Paper in Support of an AAEA Selected Poster
AAEA Annual Meetings, Portland, Oregon
July 29 – August 1, 2007

Tractors on eBay:

Differences between Internet and In-Person Auctions

Florian Diekmann, Brian E. Roe, Marvin T. Batte*
Department of Agricultural, Environmental and Development Economics
Ohio State University

Corresponding Author:

Brian Roe
Agricultural, Environmental, and Development Economics
Ohio State University
2120 Fyffe Rd.
Columbus, OH 43210-1067
Phone: 614-688-5777
Fax: 614-292-7710
Email: roe.30@osu.edu

* Diekmann is Project Manager, Center for Innovation-Based Enterprise, Department of Agricultural, Environmental and Development Economics, Ohio State University. Roe is Professor, and Batte is Van Buren Professor, both in Department of Agricultural, Environmental and Development Economics, Ohio State University. This research was supported in part by the Fred N. VanBuren Program in Farm Management, the Center for Innovation-Based Enterprise and the Ohio Agricultural Research and Development Center.

Tractors on eBay: Differences between Internet and In-Person Auctions

Abstract: Internet auction platforms are changing the face of transactions in many business sectors, including agriculture. We provide one of the first systematic examinations of the differences between internet and in-person auctions in agricultural input markets. A hedonic model estimated with used tractor transactions from Midwestern sellers pooled between eBay and in-person auctions reveals statistically distinct price surfaces for the two auction venues and predicts significantly lower prices for comparable equipment sold on eBay, though this difference is attenuated for tractors fully covered by eBay's buyer protection program and is fully absent for the most frequently traded tractor. An endogenous venue-selection model reveals that larger, more-valuable tractors are less likely to be offered on eBay, a choice that should enhance seller revenues. Furthermore, sellers in states with more valuable stocks of machinery, more frequent tractor sales, and a lower propensity to use the internet for agricultural marketing are more likely to offer tractors for sale via in-person auctions than on eBay.

JEL Codes: D44, Q13

Key Words: auctions, electronic commerce, eBay, farm equipment, hedonic models

Running Title: Tractors on eBay

Few sounds capture the rhythm of agricultural economies better than the syncopated cadence of an auctioneer echoing across a clutch of farmers gathered around the auction block. This seemingly timeless portrait of economic exchange in rural America has changed however, as advances in technology alter the way auctions are conducted. The advent of telephone bidding, video links and, more recently, internet bidding platforms change the nature of auctions by broadening the pool of potential sellers and bidders. As the commercial success of eBay and other internet auctions sites suggest, the internet provides many possible advantages over in-person auctions. Internet auction sites provide extensive listings and powerful search technologies, which can contribute to the creation of liquid markets for specialized product categories, even when buyers and sellers are geographically dispersed. This is particularly important for U.S. agriculture because, as production becomes increasingly concentrated among fewer entities, the number of potential bidders in a given radius of any sales location diminishes.

A key strength of the internet – the pooling of bidders from geographically dispersed locations – can also be a weakness, as distance removes a critical advantage of in-person auctions, i.e., bidders directly inspecting merchandise. While some internet sites that hold agricultural equipment auctions attempt to directly offset this weakness by providing inspection services (e.g., IronPlanet.com), the most widely used internet auction site, eBay, does not provide such direct *ex ante* risk mitigation services. Other *ex ante* risk mitigation instruments are available to eBay buyers, however, including the posting of reliability ratings of individual sellers and the use of photos and videos that allow buyers to inspect aspects of goods from a distance. Starting in June of 2005, eBay also began offering *ex post* risk mitigation service to business equipment purchasers in

the form of a fraud protection policy that refunds a buyer's outlays up to $20,000 for business equipment (including farm equipment) sold by eBay sellers in the case of seller fraud or undisclosed equipment defects.

As online sales of farm equipment become more widespread, questions arise about the nature of price determination in online versus traditional markets. We present empirical evidence from recent Midwest auctions for used farm tractors conducted on eBay and via in-person auctions. We are interested in several questions. Do eBay and in-person auctions yield similar average prices for comparable equipment and similar hedonic surfaces for used farm tractors? Second, what influences whether tractors are offered for sale on eBay versus in-person auctions? Finally we ask if sellers systematically direct tractors to the outlet that provides the highest sales revenue.

Characteristics of eBay and in-person tractor auctions

To better understand if eBay and traditional auctions assign similar values to used tractors and why sellers may prefer one outlet to another, we first discuss how the characteristics of eBay auctions differ from in-person auctions. The auctions differ in three fundamental ways: the mode of participant interaction (internet versus in person), the auction mechanism, and the role of the marketing agent. The 'traditional' in-person auction considered in this study is an ascending-bid, open-outcry, first-price (English) auction executed by an auctioneer, while eBay employs a format that is similar, but not identical, to a second-price sealed-bid (Vickery) auction executed by eBay.[1]

Auctions mechanisms are differentiated in several domains: ascending versus descending, first-price versus second-price, and sealed versus open. Both eBay and in-person tractor auctions are ascending auctions, i.e., prices begin low and rise with

additional bidding. In-person tractor auctions are typically first-price auctions, where the highest bidder pays a price equal to the highest bid to secure the tractor, while eBay auctions are similar to a second-price auction, i.e., the winner pays the price bid by the second-highest bidder plus a small, additional increment.[2]

In-person tractor auctions are typically open outcry auctions, where bidders are aware of the number of other bidders and the highest bid at any point in the auction. In contrast, eBay auctions reveal only the 'current bid', i.e., the second highest bid plus a small increment. Each eBay bidder typically bids via proxy, i.e., enters a maximum bid and allows eBay's system to automatically bid for the buyer as needed up to the maximum bid. If each buyer were to forgo additional bids and not monitor the progress of the on-line auction, then eBay auctions would be identical to a second-price sealed-bid auction. In practice, many bidders do monitor bidding activity and often enter additional bids, including many bids during the final moments of fixed-duration eBay auctions.

Under certain assumptions, including the risk-neutrality of buyers, most auctions, including the in-person and eBay tractor auction mechanisms considered here, will yield the same price for a given good (see Klemperer 1999 for an overview of Vickery's original 'revenue equivalence theorem' and several recent generalizations). Hence, in a setting where a pool of tractors and a pool of risk-neutral buyers are both randomly assigned to eBay and in-person auctions, the absolute price for any tractor should be equivalent whether offered under the in-person or eBay format. Furthermore, as each tractor would fetch the same price in either outlet, the resulting hedonic price surface should be the same for each outlet. In reality, however, buyers may not be risk averse,

buyers are not randomly assigned to participate in eBay and in-person auctions, and sellers are unlikely to randomly assign tractors between the two auction outlets.

The presence of risk-averse buyers is one reason why the two auction formats may yield different prices. In a first-price auction, a risk-averse buyer will submit a higher bid than a risk neutral buyer with the same willingness to pay because a risk-averse buyer is willing to submit a higher bid in order to increase the likelihood of winning at the expense of lower surplus (Klemperer 1999). Klemperer (1999) shows that risk aversion has no effect on a buyer's bid in a second-price auction. If tractor bidders tend to be risk averse, then we might expect in-person auctions to yield higher prices.

Furthermore, if buyers are heterogeneous with regard to risk aversion, one might expect in-person auctions to attract those with higher risk aversion because in-person auctions allow the mitigation of risk associated with tractor quality via personal inspection of sale items and the mitigation of transactions risk by dealing with bonded auctioneers. This self-selection of risk-averse buyers to in-person auctions would exacerbate the likelihood that in-person auction prices will be higher than eBay prices.

Just as the pool of buyers for eBay and in-person tractor auctions may not be identical, so the quality of the pool of available tractors may differ between the two outlets. Though there exists no systematic evaluation of the quality of eBay and in-person auction tractors, buyers may be more suspicious of eBay items due to their inability to personally inspect sale items. Similarly, a seller would be less likely to offer a tractor with a quality defect at an in-person auction because many experienced individuals will likely inspect the item. This suggests these adverse selection pressures may induce lower bids for items sold on eBay.

eBay has introduced several measures in an attempt to reduce the possible effect of adverse selection on sale prices. First, it has pioneered the development and maintenance of an online trading partners feedback forum (Cohen 2002) where market participants continuously assess their trading partners performance with regard to payment speed and merchandise quality. This reduces the search costs for information about the reputation of market participants.[3] The feedback mechanism allows buyer and seller to leave publicly available comments about each other. A rapidly growing empirical literature that uses data from the feedback mechanism of online auctions attempts to quantify the market value of online reputations (see Bajari and Hortaçsu 2004; Dewan and Hsu 2004; Houser and Wooders 2006).

Second, in June 2005, eBay introduced its "Business Equipment Purchase Protection Program" that covers undisclosed damages or deliberate seller fraud. Any items sold in the business and industrial capital equipment category, which includes tractors, that sell for $1,000 to $20,000 are automatically enrolled in the program.

The fact that eBay auctions have a fixed-time format may also cause differences in the price generated between the two tractor auction formats. Specifically, astute eBay bidders often wait until the final moments of an auction before entering their bids in order to mute potential bidding wars with inexperienced or emotional bidders or to avoid revealing their personal valuation for the good being auctioned (Roth and Ockenfels 2002). Hence, the fixed time format may shade eBay prices lower than in-person tractor auctions where bidding continues until only one bidder remains.

Research into the relative pricing performance of eBay and in-person auctions is particularly important as the two venues feature vastly different commission levels. eBay

commissions for business and industrial capital equipment sales are one percent of the final sale price with a maximum charge of $250, a $20 listing fee, and a variety of optional fixed-fee listing enhancements (e.g., bold lettering).

In-person auctions feature commissions that typically range from 2.5 percent to 15 percent, often with no limit on the maximum total commission paid. To the best of our knowledge, detailed information concerning the average commission structures for U.S. farm equipment auctions is not available, though industry sources suggest that the bulk of commissions fall in the five to ten percent range (Musser, 2006). As a point of reference, we list the commission structure of an internet-based auction house, IronPlanet.com, which provides features similar to that of an in-person auction company, including equipment inspection and lien searches. This firm features a block-rate commission structure outlined in table 1. The difference between the total commissions paid for various sales prices can vary dramatically; the difference for a $1,000 item is about $100 and the difference for a $100,000 item is more than $6,000.

Finally, note that the auctioneers organizing and running the in-person sales are exclusive agents of the seller and charge larger commissions than eBay, which focuses on providing a robust marketplace for buyers and sellers. Do to these differences in legal status and reliance on higher commissions, the incentives to stimulate bidding and higher sales prices may be stronger for in-person auctions.

Data

We use data from internet and in-person tractor auctions conducted between June 1, 2005 and March 31, 2006 in 11 Midwestern states (IA, IL, IN, KS, MI, MN, NE, ND, OH, SD, WI). The internet sample was purchased through eBay's service provider program. The

acquired data license included detailed and complete information about auctions that took place in eBay's "Tractor and Farm Machinery" category, including the final sales price, make, model, engine horsepower, year, hours of use, auction date, seller zip code, and other information describing the auction items and the nature of the auction. The in-person auction data was purchased from Machinery Pete's Farm Equipment FACT's Report, which summarizes results from retirement, estate, dealer and consignment auctions reported by a network of more than 600 auctioneers. Provided information includes sales price, make, model, engine horsepower, year, hours of use, auction date and location (region within a state), and other descriptive information. The data do not represent the entire universe of used tractor transactions for the Midwest during this period, as other internet auction sites regularly transact tractors and some auctioneers may not report to the FACT's Report, but this likely represents a wide, representative sample from the universe of used tractors.

Several filters were applied to each data set to arrive at a sample used for analysis. For both samples, tractors with model years earlier than 1960 were excluded to focus on tractors that were most likely purchased for operational rather than collectible purposes. Also tractors of 30 horsepower and less were excluded to focus on tractors most likely to be used in agriculture rather than nursery or landscape operations. Items that were classified by the seller as "for parts" or "not running" and items that were sold with expensive additional implements such as backhoes were excluded. Items with less expensive implements such as loaders or mowers were included. Finally, the data set was also limited to the 13 manufacturers (makes) that contributed more than 89 percent of

sample observations. The complete data set (see table 2 for summary statistics) included 588 eBay observations and 1,770 in-person observations for a total of 2,358.

Modeling and Analysis

We are interested in understanding if the two auction venues are different from either the buyer's or the seller's point of view. To assess this empirically we estimate an endogenous switching regression model (Maddala 1983, chapter 8), which consists of two key modeling components. In the first stage we model the seller's decision concerning the sales venue for a particular tractor:

(1) $S_i^* = \delta([\ln(P_{i1}) - c_{i1}] - [\ln(P_{i0}) - c_{i0}]) + \boldsymbol{\gamma}\mathbf{Z_i} + u_i \equiv \boldsymbol{\alpha}\mathbf{A_i} + u_i,$

where P_{i1} (P_{i0}) is the price tractor i would earn if sold on eBay (in person), c_{i1} (c_{i0}) is the financial cost of selling a tractor on eBay (in person), δ is a parameter to be estimated, $\mathbf{Z_i}$ is a column vector of other factors that might influence the seller's choice of sale venue for tractor i, $\boldsymbol{\gamma}$ is a row vector of parameters to be estimated, u_i is an unobserved component driving venue selection, $\boldsymbol{\alpha}$ is a row vector containing δ and $\boldsymbol{\gamma}$, and $\mathbf{A_i}$ is a column vector containing $[\ln(P_{i1}) - c_{i1}] - [\ln(P_{i0}) - c_{i0}]$ and $\mathbf{Z_i}$. If $S_i^* \geq 0$ the tractor is sold on eBay ($S_i = 1$); otherwise it is sold at an in-person auction ($S_i = 0$).

After selecting a venue, each tractor is then sold for a price, which is represented by a venue-specific hedonic equation:

(2) $\ln(P_i) = k_0 + \boldsymbol{ß}_0\mathbf{x_i} + u_{0i}$, if $S_i = 0$ (tractor sold in person)

or

(3) $\ln(P_i) = k_1 + \boldsymbol{ß}_1\mathbf{x_i} + u_{1i}$, if $S_i = 1$ (tractor sold on eBay),

where k_j is the price intercept for venue j, $\mathbf{x_i}$ is a column vector of attributes of tractor i; $\boldsymbol{ß_j}$ is a row vector of marginal implicit prices for each attribute in venue j, and u_{ji} represents

unobserved factors that drive the price for tractor i in venue j. Hedonic pricing analysis is commonly used for the study of markets with differentiated goods (Lancaster 1971; Rosen 1974). Hedonic models assume that the price of good is a function of the value of its individual attributes. If robust markets exist, each attribute will have a well-defined shadow price (the individual elements of $\boldsymbol{\beta}_j$) and the price (or logarithm of price) of the good is a function (a mere summation in our case) of these shadow prices.

We must also consider that the unobserved factors driving venue selection (u_i) may be correlated with the unobserved factors driving price (u_{ji}) via covariance factors σ_{ju}. If this is the case, estimates of (2) and (3) will yield inconsistent estimates of the shadow values of tractor attributes in each venue as each specification fails to account for unobserved factors that drove its placement into that market. Consistent estimates may be generated by estimating:

(4) $\ln(P_i) = k_0 + \boldsymbol{\beta}_0\mathbf{x}_i + \sigma_{0u}W_{0i} + e_{0i}$, if $S_i = 0$ (tractor sold in person)

and

(5) $\ln(P_i) = k_1 + \boldsymbol{\beta}_1\mathbf{x}_i - \sigma_{1u}W_{1i} + e_{1i}$, if $S_i = 1$ (tractor sold on eBay),

or by estimating

(6) $\ln(P_i) = k_0 + \boldsymbol{\beta}_0\mathbf{x}_i + S_i[k_1 - k_0 + (\boldsymbol{\beta}_1 - \boldsymbol{\beta}_0)\mathbf{x}_i - \sigma_{1u}W_{1i}] + (1 - S_i)\,\sigma_{0u}W_{0i} + e_i$,

where $W_{1i} = \varphi(\boldsymbol{\alpha}^*\mathbf{A_i})/\Phi(\boldsymbol{\alpha}^*\mathbf{A_i})$, $W_{0i} = \varphi(\boldsymbol{\alpha}^*\mathbf{A_i})/[1 - \Phi(\boldsymbol{\alpha}^*\mathbf{A_i})]$, $\varphi(\bullet)$ is the standard normal density function, $\Phi(\bullet)$ is the standard normal distribution function, $\boldsymbol{\alpha}^*$ is a consistent estimate of $\boldsymbol{\alpha}$, and the e_i's are the new residuals with zero conditional means (e.g., $e_i = u_{ji} + \sigma_{ju}W_{ji}$). The structure of e_i implies these residuals will be heteroscedastic. Furthermore, the residuals may contain additional structure because, in the case of eBay sales, we identify that some tractors are offered by the same seller and, in the case of in-

person auctions, we identify that some tractors are offered at the same auction event. One might imagine that final auction prices will be driven by unobservable factors that are constant across all tractors sold by the same eBay seller (due to reputation, location) and all tractors sold at the same event (due to weather, reputation of auctioneer, pool of bidders). Hence, the use of a panel estimator may improve the estimate's efficiency.[4]

Our empirical strategy is to (a) use maximum likelihood estimation to obtain $\boldsymbol{\alpha}^*$, a consistent estimate for $\boldsymbol{\alpha}$ from the reduced-form version[5] of equation (1), to develop consistent estimates of Φ_i and φ_i; (b) estimate equation (6) with a generalized least squares random effects estimator[6] after substituting in consistent estimates Φ_i^* and φ_i^*; and (c) use maximum likelihood to re-estimate equation (1) after substituting in predicted prices[7] generated from estimated parameters obtained in step (c). The standard errors are clustered on the seller-specific or event-specific identification for each of these steps. In addition, for steps (b) and (c), we use a jackknife procedure to develop standard errors that are robust to the heteroscedasticity of these residuals.

Step (a) is the necessary first-stage reduced-form regression to determine venue selection. Step (b) affords us a clean opportunity to test for structural differences between the intercepts and shadow prices in the hedonic models for tractors in each sales venue.[8] Step (c) is the structural version of step (a); i.e., it allows us to revisit the selection equation in a manner that clearly identifies the relative importance of price and non-price elements in the seller's venue selection decision.

Results

The estimated coefficients for the fully interacted hedonic model (equation 6) are presented in the first two columns of table 3. The first column provides the estimated

coefficients for attributes as determined via in-person auctions while the second column lists the estimates for the eBay interaction terms. The model fits the data well (overall R^2 of 0.86). Alternative functional forms (e.g., log-log formulations for continuous variables such as hours and age) provide no better fit to the data than the current log-quadratic form. The correlation of error terms across individual sellers is quite large ($\rho = 0.42$).

An *F*-test of the joint significance of all eBay interaction terms is highly significant ($F = 5.54$, $p < 0.001$), suggesting that the two venues yield distinct hedonic price models. Omitting the intercept term from this test, which is highly significant on its own, still yields a highly significant test statistic ($F = 4.44$, $p < 0.001$). Taken together, these tests suggest that sales on eBay result in both a significant, negative shift in base price and a significantly different set of attribute shadow prices.

When separate regressions are performed for the eBay and in-person auction data (appendix), we also find that the in-person hedonic model fits the data better than does the eBay model ($R^2 = 0.87$ versus 0.71). This may suggest that in-person auctions offer the seller more confidence in the range of prices that will be received for a particular model of tractor with a given set of attributes, while eBay auctions may yield greater variability in the eventual sale price. Furthermore, the separate regressions indicate a much larger random effects correlation coefficient for the eBay auctions ($\rho = 0.71$ versus 0.14). This is not too surprising given that the unit of observation for eBay sales is the individual seller while for in-person auctions it is the auction event. One might hypothesize that there will be greater correlation among unobservable components when repeat sales emanate from the same individual seller, particularly given the seller

reputation information provided by eBay. Individual auctions may aggregate tractors from many sellers with the only common elements being time, location and auctioneer.

To more precisely identify the source of differences between the two venues, one can inspect individual eBay interaction terms and test particular subsets of these terms. Several individual interaction terms are significantly different from zero and several joint tests for categorical classifications are significant.

The first notable result is that the eBay intercept interaction term is negative and significant, i.e., controlling for all attributes and for the fact that attributes may be valued differently in each venue, the fact that the item is sold on eBay means a lower selling price. The magnitude of this coefficient is quite large: eBay sales generate 27 cents on the dollar compared to in-person auctions. While representing a substantial discount, the coefficient cannot be interpreted separately from the other eBay interaction terms. That is, 27 cents on the dollar is the base discount for tractors sold on eBay. We show that other key attributes are valued more highly in the eBay market and will offset, to some extent, this base discount. To fully explore the overall influence of the interaction term, we later predict venue-specific prices for each tractor, and these predictions take all interaction terms into consideration. In general we find the other eBay interaction terms attenuate the substantial discount represented by the eBay intercept interaction term.

Several attribute-specific differences are apparent after studying the interaction terms. For example, tractors with attached implements fetch a 20 percent higher value on eBay (t = 2.71, p = 0.007) while tractors sold on a weekend generate 11 percent less on eBay (t = -1.97, p = 0.05). There also exist some seasonal differences between in-person and eBay price patterns; specifically, eBay features marginally lower sales prices in

January and higher sales prices in June than in-person auctions. As a group, however, the month dummy eBay interaction terms are insignificant ($F = 1.37$, $p = 0.20$). In-person auctions tend to further discount older tractors compared to eBay ($F = 14.85$, $p < 0.001$, see figure 1). Also, eBay sales value horse power in a marginally different fashion than in-person auctions ($F = 2.65$, $p = 0.07$), with eBay marginal values being higher over the relevant ranges of horse power (see figure 1).

The two venues appear to place similar marginal values on many attributes. For example, the joint tests of significance for the interaction terms involving the different transmission features (four-wheel drive, $t = -0.78$, $p = 0.44$ and manual transmission, $t = 0.76$, $p = 0.45$), type of engine (gas vs. diesel, $t = -0.75$, $p = 0.45$), hours of use ($F = 0.45$, $p = 0.64$), and makes ($F = 0.65$, $p = 0.80$) reveal no significant differences.

One distinction between in-person and eBay auctions is that fraud and misrepresentation is more easily avoided with in-person auctions because the buyer is normally present to inspect the item and because many auctioneers provide inspection services. This could lead to a significant decline in prices for goods traded on eBay and could hinder the growth of sales volume. Indeed, the eBay interaction term with the intercept in the model just discussed was highly negative, suggesting that base prices were considerably lower on eBay compared to in-person auctions.

To combat this issue and to improve buyer confidence, eBay offers a free buyer protection program that reimburses buyers up to $20,000 for transactions that feature seller fraud or undisclosed product defects. In order to investigate the possible effects of such a program on the eBay market, we re-estimate the models using a sub-sample of

observations for which the final sales price is $20,000 or less. The results are presented in the first and second columns of table 4.

The first thing to notice about the results from this restricted sample is that the eBay intercept interaction term is 57 percent smaller than when using the full sample (-0.745 versus -1.313). This translates to an eBay price that is roughly 47 cents for every dollar received from an in-person auction, which is considerably better than the $0.27 figure from the full-sample model. This suggests that, for used tractors that tend to sell for less than $20,000, the base discount for selling on eBay is smaller. Like the model featuring all observations, the model of the restricted sample reveals significantly different hedonic surfaces for the two auction venues. While the joint test that all eBay interaction terms are equal to zero is soundly rejected ($F = 3.87$, $p < 0.001$), the test statistic is 30 percent smaller than the comparable statistic for the full sample. Taken together, these two pieces of evidence provide some indirect evidence that eBay's buyer protection program may be providing the desired effect and driving prices from eBay and in-person auctions to have more similar hedonic surfaces, though clearly these results suggest substantial differences remain.

Another more straightforward way to verify if the two auction venues are generating similar prices is to simply compare the distributions of price for a single used tractor model that is frequently sold in both outlets. The most commonly sold used tractor in this data set is the John Deere 4020. More than 57,000 units of this tractor were produced by John Deere at its Waterloo, Iowa, factory between 1963 and 1971, making it one of the most common models ever produced in U.S. agriculture. Our data set includes the sales price of 83 units, including 23 sold via eBay. Tests fail to reject that the two

sub-samples of tractors are identical with respect to age (t = 0.97, p=0.33; Kruskal-Wallis [K-W] $\chi^2(1)$ = 1.21, p=0.27), hours (t = 0.67, p=0.51; K-W $\chi^2(1)$ = 0.88, p=0.25), the inclusion of ancillary implements (Pearson's $\chi^2(1)$ = 0.16, p=0.69), and reliance upon diesel fuel (some in each sub-sample feature gas engines, Pearson's $\chi^2(1)$ = 0.86, p=0.36). By design all John Deere 4020's had the same horsepower, though a chi-square test rejects that both venues sold the same percent of 4020's with manual transmission (about 13 percent of eBay 4020's feature manual transmission while none in in-person auctions lists this feature, Pearson's $\chi^2(1)$ = 8.12, p=0.004).[9] Hence, other than the difference in transmission types, eBay and in-person offerings of the 4020 appear to quite similar with regard to the attributes used in the hedonic model.

Figure 2 is the box plot of the sales price distributions for each venue, where the top (bottom) of the box represents the 75th (25th) percentile value, the solid horizontal line across each box is the median, and the 'whiskers' represent the largest observed values in either direction within the inner fence.[10] Dots appearing outside the whiskers represent potential outliers within the distribution. The mean in-person auction price ($8,212.50) is quite close to that of the eBay sample ($8,166.37). Both a t-test (t = 0.06, p = 0.95) and the non-parametric K-W test ($\chi^2(1)$ = 0.08, p = 0.77) fail to reject the equivalency of sales price between the two sub-samples. Hence, in-person and eBay auctions provide similar price distributions for the John Deere 4020's sold in the Midwest during this time frame. This provides some additional evidence of convergence in average sales prices for used tractors that sell for less than the upper limit of eBay's consumer protection policy,[11] though a rigorous test of the effect of the policy eludes us due to a lack of data that precedes the beginning of eBay's buyer protection program.

Predicted Prices, Sales Revenue and Equalizing Commissions

We have identified that separate hedonic surfaces emerge in different auction venues, and that the difference between the venues may be attenuated for tractors that sell in a price range covered by eBay's buyer protection program. The hedonic models use sale price as the dependent variable, while sellers are more likely to be interested in the sales revenue they keep rather than the price that sales generate. In other words, sellers care both about the price generated at sale and the costs of transacting the sale (e.g., commissions, fees and other costs). To explore this aspect we predict both the in-person and eBay auction price of all used tractors using the models from the full and restricted samples. The average and median prices for all tractors in each data sample, as well as for six specific models, are listed in table 5.

In addition to predicting prices for sales in each venue, we also calculate the difference in the seller's net revenues between the two outlets. To calculate this we first take the predicted in-person sales price and apply the commission structure in table 1, including the average fees listed in the footnotes to table 1. Next, we subtract this from the predicted eBay sales price less commission (the minimum of one percent of sales value and $250) and typical fees ($20 listing fee plus $55 in optional advertising fees). This difference is listed in column 3 of table 5. The fourth column presents the flat commission fee that would need to be assessed to the in-person auction to equate net revenue from selling the tractor in the two venues under the assumption that the fixed fees for in-person and eBay venues remain at $450 and $75. Note if the eBay price less fixed fees is higher than that for the in-person auction, only a subsidy for selling at the in-person auction would equate the net revenue. For these cases column four lists 'NA'.

The top half of table 5 features predictions from the model for used tractors of all prices and provides three examples of tractors for which the range of in-person sales price exceeds $20,000. For each example model and for the average and median of all tractors, in-person auctions generate greater net revenues than eBay sales under the assumed commission structure. For example, the average across all tractors in the sample results in eBay revenue that is $9,795 less than the in-person auction revenues. The size of the flat commission necessary to equate net revenue between the two venues is 55.2 percent. The range of commissions observed for in-person auctions rarely exceed 15 percent, suggesting that net revenues generated for used tractor sellers on eBay are substantially lower, particularly for the higher-price models explored in the top half of the table.

The bottom half of table 5 utilizes the hedonic model based on tractors that sold for less than $20,000. When all tractors in this sub-sample are considered, the average difference in net revenues generated by the two auction venues is much smaller, with an advantage of $872 for in-person auctions. It would only take an 29.2 percent flat commission rate to equate the net revenue generated by the two sources, a rate lower than those observed in the top half of the table, but considerably higher than those observed in in-person auctions. Also note that our commission and fees calculations do not adjust for one fundamental difference in costs, i.e., that eBay tractors do not need to be transported to a central sale location. Information concerning the distance between a seller's home and the location of in-person sales was not available. The additional transportation cost is unlikely to alter the sign of the net revenue difference for either the average or median tractor in the full sample, but it may have a larger relative influence for the lesser-valued tractors in the bottom half of table 5.

Auction Venue Selection

The hedonic analysis suggests that the two auction outlets feature distinct price intercepts and surfaces while the analysis of predicted sales revenues suggests that, for many tractor models, the net revenues will be substantially larger in one outlet than another. If this were the case, and if market participants were well informed of these patterns, sellers may steer[12] tractors with certain attributes towards the market that generates higher value. To investigate this we now discuss our estimates of the reduced-form and structural versions of the venue selection model. The estimated probit coefficients for the reduced-form model, along with robust standard errors, are presented in tables 3 and 4 for the full sample and for the sample of tractors that sold for less than $20,000. The structural selection models appear in table 6.

If sellers are motivated by maximizing sale price and are fully aware of the different hedonic surfaces of the two markets, one would hypothesize that the reduced-form selection model coefficients would agree in sign and significance with the eBay interaction terms from the hedonic price model. That is, if the attribute features a larger shadow price on eBay, you would expect tractors with that attribute to be sold on eBay.

In both the full-sample and restricted sample models, however, many coefficients fail to agree in sign and significance with the eBay interaction terms in the analogous hedonic model. For example, in the full-sample reduced-form selection model (table 3, column 3), the coefficient for *Manual* is negative and significant while the eBay interaction term in the hedonic price model (table 3, column 2) is positive though insignificant. All else equal a used tractor with a manual transmission sells for no less on eBay. However, all else equal, a used tractor with a manual transmission is less likely to

be offered for sale on eBay. This lack of agreement holds for numerous attributes, including for four makes and three sale months. The quadratic terms in the probit for *Hours* and *Horse* also feature distinctly different curvatures. Similar divergences hold for the model estimated with the restricted sample.

Two variables featured in the reduced-form selection model are excluded from the hedonic models for the purposes of adequately identifying the endogenous switching regression model – each of these variables is highly significant in both the full and restricted samples. First, as a state's average per-farm value for machinery and equipment[13] increases, sellers from that state are less likely to offer their tractors on eBay. This may suggest that adequate in-person secondary markets exist in states where farms carry highly valued inventories of machinery and equipment. States where farms hold lower-valued inventories of machinery and equipment may feature thinner in-person secondary markets and rely more heavily upon electronic markets to transact used tractors. A similar argument may hold for the *StateSale* variable, which is calculated as the number of tractors in the current data set from a particular state divided by the number of total tractors (in thousands) held in inventory in that state. The greater is the volume of transactions in our data set from a particular state as a fraction of all the tractors held in that state, the less likely it is that the tractor is offered on eBay. Again, states with larger volumes of tractors offered for sale may stimulate more in-person auction possibilities, which would limit offerings on eBay.

Revenue Maximization and Venue Selection

We now revisit the issue of whether sellers are choosing the sales venue that will maximize net sales revenue. One test of the precept of net revenue maximization is

presented in table 5, where we predict the probability that the six example tractors used in the previous section are offered on eBay using the results of the reduced-form venue-selection model reported in table 3. If sellers are efficiently allocating different tractors between the two venues, we would expect the predicted probability of offer on eBay to reflect the difference in predicted net revenues. For the three more expensive tractors (top half of table 5), each is predicted to fetch higher prices and net revenue from in-person auctions. The predicted probability of sale on eBay for each is also quite low.

To explore this more thoroughly, we report the structural venue-selection probit model in table 6, where an eBay sale is the dependent variable and the difference in net revenues predicted from the hedonic regression results and subsequent calculations involving commissions, expressed in thousands of dollars, is one of the independent variables. The difference in net revenues is highly significant ($t = 8.36$, $p < 0.001$), which suggests that sellers target tractors to the venue that will fetch the greatest revenue. The marginal effect of a change in expected net revenue is modest, however, with the change in probability of a sale to eBay changing by less than one percent for an incremental change in predicted net revenue. The additional identifying regressors used in the reduced-form selection model continue to hold their same sign and significance in the structural model, i.e., greater machinery values and greater sales volume in the state of sale depress the likelihood of an eBay sale. An additional regressor, which was insignificant in initial reduced-form estimations and excluded from the reduced-form model reported in tables 3 and 4, is the proportion of farmers in the state of sale that report using the internet for agricultural marketing purposes. For the full sample, this variable is a positive and significant predictor of eBay sales. That is, for states in which a

greater portion of farmers use the internet for agricultural marketing, this propensity appears to spill over to capital equipment marketing.

For the less expensive tractors explored in the lower half of table 5, where prices and net revenues are predicted using the restricted sample model, the predicted reduced-form probabilities do not reflect uniformly the difference in predicted revenues. For example, the sale of the Versatile-make tractor on eBay is predicted to generate more in net revenue than would a traditional auction. However, the reduced-form venue-selection model only places the probability of an eBay sale at two percent. The other two sample tractors in the bottom half of table 5 do predict that the tractors will be offered in the venue with the highest predicted net revenue.

When we repeat the structural probit estimation for this sub-sample (table 6, column 2), we also find the difference in predicted revenues is positive and significant ($t = 7.15$, $p < 0.001$). In other words, it appears that, for the sub-sample of tractors selling for less than $20,000, sellers are systematically directing tractors to be sold in the outlet that is predicted to yield higher net sales receipts. Furthermore, the marginal effect of the difference in revenues is much larger in this sample of lesser-valued tractors (4.4 percent versus 0.6 percent). The signs and marginal effects of the other venue selection variables are similar between the two samples, though the internet marketing variable in the sample of lesser-valued tractors fails to be statistically significant.

Discussion and Conclusions

Markets for durable and non-durable agricultural inputs are being altered by the emergence of internet-based trading venues. We explore differences between internet and traditional markets for used tractors by estimating an endogenous switching model in

which the second-stage estimates are hedonic price models fit to data from eBay and in-person auctions. We find the eBay and in-person auctions yield distinct hedonic price surfaces and that the average price received in eBay auctions is substantially lower than that received in in-person auctions.

Several possible explanations exist for this divergence. First, the first-price auction mechanism used at in-person auctions is known to generate higher prices than the second-price mechanism used by eBay if buyers are risk averse. Risk-averse buyers may self-select to in-person auctions because they can personally inspect items and deal with licensed and bonded auctioneers. Without data on the characteristics of buyers at each auction venue, however, we cannot test this hypothesis. Second, buyers may suspect adverse selection and shade bids for eBay items lower. eBay buyers are protected from seller fraud and misrepresentation for items that sell for less than $20,000 and, if adverse selection were an issue, we would expect to find greater equivalency between eBay and in-person bids for tractors that sell in this price range. Indeed, we find the percentage discount for eBay tractors is substantially smaller for items that sell for less than $20,000. In fact, for the most frequently traded model in our data set, which normally sells for prices well below the $20,000 threshold, the distribution of prices obtained in eBay and in-person auctions is no different. However, without eBay data that precedes the implementation of this eBay buyer protection policy, we cannot definitively say that it is the buyer protection policy that causes this greater price equivalency, nor draw solid conclusions that adverse selection is driving the underlying divergence in prices between the two venues. Hence, substantial work remains to unravel the explanation for the substantial eBay used tractor discount we uncover in our data.

From a strategic point of view, the presence of an eBay discount suggests that, from the buyer's point of view, purchasing newer, more powerful tractors on eBay may offer the opportunity to source key machinery at a discount compared to traditional in-person auctions. However, these buyers must bear additional risk both because they cannot personally inspect the merchandise and because occurrences of fraud or misrepresentation cannot be fully covered under existing eBay *ex-post* risk protection programs. Indeed the hedonic equation for eBay auctions features greater price variation. Indirect evidence, in the form of highly correlated within-seller error terms from the random-effects regression of an eBay-only sample ($\rho = 0.69$), suggests that *ex-ante* reputational devices such as eBay's seller rating mechanism provide important information that is valued by buyers.

From a seller's point of view, eBay is attractive because it offers great flexibility (e.g., absolute freedom to choose sale dates, no transportation of equipment to a central location) and low commissions (capped at $250). However, for tractors that sellers think will sell above the $20,000 limit of the eBay buyer protection program, our calculations suggest that in-person auctions generate greater total seller revenue, i.e., the higher commissions paid to in-person auctioneers are outstripped by higher selling prices. Indeed, the in-person flat commission rate that would equalize seller revenues gained from eBay and in-person auctions averages 55 percent, which is more than triple the highest commission charged by in-person auctioneers.

Smaller, older tractors, which commonly sell for prices less than $20,000, can often generate more revenue if sold on eBay. The in-person flat commission rate that would equalize seller revenues gained from eBay and in-person auctions averages only

29 percent across our sample of used tractors that sell for less than $20,000, while 39 percent of the tractors that sold for less than $20,000 in our sample are predicted to generate more seller revenue if sold on eBay.

In addition to informing potential used tractor market participants and providing insight into the emerging internet market for agricultural durable goods inputs, these results may also have implications for government statistical agencies that track the prices of durable equipment for purposes of productivity measurement and input index calculations. If a substantial percent of farm equipment is sold on internet auction sites and these sites generate different price levels and hedonic price surfaces, then agencies must account for this heterogeneity in their data sampling methodology.

Our auction venue selection model confirms that larger, diesel tractors are more likely to be offered at in-person rather than eBay auctions, suggesting that sellers may already realize that in-person auctions offer better sales opportunities for these types of machines. Indeed, for both the overall sample and for the sample of tractors covered by eBay's buyer protection program, the predicted difference in net revenues between the two auction venues is a significant driver of venue selection. We also find several state-level attributes that drive the selection between eBay and in-person sales. Sellers in states with a higher valued stock of machinery and equipment and more frequent tractor sales are more likely to offer tractors for sale through an in-person auction, while sellers from states in which farmers report more frequent use of the internet for agricultural marketing purposes are more likely to offer tractors on eBay.

Clearly additional research is necessary to help better understand the increasingly important internet marketplace. Data concerning the explicit and implicit costs and

benefits that sellers and buyers attach to internet and in-person auctions is needed to better articulate the differences that exist between these important agricultural market outlets and the drivers of observed price differences between the two venues. Furthermore, additional research to assess *ex-post* consumer satisfaction with tractors purchased in each venue is needed to more fully explore if each venue is delivering goods of similar quality.

Endnotes

[1] eBay also features "Buy it now", "Fixed Price", private, Dutch and restricted-access auction formats; our empirical analysis is limited to the second-price auction format.

[2] Even though the winner bidder pays more than the second-place bid, it maintains the key characteristic of divorcing the winning bid amount from the act of winning, which facilitates bidders bidding their true willingness to pay for an object.

[3] eBay provides several other instruments and policies to create trust, including escrow, fraud alert, protection claim, the "SquareTrade" conflict-resolution service, and explicit rules against certain deceptive practices (shill bidding, inappropriate bid retraction, etc.).

[4] In the selection equation, we do not have enough information to identify if the same seller has offered tractors to both eBay and in-person auctions; hence, a panel estimator approach is not pursued for the first stage of estimation.

[5] Specifically, $\delta[\bullet]$ in equation (1) is replaced with $\boldsymbol{\lambda}\mathbf{x}_i$ where $\boldsymbol{\lambda}$ is a row vector of reduced form selection parameters and $\mathbf{x}_i$ is the column vector of tractor attributes used in equations (2) and (3).

[6] The random effects estimator provides an estimate of the correlation of error terms across related sales, which is denoted in the results as ρ. We reject a fixed effects estimator because many of the seller-specific and event-specific dummy variables tend to be highly collinear with other dummy variables such as make, which leads to convergence problems. Furthermore, a Breusch-Pagan Lagrangian multiplier test for random effects firmly rejects the null hypothesis that the variance of the seller- and event-specific error components equals zero for the full sample ($\chi^2(1) = 142.13$, $p < 0.0001$) and the sample of tractors with sales price less than \$20,000 ($\chi^2(1) = 85.22$, $p < 0.0001$).

[7] The predicted prices used in this step are merely the $\boldsymbol{\beta}_j^* \mathbf{x}_i$, where $\boldsymbol{\beta}_j^*$ is the parameter estimate from step (b) because we now have observations for all tractors (see Maddala 1983, pg. 237). Also note that the difference in financial costs of selling in the two venues is explicitly modeled in step (c) using the commission and fees a tractor would accrue in each venue according to its predicted price; in step (a) these values were unobserved and absorbed into the intercept term.

[8] We also report estimates from equations (4) and (5) in the appendix.

[9] No qualitative results of subsequent tests between eBay and in-person price distributions for the John Deere 4020 change if these manual models are dropped.

[10] The upper (lower) boundary of the inner fence is determined by adding (subtracting) 1.5 times the inter-quartile range to the 75^{th} (25^{th}) percentile.

[11] Ideally we would repeat this analysis for a popular model that typically sells for more than $20,000 and is traded broadly in both in-person and eBay auctions. However, more expensive models tend to be newer, and fewer total units are typically produced for newer models. Hence, we could not identify any single model within this data set that would have provided a robust test in a higher price range.

[12] Pun intended.

[13] This value and the subsequently discussed value for the number of tractors held in inventory by farmers in a particular state are taken from the 2002 Census of Agriculture.

References

Bajari, P., and A. Hortaçsu. 2004. "Economic Insights from Internet Auctions." *Journal of Economic Literature* 42(2): 457-86.

Cohen, A. 2002. *The Perfect Store: Inside eBay*: Little, Brown and Company.

Dewan, S., and V. Hsu. 2004. "Adverse Selection in Electronic Markets: Evidence from Online Stamp Auctions." *The Journal of Industrial Economics* 52(4): 497-516.

Houser, D., and J. Wooders. 2006. "Reputation in Auctions: Theory, and Evidence from eBay." *Journal of Economics & Management Strategy* 15(2): 353-69.

Klemperer, P. 1999. "Auction Theory: A Guide to the Literature." *Journal of Economic Surveys* 13(3): 227-86.

Lancaster, K. 1971. *Consumer Demand: A New Approach*. New York: Columbia University Press.

Maddala, G.S. 1983. *Limited-Dependent and Qualitative Variables in Econometrics*, Cambridge University Press, New York.

Musser, S., Treasurer, National Auctioneers Association, Personal Communication, September 21, 2006.

Rosen, S. 1974. "Hedonic Prices and Implicit Markets: Product Differentiation in Pure Competition." *Journal of Political Economy* 82: 34-55.

Roth, A.E. and A. Ockenfels. 2002. "Last-Minute Bidding and the Rules for Ending Second-Price Auctions: Evidence from eBay and Amazon Auctions on the Internet," *American Economic Review* 92(4):1093-1103.

U.S. Department of Agriculture, National Agricultural Statistics Service. 2005. "Farm Computer Usage and Ownership," Washington, DC.

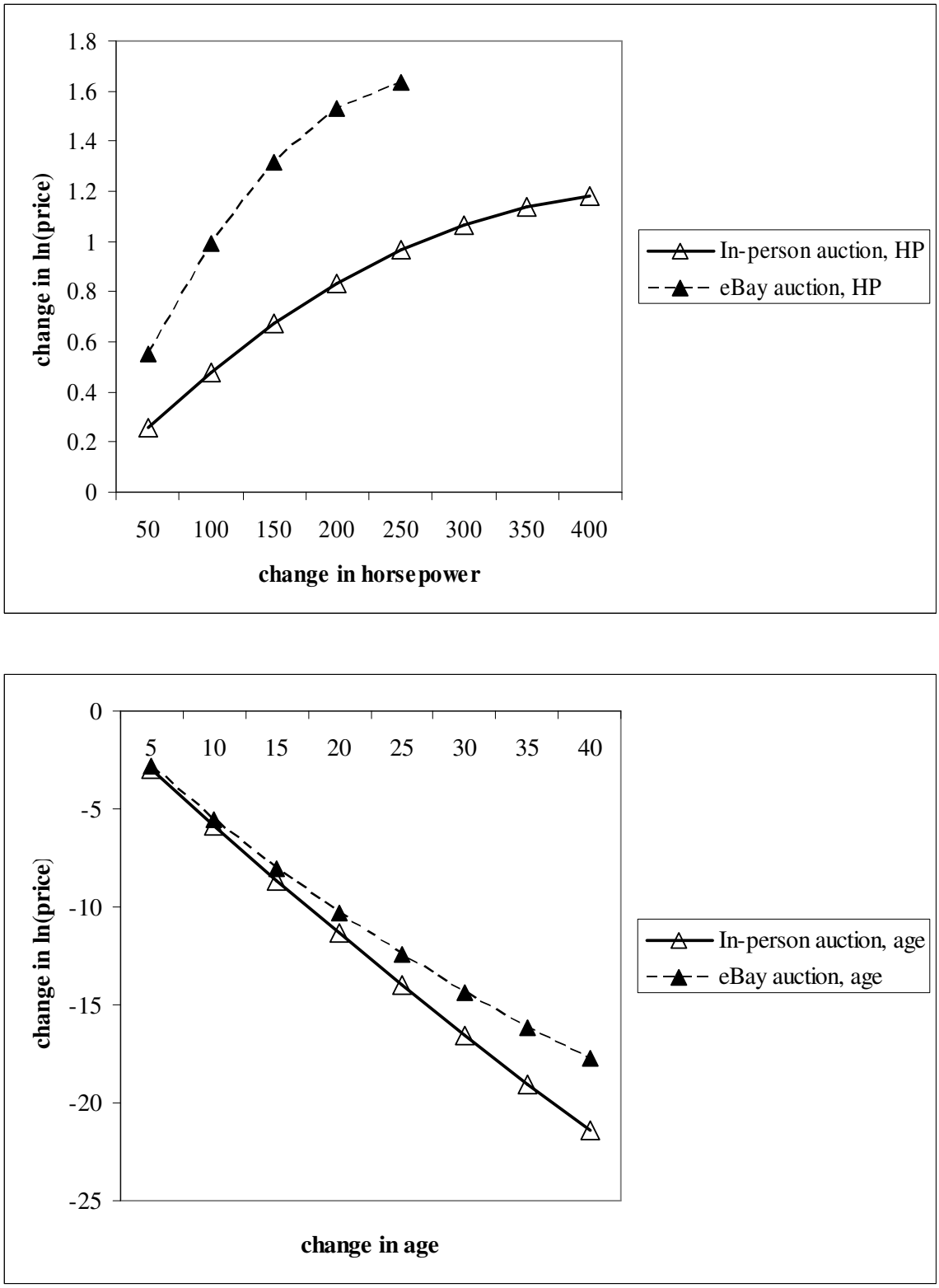

Figure 1. Quadratic effects of horsepower (top panel) and age (lower panel) in full sample hedonic model.

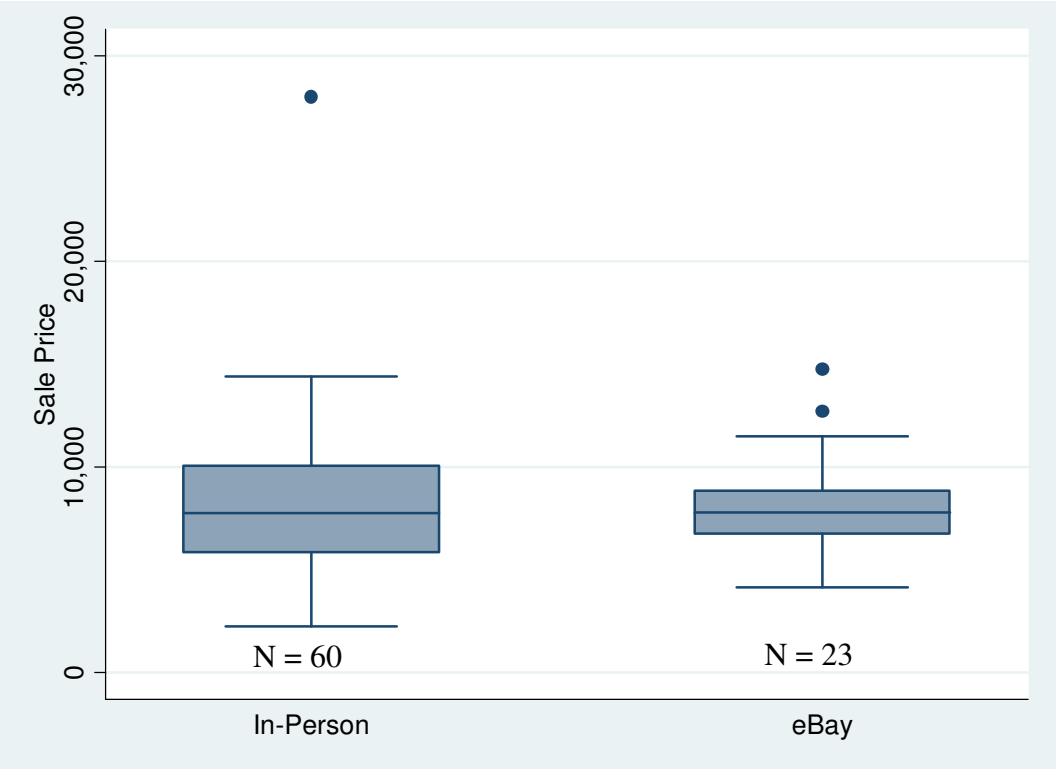

Figure 2. Box plot of distribution of sale prices for John Deere 4020 model by auction venue.

Table 1. Sample of Farm Equipment Commission Structure for Full Service Auctions

Final Selling Price	% Commission
< $10,000	12.5%
$10,000 to $19,999	8.4%
$20,000 to $49,000	7.4%
$50,000 to $99,999	6.9%
≥ $100,000	6.4%

Notes: An average of $450 in fixed fees are also assessed to the seller in addition to the calculated commission.

Table 2. Sample Summary Statistics

		Overall			Group Means[a]	
Variable	Definition	Mean	S.D.	Range	In-Person	eBay
Price	Final sale price (U.S. $)	19,473.57	22,663.06	180 – 158,000	24278.89	8492.04
eBay	=1 if sold on eBay	0.30	0.46	0 – 1	0.00	1.00
Horse	Engine horsepower (100)	1.25	0.78	0.30 – 4.70	1.45	0.77
Age	Years since date of manufacture	24.98	12.76	1 – 46	23.60	28.21
Hours	Engine hours (1000)	4.11	2.22	0.51 – 28.34	4.44	3.35
Implement	=1 if tractor sold with implement	0.15	0.36	0 – 1	0.10	0.28
Diesel	=1 if engine fuel is diesel	0.88	0.32	0 – 1	0.94	0.74
Manual	=1 if transmission is manual	0.49	0.50	0 – 1	0.44	0.59
4WD	=1 if four-wheel drive	0.35	0.48	0 – 1	0.41	0.24
Weekend	=1 if auction ends on weekend	0.26	0.44	0 – 1	0.25	0.30
Jun	=1 if sold in June	0.06	0.24	0 – 1	0.05	0.07
Jul	=1 if sold in July	0.10	0.30	0 – 1	0.10	0.07
Aug	=1 if sold in August	0.09	0.29	0 – 1	0.09	0.11
Sep	=1 if sold in September	0.07	0.26	0 – 1	0.07	0.09
Oct	=1 if sold in October	0.05	0.21	0 – 1	0.03	0.09
Nov	=1 if sold in November	0.09	0.29	0 – 1	0.09	0.10
Dec	=1 if sold in December	0.16	0.37	0 – 1	0.18	0.11
Jan	=1 if sold in January	0.09	0.28	0 – 1	0.07	0.12
Feb	=1 if sold in February	0.11	0.28	0 – 1	0.11	0.10
Mar	=1 if sold in March	0.18	0.38	0 – 1	0.20	0.14
JD	=1 if make is John Deere	0.46	0.50	0 – 1	0.50	0.38
IH	=1 if make is International	0.15	0.36	0 – 1	0.15	0.18
MF	=1 if make is Massey Fergusson	0.05	0.22	0 – 1	0.03	0.10
Ford	=1 if make is Ford	0.06	0.23	0 – 1	0.03	0.11
CaseIH	=1 if make is Case-International	0.09	0.28	0 – 1	0.11	0.03
Case	=1 if make is Case	0.05	0.21	0 – 1	0.05	0.04
FNH	=1 if make is Ford-New Holland	0.03	0.16	0 – 1	0.02	0.03

		Overall			Group Means[a]	
Variable	Definition	Mean	S.D.	Range	In-Person	eBay
AC	=1 if make is Allis Chalmers	0.04	0.19	0 – 1	0.03	0.04
Oliver	=1 if make is Oliver	0.03	0.16	0 – 1	0.02	0.04
NH	=1 if make is New Holland	0.01	0.11	0 – 1	0.01	0.02
White	=1 if make is White	0.01	0.12	0 – 1	0.02	0.01
Versatile	=1 if make is Versatile	0.02	0.13	0 – 1	0.03	0.00
Belarus	=1 if make is Belarus	0.01	0.08	0 – 1	0.00	0.02
Macval	State-level mean value of machinery & equipment per farm[b]	92.47	16.17	68.10 – 124.30	95.59	83.07
StateSale	# tractors in data set from state divided by 1000's of tractors in state[b]	1.57	0.59	0.48 – 2.40	1.65	1.32
NetMarket	% of state's farmers claiming to use the internet to engage in agricultural marketing activities[c]	10.82	1.72	7 – 13	10.95	10.44

a – For all continuous variables, group means are significantly different from one another at the one percent level as determined by a Kruskal-Wallis nonparametric test. For all categorical (month and make) and all binary variables, groups differ from one another at the one percent level as determined by a Pearson χ^2 test.

b – Data taken from 2002 Census of Agriculture for the state in which the tractor was sold, i.e., seller's listed state of residence for eBay sales and state of auction for in-person sales.

c – Data taken from the U.S. Department of Agriculture (2005).

Table 3. Endogenous Switching Regression: All Tractors

	ln(price)		
	In-Person	eBay Interaction	Prob(sold on eBay)
Constant	10.538***	-1.313***	4.039***
	(0.141)	(0.318)	(0.718)
Features			
Implement	0.070*	0.184***	0.197*
	(0.036)	(0.068)	(0.103)
4WD	0.030	-0.091	-0.031
	(0.041)	(0.117)	(0.122)
Manual	-0.152***	0.050	-0.653***
	(0.034)	(0.066)	(0.109)
Diesel	0.187***	-0.069	-0.449***
	(0.056)	(0.092)	(0.125)
Hours	-0.043***	0.009	-0.080*
	(0.017)	(0.055)	(0.042)
$Hours^2$	0.001	0.0009	0.005**
	(0.0009)	(0.0045)	(0.003)
Horse	0.539***	0.673	-1.772***
	(0.083)	(0.619)	(0.267)
$Horse^2$	-0.061***	-0.162	0.298***
	(0.015)	(0.281)	(0.061)
Age	-0.063***	0.015	0.032
	(0.008)	(0.014)	(0.024)
Age^2	0.0002*	0.0001	-0.0005
	(0.0001)	(0.0002)	(0.0004)
Make			
IH	-0.355***	-0.028	0.387**
	(0.038)	(0.086)	(0.161)
MF	-0.518***	0.010	0.874***
	(0.068)	(0.129)	(0.181)
Ford	-0.298***	0.043	0.255
	(0.077)	(0.112)	(0.175)
CaseIH	-0.062	-0.182	-0.121
	(0.047)	(0.167)	(0.198)
Case	-0.745***	0.023	0.270
	(0.050)	(0.135)	(0.192)
FNH	-0.156**	0.062	0.536***
	(0.071)	(0.117)	(0.198)
AC	-0.504***	0.070	0.330
	(0.078)	(0.151)	(0.216)
Oliver	-0.541***	0.136	0.275
	(0.063)	(0.113)	(0.224)

	ln(price)		
	In-Person	eBay Interaction	Prob(sold on eBay)
NH	-0.310**	0.198	0.627
	(0.129)	(0.159)	(0.399)
White	-0.584***	-0.211	0.135
	(0.090)	(0.354)	(0.287)
Versatile	-0.458***	0.258	0.228
	(0.074)	(0.802)	(0.617)
Belarus	-1.200**	0.493	2.133***
	(0.502)	(0.535)	(0.542)
Sale Timing			
Weekend	0.097***	-0.117**	-0.222*
	(0.033)	(0.059)	(0.132)
Jun	-0.130*	0.183*	0.403
	(0.069)	(0.108)	(0.263)
Jul	0.058	-0.042	0.196
	(0.079)	(0.108)	(0.238)
Aug	-0.050	0.066	0.047
	(0.058)	(0.090)	(0.211)
Sep	-0.075	0.018	0.218
	(0.067)	(0.109)	(0.239)
Oct	-0.085	0.067	0.489*
	(0.079)	(0.115)	(0.283)
Nov	0.025	-0.058	0.059
	(0.050)	(0.089)	(0.236)
Dec	-0.048	0.010	-0.073
	(0.048)	(0.098)	(0.222)
Jan	0.158***	-0.161*	0.506*
	(0.055)	(0.097)	(0.270)
Feb	0.037	-0.067	0.226
	(0.041)	(0.076)	(0.183)
Identify Outlet			
Mach Value	--	--	-0.025***
			(0.005)
StateSale	--	--	-0.528***
			(0.130)
σ	-0.030		
	(0.076)		
ρ	0.42		
With-in R^2	0.83		
Between R^2	0.82		
Overall	0.86		
pseudo-R^2			0.33

Notes: The first two columns are generalized least squares random effects (GLSRE) estimates of shadow values for tractor features sold at in-person auctions (column 1) and

the difference between in-person and eBay shadow values (column 2). Jackknife robust standard errors clustered on seller (eBay) or sales event (in-person) are reported in parentheses. Maximum likelihood probit coefficients for the selection equation are presented in column 3 with jackknife robust standard errors in parentheses. *, **, *** denote coefficients that are statistically different from zero at the ten, five and one percent levels. N=2,358.

Table 4. Endogenous Switching Regression: Tractors sold for less than $20,000

	ln(price)		
	In-Person	eBay Interaction	Prob(sold on eBay)
Constant	9.533***	-0.745**	4.692***
	(0.315)	(0.363)	(0.617)
Features			
Implement	0.111**	0.180***	0.117
	(0.044)	(0.064)	(0.110)
4WD	-0.088**	0.058	-0.032
	(0.041)	(0.103)	(0.145)
Manual	-0.070*	-0.014	-0.718***
	(0.040)	(0.073)	(0.107)
Diesel	0.239***	-0.092	-0.564***
	(0.060)	(0.087)	(0.126)
Hours	0.004	-0.089	-0.177**
	(0.024)	(0.055)	(0.082)
$Hours^2$	-0.001	0.008*	0.012*
	(0.002)	(0.005)	(0.007)
Horse	0.436***	0.933***	-1.167***
	(0.124)	(0.299)	(0.405)
$Horse^2$	-0.081**	-0.319***	0.266**
	(0.034)	(0.091)	(0.131)
Age	-0.006	-0.015	-0.028
	(0.021)	(0.024)	(0.027)
Age^2	-0.0006*	0.0006	0.0005
	(0.0003)	(0.0004)	(0.0005)
Make			
IH	-0.368***	0.030	0.353**
	(0.041)	(0.088)	(0.157)
MF	-0.536***	0.078	0.879***
	(0.074)	(0.129)	(0.181)
Ford	-0.363***	0.112	0.372**
	(0.070)	(0.107)	(0.177)
CaseIH	-0.229**	-0.148	0.309
	(0.094)	(0.155)	(0.298)
Case	-0.685***	0.062	0.131
	(0.050)	(0.130)	(0.183)
FNH	-0.335	0.298	0.897***
	(0.236)	(0.272)	(0.290)
AC	-0.499***	0.143	0.297
	(0.083)	(0.136)	(0.205)
Oliver	-0.565***	0.162	0.260
	(0.065)	(0.111)	(0.222)

	ln(price)		
	In-Person	eBay Interaction	Prob(sold on eBay)
NH	-0.408	0.551*	0.490
	(0.271)	(0.300)	(0.538)
White	-0.638***	0.097	0.026
	(0.086)	(0.192)	(0.300)
Versatile	-0.229**	0.812	-0.191
	(0.094)	(0.840)	(0.648)
Belarus	-0.826***	0.183	1.794***
	(0.222)	(0.301)	(0.545)
Sale Timing			
Weekend	0.074*	-0.079	-0.201
	(0.040)	(0.060)	(0.135)
Jun	-0.165**	0.249	0.416
	(0.074)	(0.119)	(0.271)
Jul	-0.022	0.055	0.332
	(0.099)	(0.122)	(0.260)
Aug	-0.089	0.095	0.029
	(0.063)	(0.095)	(0.216)
Sep	-0.131	0.078	0.304
	(0.082)	(0.120)	(0.249)
Oct	-0.139	0.138	0.724***
	(0.100)	(0.130)	(0.283)
Nov	-0.007	-0.065	0.126
	(0.070)	(0.102)	(0.253)
Dec	-0.132**	0.073	0.081
	(0.063)	(0.105)	(0.246)
Jan	0.085	-0.072	0.663**
	(0.070)	(0.102)	(0.299)
Feb	0.007	-0.029	0.328
	(0.053)	(0.085)	(0.204)
Identify Outlet			
Mach Value	--	--	-0.024***
			(0.005)
StateSale	--	--	-0.530***
			(0.141)
σ		0.046	--
		(0.080)	
ρ		0.368	--
With-in R^2		0.63	
Between R^2		0.63	--
Overall R^2		0.64	
pseudo-R^2			0.29

Notes: The first two columns are generalized least squares random effects (GLSRE) estimates of shadow values for tractor features sold at in-person auctions (column 1) and

the difference between in-person and eBay shadow values (column 2). Jackknife robust standard errors clustered on seller (eBay) or sales event (in-person) are reported in parentheses. Maximum likelihood probit coefficients for the selection equation are presented in column 3 with jackknife robust standard errors in parentheses. *, **, *** denote coefficients that are statistically different from zero at the ten, five and one percent levels. N = 1,627.

Table 5. Predicted Prices, Net Revenues, Equalizing Commissions and Sale Venue.

	Predicted Price: eBay	Predicted Price: In-Person	Net Revenue: eBay – In-Person	Equalizing Flat Commission	Predicted Prob(Sell on eBay)
Full Sample Model					
Average of All Tractors in Full Sample	9,789	21,448	-9,795	55.2%	0.25
Median of All Tractors in Full Sample	7,706	10,996	-2,068	31.3%	0.15
John Deere, Diesel Manual, 2WD, 300 HP, 2,000 hours, 10 years old, June weekend sale	32,737	55,132	-18,466	41.2%	0.01
Ford-New Holland, Diesel, Automatic, 4WD, 170 HP, 6,000 hours, 10 years old, August Weekday	16,468	24,875	-6,356	34.8%	0.09
Case–International, Diesel, Automatic, 4WD, 145 HP, 4,600 hours, 8 years old, February weekday	18,536	45,456	-23,367	59.8%	0.08
<$20,000 Model					
Average of All Tractors in <$20,000 Sample	5,855	8,077	-872	29.2%	0.34
Median of All Tractors in <$20,000 Sample	5,326	7,038	-489	26.1%	0.25
Versatile, Diesel, Manual, 4WD, 7,000 hours, 280 HP, 25 years old, December weekday sale	10,541	11,557	224	10.4%	0.02
Allis Chalmers w/ loader, Gas, Manual, 2WD, 2,500 hours, 50 HP, 43 years old, October weekend	3,141	2,372	1,416	NA	0.53
International, Diesel, Manual, 2WD, 4,000 hours, 146 HP, 27 years old, August weekend	6,804	9,464	-1,141	29.6%	0.07

Notes: Prices predicted from hedonic models in table 3 (top half) and table 4 (bottom half), net revenue and equalizing flat commission calculations reflect commissions discussed in text, 'NA' reflects that eBay sales generate greater net revenue prior to application of relevant commissions (though not fees), probability of sale on eBay predicted using models presented in table 3 (top half) and table 4 (bottom half).

Table 6. Probit of Structural Selection Model

	Full Sample	< $20,000
E[Net Revenue: (eBay – In-Person)]/1000	0.024***	0.128***
	(0.003)	(0.018)
	[0.006]	[0.044]
Internet Marketing	0.047**	0.031
	(0.022)	(0.024)
	[0.013]	[0.011]
Mach Value	-0.033***	-0.031***
	(0.002)	(0.003)
	[-0.009]	[-0.011]
StateSale	-0.577***	-0.529***
	(0.066)	(0.076)
	[-0.156]	[-0.184]
Intercept	2.783***	2.896***
	(0.245)	(0.265)
Pseudo-R^2	0.18	0.16
N	2358	1627

Notes: Maximum likelihood probit coefficients with jackknife robust standard errors clustered on seller or sales event in parentheses. Marginal effects evaluated at sample means are listed in brackets. *, **, *** denote coefficients that are statistically different from zero at the ten, five and one percent levels.

Appendix

Table A1. Individual Estimated Hedonic Models by Sales Venue.

	Full Sample		<$20,000 Sample	
	eBay	In-Person	eBay	In-Person
Constant	9.183***	10.730***	8.740***	9.666***
	(0.315)	(0.131)	(0.182)	(0.296)
Features				
Implement	0.245***	0.070*	0.292***	0.111**
	(0.070)	(0.037)	(0.053)	(0.046)
4WD	-0.048	0.030	-0.027	-0.088*
	(0.109)	(0.040)	(0.094)	(0.048)
Manual	-0.161***	-0.189***	-0.134**	-0.118***
	(0.059)	(0.033)	(0.059)	(0.037)
Diesel	0.084	0.137**	0.136*	0.180***
	(0.086)	(0.056)	(0.074)	(0.058)
Hours	-0.038	-0.055***	-0.082**	-0.010
	(0.049)	(0.017)	(0.040)	(0.025)
$Hours^2$	0.002	0.002*	0.007*	-0.0003
	(0.004)	(0.001)	(0.004)	(0.0019)
Horse	1.125*	0.434***	1.183***	0.348***
	(0.582)	(0.077)	(0.263)	(0.127)
$Horse^2$	-0.243	-0.044***	-0.368***	-0.076**
	(0.260)	(0.014)	(0.069)	(0.037)
Age	-0.045***	-0.059***	-0.019*	0.001
	(0.011)	(0.007)	(0.011)	(0.020)
Age^2	0.0003	0.00018	-0.00008	-0.0008**
	(0.0002)	(0.00013)	(0.0002)	(0.0003)
Make				
IH	-0.315***	-0.349***	-0.269***	-0.377***
	(0.083)	(0.039)	(0.084)	(0.044)
MF	-0.411***	-0.474***	-0.360***	-0.489***
	(0.107)	(0.070)	(0.090)	(0.073)
Ford	-0.227***	-0.293***	-0.229**	-0.357***
	(0.173)	(0.073)	(0.090)	(0.069)
CaseIH	-0.274	-0.081*	-0.417**	-0.204**
	(0.173)	(0.041)	(0.138)	(0.096)
Case	-0.710***	-0.747***	-0.602***	-0.702***
	(0.140)	(0.053)	(0.144)	(0.058)
FNH	0.007	-0.152**	0.055	-0.202
	(0.106)	(0.064)	(0.094)	(0.296)
AC	-0.393**	-0.500***	-0.320**	-0.489***
	(0.156)	(0.072)	(0.133)	(0.074)

Oliver	-0.372***	-0.536***	-0.384***	-0.559***
	(0.088)	(0.065)	(0.078)	(0.067)
NH	-0.096	-0.300**	0.167*	-0.140
	(0.093)	(0.125)	(0.093)	(0.268)
White	-0.775**	-0.617***	-0.518***	-0.695***
	(0.349)	(0.090)	(0.133)	(0.087)
Versatile	-0.180	-0.443***	-0.502	-0.175
	(0.688)	(0.071)	(0.527)	(0.108)
Belarus	-0.565***	-1.069	-0.512***	-0.714
	(0.179)	(1.070)	(0.177)	(0.724)
Sale Timing				
Weekend	-0.029	0.093***	-0.004	0.058
	(0.047)	(0.035)	(0.041)	(0.048)
Jun	0.090	-0.125**	0.137	-0.145**
	(0.085)	(0.062)	(0.091)	(0.066)
Jul	0.025	0.019	0.050	-0.077
	(0.080)	(0.075)	(0.078)	(0.104)
Aug	0.020	-0.048	0.001	-0.084
	(0.072)	(0.061)	(0.080)	(0.071)
Sep	-0.008	-0.089	-0.018	-0.157
	(0.094)	(0.075)	(0.097)	(0.101)
Oct	0.028	-0.037	0.041	-0.083
	(0.099)	(0.072)	(0.096)	(0.093)
Nov	-0.020	0.035	-0.069	-0.015
	(0.069)	(0.052)	(0.060)	(0.079)
Dec	-0.003	-0.057	-0.035	-0.150**
	(0.096)	(0.049)	(0.094)	(0.065)
Jan	0.055	0.174***	0.053	0.141**
	(0.071)	(0.051)	(0.075)	(0.067)
Feb	-0.023	0.062	-0.009	0.060
	(0.067)	(0.040)	(0.066)	(0.052)
σ	0.113	-0.196**	0.153	-0.114
	(0.123)	(0.080)	(0.109)	(0.087)
ρ	0.710	0.143	0.725	0.049
Within-R^2	0.72	0.84	0.70	0.62
Between-R^2	0.61	0.89	0.56	0.65
Overall-R^2	0.71	0.87	0.64	0.63
N	588	1770	549	1078

Notes: Generalized least squares random effects (GLDRE) estimates of shadow values for tractor features sold at in-person and eBay auctions. Jackknife robust standard errors clustered on seller (eBay) or sales event (in-person) are reported in parentheses. *, **, *** denote coefficients that are statistically different from zero at the ten, five and one percent levels.