade.

The ICTA auction trades only the internationally recognized grades of coffee and does not trade in the other, less-recognized grades. Of the 127 completed transactions in the data from the online auction, we could match the grade in the ICTA data for only 85 of those transactions. These 85 transactions formed our data set. The remaining 42 transactions were for grades that are not traded in the ICTA auction and were left out of the analysis.

Regression Models

To evaluate hypotheses H1 through H4, we investigate the following models through standard regression analysis using OLS estimate of the parameters. Model B is the complete model, while Model A excludes the control variable r_g , since there is some level of multi-collinearity in the data.

$$\text{MODEL A: } se_g - sp_g = \beta_0 + \beta_1 * h_g + \beta_2 \sigma_g^2 + \beta_3 * \text{Ln(DAYS)} + \beta_5 \text{HIGH} + \beta_6 Q$$

$$\text{MODEL B: } se_g - sp_g = \beta_0 + \beta_1 * h_g + \beta_2 \sigma_g^2 + \beta_3 * \text{Ln(DAYS)} + \beta_4 r_g + \beta_5 \text{HIGH} + \beta_6 Q$$

In Models A and B, se_g is the unit price of coffee grade g in the electronic auction, while sp_g is the unit average price of coffee grade g in the immediately previous ICTA physical auction. σ_g represents the price volatility of coffee grade g and is measured by the standard deviation of the average price of coffee grade g in the physical ICTA auctions over the 1 year period of the study. H_g represents the availability of coffee grade g and is defined as the percentage of weeks that coffee grade g was traded in the ICTA auctions. r_g is the range of buyer valuations for coffee grade g at a single auction and it is estimated from the ICTA auction data in the following way: For each of the weekly ICTA auctions, we have the lowest and highest price at which coffee grade g was sold at that auction. From this data, we determine the range of the selling price for coffee grade g for that auction, and we take the maximum range for coffee grade g for all auctions in the 1 year period of the study, as a proxy for r_g . DAYS is the number of days since the inception of the platform. As is common in the literature, we use the logarithm function to model a decreasing rate of learning over time (Epple et al. 1991). HIGH and Q are control variables explained earlier.

Results

The results of statistical tests for the percentage difference in selling price between the two formats are shown in Table 1. The mean and median difference in price between the electronic and physical auctions for the same grade of coffee is 3.87 percent and 4.06 percent, respectively. The electronic auction prices were higher in 80 percent of the cases (68 out of 85). The test statistics for the t-test, Wilcoxon signed rank test and the sign test are all significant at the 1 percent level based on a two-tailed test. We conclude from Table 1 that our analysis supports Hypothesis H1.

The results of the regression analysis for Models A and B are shown in Table 2. We use ordinary least squares estimation of the parameters. The coefficient β_1 is significant and negative in both models at the 5 percent level. Thus, coffee grades with a higher value of h_g (traded more frequently in the physical auction) have a lower price difference between the electronic and physical auctions. The coefficient, β_2 is also significant and positive in both models at the 10 percent level. Thus, coffee grades that have a higher price variance over time also have a higher difference in price between the electronic and physical auctions. The coefficient β_3 is significant and positive at less than the 5 percent level, indicating that the price difference between the electronic and physical auction formats increased over time. We conclude from the above analysis that the data supports hypotheses H2 through H4.

The coefficient β_5 for the dummy variable HIGH, is significant and negative in Models A and B reported in Table 2. As expected, premium coffee grades that typically require a higher level of touch and feel to verify quality, are associated with a higher price in the physical auction. The coefficient β_6 is not significant in any of the models in Table 2. Thus, the lot size does not affect the difference in price between the two auction formats.

Table 1. Price Difference between Electronic and Physical Auctions	
	Percent difference in price $(\frac{se_g - sp_g}{se_g}) * 100$
Mean	3.87%
t-value (p-value)	5.8 (0.000)***
Median	4.06%
Wilcoxon Signed Rank z-value (p-value)	5.03 (0.000)***
Percent Positive	80%
Sign Test z-value (p-value)	5.42 (0.000)***

Significant at the ***(1%), **(5%) and *(10%) levels based on a 2-tailed test. p-values are in parenthesis

Variable	Parameter	Model A	Model B
Constant	β_0	1.54 (0.98)	1.69 (1.04)
h_g	β_1	-5.38 (-2.56)**	-5.16 (-2.34)**
σ^2_g	β_2	0.05 (1.84)*	0.059 (1.65)*
Ln(DAYS)	β_3	0.74 (2.61)***	0.687 (2.13)**
r_g	β_4		-0.011 (-0.37)
HIGH	β_5	-0.98 (-1.82)*	-0.983 (-1.8)*
Q	β_6	0.00002 (0.87)	0.00002 (0.86)
R^2		13.5%	13.6%

t-values in parenthesis. Significance shown at the ***(1%), **(5%) and *(10%). Levels based on a two-tailed test. Models A and B are explained in the text.

Discussion

Whether the buyer or seller takes the gains from the online format is ultimately an empirical issue. We find that the price of coffee is approximately 4 percent higher in the online auction when compared to the price of the same grade of coffee in the physical ICTA auction. We provide two explanations for this difference in price between the two formats. First, the online format increases the bargaining power of the seller by providing continuously updated information on international selling prices. Second, the buyer is willing to pay a higher price because the daily operations of the online format allow the buyer to complete transactions quickly and take advantage of variations in international coffee prices. Our finding that online auction prices are higher is encouraging to producers and government agencies entrusted with their protection. Since the bargaining power of the seller may be different in other commodities, online auctions may not always lead to higher prices. Facilities that increase the bargaining power of the seller, such as storage and refrigeration facilities to increase shelf life, will increase the value that the producer captures from the online format.

We find that two characteristics of a coffee grade affect the difference in price between the electronic and physical auctions. The price difference is higher for coffee grades that have a higher volatility of price over time. For such coffee grades, the buyer is willing to pay a premium to avoid the price risk associated with waiting for the weekly ICTA auction and the convenience of executing the trade instantly in the online format. The other characteristic that affects the difference in price between the two formats is the availability of the coffee grade in the physical auction. Grades that are infrequently traded have a higher price difference between the two trading formats. Buyers are willing to pay a premium to avoid the availability risk associated with waiting for the physical auction. An immediate implication of these findings is that the benefits of the online platform are most pronounced for commodities that have high price volatility and that are traded less frequently. As platform providers such as ITC Limited contemplate extensions of the platform, they should focus on such commodities.

We find strong evidence of a learning curve effect on the price difference between the two formats. As buyers become more familiar with the online auction format and its advantages, they are willing to pay a higher price for trades executed on that platform. Thus, providing initial incentives can be an effective way to lure buyers into the online format and to overcome initial resistance. We find no significant difference in our estimates of the number of active bidders on the online and physical auctions and no evidence of a difference in buyer collusive behavior between the two formats. In fact, the estimated coefficient (although not significant) is negative, indicating the possibility of more active bidders in the physical ICTA auction, perhaps due to the novelty of the online format.

Interestingly, we find evidence of a price premium on the physical auction for the higher coffee grades that have a higher need to verify quality. Based on the fitted value, higher coffee subgrades within each major bean classification have a 1 percent negative price effect on the online exchange. Two factors make this effect interesting. First, an internationally accepted grading standard exists for coffee beans. The standards specify the size of beans and the percentage of imperfections acceptable for each subgrade/. Second, in the physical auction, the seller carries only a sample to the auction and not the whole lot. The price premium may be based on the psychology of the buyer who is more willing to complete a transaction anonymously for commodity items (lower coffee grades), but is more comfortable with the physical proximity associated with the ICTA auctions for higher

priced specialty grades. An implication of this finding is that the development of standardized quality certification methods must precede the online auction, so that physical proximity is of lesser consequence.

Summary and Limitations

Empirical research in IS has focused on the use of IT by U.S. businesses and multinationals. However, the impact of IT on the global agricultural supply chain has largely been ignored in the literature. Nascent online exchanges that trade in standardized commodities are becoming an important part of the global agricultural supply chain with the potential to affect the livelihood of millions of people around the world. In this paper, we compare the selling price of coffee in a recently commissioned online coffee auction in India with those in the corresponding weekly physical auction run by the Indian Coffee Traders Association. Our results indicate that online prices are slightly higher on the average and the difference is statistically significant. Further, the price difference is higher for certain coffee grades that benefit more from the daily format of the online auction.

Can online commodity auctions bring the benefits of IT to the rural masses in the developing world? This issue was highlighted in a recent article in *The Economist* (Anonymous 2005) that expressed skepticism about the benefits of such technology reaching the farmers. While higher prices in the online format for commodities indicate higher earnings for farmers, the price difference is modest (4 percent). However, we also find that it is increasing over time. Further, our analysis indicates that the price difference is even higher for commodities that have higher price volatility and less availability. In addition, buyers will fully realize the transaction cost savings when they procure entirely from the online auction. Currently, they still have to travel to the physical auction to fulfill their procurement needs. For the above reasons, we are of the opinion that the initially small (but statistically significant) price difference will increase over time as buyers move over to the new trading format and new online auctions are introduced in other suitable commodities.

Some of the limitations of this research are similar to those that apply to other empirical research using secondary data. While we have used several control variables in the regression analysis to test our hypotheses, there is always the possibility of extraneous factors influencing the results. Specifically, there may be characteristics of a coffee grade that are not captured in our analysis, but that maybe the primary explanation behind our results. Likewise, there may be alternative explanations for the price difference between the two formats. We have used imperfect proxies for several variables that are difficult to measure through our data. Specifically, our data does not have the difference in the number of active bidders in each auction format and the range of buyer valuations (r_g) is an indirect way to capture its impact on the price difference.

In closing, we believe that the use of information technology to transform the agricultural supply chain has the potential to affect the lives of millions of people around the world. It constitutes an important research area that has been inadequately examined in the information systems literature.

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