Pigs in Cyberspace:
A Natural Experiment Testing Differences between Online and Offline Club-Pig Auctions

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Abstract: We find sale prices and net revenues received by sellers in the Midwestern club-pig market are higher at traditional face-to-face auctions than at comparable Internet auctions. The comparison overcomes adverse selection issues that commonly plague such analyses by using data from sellers that allocated pigs to both markets based solely on exogenous differences in dates between online and offline auctions. Furthermore, both auctions feature ascending price formats with 'soft-endings' and remaining quality variation is controlled by using detailed information on animal, seller and event characteristics. The results suggest that the higher prices and net revenues from traditional auctions are attributable to remaining differences in auction format and buyer pools. Furthermore, sellers may be willing to forgo higher revenues to capture the convenience and flexibility provided by Internet auctions, to reach buyers in other regions that face different seasonality in demand and to stimulate demand for privately negotiated sales.

Keywords: auctions, electronic commerce, two-sided markets, livestock marketing, hedonic models
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The performance of brick and mortar institutions relative to Internet alternatives is of increasing interest in many markets including those in the agricultural sector. While mature Internet markets exist for many domestic sectors, Internet penetration among U.S. farmers lags the general population (76% vs. 59%, USDA 2009). With Internet penetration rising steadily among farm households, online markets for agricultural inputs and outputs hold great promise for increasing market efficiency, particularly for items that may face thin local markets and high search costs. However, online markets must overcome issues of trust, as inspection of goods can be more difficult due to the physical distance that often separates online buyers and sellers. Furthermore, Internet markets are newer and face competition for participants on both sides of the market from traditional market venues, i.e., the two-sided market challenge of attracting enough participants on both sides of the market to sustain sufficient trade (Rochet and Tirole, 2006). Once these barriers are surmounted, questions still persist concerning the relative efficiency and attractiveness on online markets compared to existing physical markets.

In one striking example from the agricultural sector, Diekmann, Roe and Batte (2008) find large differences between eBay and traditional auction prices for used farm machinery where the median used tractor in their data set was estimated to sell for 30% less on eBay. The authors hypothesize several possible explanations for this large difference, including adverse selection issues that may lower the quality of offerings on eBay. Similarly, Banker, Mitra and Sambamurthy (forthcoming) find that premium Indian coffee beans, which require quality verification due to high variability, sell for significantly less on a digital platform than in a parallel analog market. However, outside of markets for agricultural goods, online platforms are not uniformly associated with lower sales prices for good of heterogeneous quality. In studies involving used cars, Internet prices were generally equivalent or higher than comparable offline sales (Wolf and Muhanna, 2005; Garciano and Kaplan, 2001), though Overby and Jap (2009) find sizable online discounts for older, high-mileage cars that are commonly associated with high quality variability.

Diekmann, Roe and Batte (2008) hypothesize that several auction format issues may exacerbate observed differences in channel-specific prices, including eBay's use of a hard versus a soft closing time for auctions, which has been shown to induce Internet bidders to snipe and drive down final auction values (Roth and Ockenfels 2002). Another auction format difference is that traditional auctions use a first-price format, which tends to inflate prices in the presence of risk-averse bidders, while second-price auction formats similar to that used by eBay are not influenced by bidder risk attitudes.

Comparisons of online and traditional platforms also face a fundamental econometric challenge because the quality of items offered for sale may be endogenous to the channel in which it is offered, leading comparisons of values generated in each market to be driven by unobserved heterogeneity rather than by other cross-channel differences. Indeed, Wolf and Muhanna (2005), Overby and Jap (2009) and Overby (2010) find indirect evidence that wholesale used cars are sorted between online and offline channels based upon quality.

We overcome this econometric challenge by using data from three reputable sellers in the Midwestern club pig market who regularly sell animals into both Internet and traditional auctions. Because all animals must be sold during a narrow time interval at a young age to qualify for this particular market and because sale dates for traditional and Internet auctions are spaced sufficiently far apart, we find that animal birth date acts as a randomization device that allows us to circumvent concerns that sellers are sorting animals between channels based upon unobserved quality attributes. Furthermore, we have detailed information on animal characteristics to control for observable traits that drive sale price and control for differences in transactions costs for each type of auction. Hence, the remaining difference in channel-specific values can be chalked up to differences in the efficiency of auction mechanism, the composition of buyer pools and the convenience factor related to selling via Internet auction.

These channel specific differences are statistically significant and have moderate economic impact. We estimate channel-specific hedonic functions and find that net revenue generated in traditional auctions is significantly higher. Specifically, the median animal would have generated nearly 2% more net revenue and a 1% higher sale price had it sold in a traditional auction than in the Internet auction.

The remainder of this article is organized as follows. We first discuss the nature of the show pig market and the details of the two auction formats from which we gather data. We then introduce the data and discuss the mechanism that assigns pigs to a particular auction mechanism. We then discuss how prices and net revenues differ across the two auction formats within our data set and how the two auction channels co-exist within the Midwestern market. Finally we discuss how our results fit into the existing literature concerning cross-channel competition and conclude.

The Club-Pig Market

The club pig or show pig market involves the sale of young pigs by swine farmers to individuals who exhibit pigs in county, state and regional livestock fairs.[1] By rule, youth exhibitors, who drive much of the demand in this market, must acquire the pigs several months prior to a

[1] Some pigs may also be sold to other breeders who hope to develop hog genetic lines that will yield pigs desired by this same group of buyers. The term 'club' pig comes from the fact that many youth buyers are part of 4-H clubs.

competition so that they can feed, care for and prepare the pig for competition. Competitors exhibit their pig in a show ring against others where all pigs are of a similar breed, size and gender. A judge with knowledge of preferred swine attributes ranks the pigs in each competition and ranks the winners across small groups for each breed (e.g., grand champions). Winners obtain cash prizes that vary with rank order. Winning animals are highly valued as breeding stock and may earn substantial additional revenues via sale in highly publicized auctions.[2]

Key structural elements of the exhibitions involve the fact that buyers must purchase pigs several months prior to a show, which implies that pig quality may change as part of the natural growth process and due to buyer care and handling practices. Therefore, end quality is not perfectly observable at the time of purchase. Furthermore, the pigs must be purchased such that the pig does not get too large prior to the show, which would induce a penalty. These two elements together imply that pigs must be purchased at a young age (two to three months) to qualify for competitions so that sellers must market hogs quickly after birth during a narrow window of each pig's life.

Data

We collected sale price and transaction cost data from three Midwestern farms that raise pigs for the club pig market and that sell via both Internet and traditional auctions. All three farms have established reputations in this market, including active websites listing animals they have sold that have go on to win champion honors at various shows. We have data on 305 pigs sold between February and July of 2010 including 159 sold via traditional auction and 146 sold via Internet auction (table 1). The Internet auction sales represent all pigs sold via Internet by these

[2] For example, the Grand Champion Barrow at the 2010 Ohio State Junior Fair sold for $42,000, of which $9,000 went to the youth exhibitor. $9,000 is about 45 times the contemporaneous commodity market price for a similar weight hog.

three farms during the this time period, while other pigs not in our data set may have been sold via traditional auctions or via private negotiated sales.

To isolate the impact of sale platform on price and seller net revenue, we control for other observable characteristics of each pig including age, gender, breed and physiological defects (see table 2 for summary statistics). We control for seller reputation by adding dummy variables for each farmer contributing pigs to the sample. Also, to control for seasonality that may drive prices in the show pig circuit (demand decreases as the year progresses due to the timing of most county and regional fairs), we add a linear time trend.

Internet and Traditional Auctions

The Internet auction platform we study is operated by a private firm in the Midwest who also conducts traditional auctions. More than 150 sellers from 24 states use the platform for sales though the three sellers we track multi-home, i.e., sell pigs in several venues. The platform uses both fixed and variable fees for sellers ($20/head plus 10% of sale price) and a variable fee for buyers (10% of sale price) where half of the variable fee charged to buyers is returned to the seller to cover coordination and shipping costs with the buyer.

The buyer's premium holds two implications for our data. First, there are two distinct prices for Internet auctions: the raw sale price and the buyer's price, where the latter includes the 10% buyer's premium. In all analysis, we compare and model both prices. Second, there is some uncertainty as to the seller's true net revenue from the sale because half the buyer's premium is returned to the seller to cover the costs of coordinating pig delivery and we were unable to obtain the seller's costs for coordinating delivery. Therefore, we calculated seller net revenue under two extreme assumptions: (1) the costs of coordination fully equaled the money returned to the seller and (2) the costs of coordination were zero. The qualitative results from the regression results did not change. Hence, all numbers in the figures, tables and text assume that sellers costs of coordination equaled the returned buyer's premium (assumption 1).

The auction uses a maximum bid function that resembles a second-price mechanism. Specifically, bidders enter a current bid and may enter a maximum bid where the computer interface will increase that individual's bid up to the maximum bid if another bidder exceeds the current bid. Bidders may increase their maximum bid prior to the close of auction, though the bidder is not automatically notified of being outbid and must monitor the auction in real time.[3]

Bidding is on individual pigs (not on lots or pens of pigs) and each listing is scheduled to end at a specified time where the closing time for each pig's auction is at least two minutes apart. Unlike eBay, closing times are 'soft', i.e., the ending time is extended if any bids have arrived in the past five minutes.

Buyers and sellers work together to arrange transportation for purchased pigs from the seller's location to the buying farm, with buyer and seller often arranging a rendezvous at an upcoming regional sale or show and costs covered by the half of the buyer's premium. Other costs associated with the sale are those associated with taking a digital picture of each pig and writing a description of the pig for the online auction catalog, which are estimated to require about 15 minutes per pig.

The live 'traditional' auctions all occurred within Ohio and Indiana, which are the home states of the three sellers in our data set. All live auctions featured a standard first-price, ascending, open-outcry format. Sellers face a 2% commission and no fixed sale fee imposed by the auctioneer.

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[3] The online auction site owner reports that approximately 80% of bidders enter a single bid and do not return to update it.

However, sellers do face preparation and transportation costs to move pigs to the central sale facility and costs associated with running the auction, which we estimate based on discussions with the sellers. These include the cost of operating the truck and trailer used to move the animals to the show (plus a return empty trip), which we assume to cost $1.25 per mile. Also, the sellers incur labor costs for preparing and loading the animals for transport (3 minutes/pig plus 30 minutes per load), traveling to and from the sale location (2 to 4 people for 1 – 6 hours) and hours on site during the auction (2 to 4 people for 6 – 8 hours). We assume labor costs of $9.75 per hour, which was the prevailing wage hourly paid to livestock laborers in the Eastern Cornbelt region during spring sale season (USDA 2010) and use detailed information on the distance from the farms involved to the live sale sites to calculate travel and time costs. Finally, the sellers face costs for renting the sale facility ($125 - $250 per event), employing individuals to assist the auctioneer ($375 to $750 per event), and bedding for the animals while on site ($1/pig). These additional costs vary by sale and range from $24 to $129 per pig (see table 1). Also note that transportation increases the odds of stress, injury or death while co-mingling of animals from different sellers at the auction site (which occurs in one of the live auction events) increases the odds of disease, which can harm the growth of the pig once purchased.

Buyers at traditional auctions face no explicit fixed or variable fee, though they do incur transportation costs to attend the sale and time costs involved in attending the sale, which are likely greater than those absorbed by Internet bidders.

Exogenous Assignment to Channel

One roadblock to isolating the effect of auction platform on sale price and revenue is that of endogenous sorting of items by sellers across channels. That is, a comparison of prices and net revenues generated by pigs sold in each venue may suffer from unobservable systematic variation in the animals allocated to each channel. An ideal test would result from sellers randomly assigning individual pigs to the different platforms. If this were the case, then we could test for differences in prices across platforms while holding constant the observable attributes that drive price via statistical means such as regression or matching. However, sellers may choose the channel for an item based on unobserved qualities or characteristics of each animal. In such a case, then this ancillary selection process can confound our interpretation of simple comparisons of prices across platforms as any observed price differences may be due to the selection process leading some items to be sold in one platform but not another.

We overcome this endogenous selection problem by exploiting natural variation in the timing of sales between Internet and live auction formats and the fact that each farmer in the data set sells to both Internet and live auctions. Because animals must be owned by the eventual buyer for a sufficient length of time prior to a contest and because the contests penalize pigs that have grown too large, it implies a narrow age range for all pigs sold (two to three months of age). Sellers have pigs born year round and seek sales venues available to sell the pigs before they become too old for the show pig market. For our sellers only one type of auction venue was available at any given time during the first half of 2010, meaning that sellers took all animals of a certain age range and sold them in the type of sale that was available.[4]

[4] Sellers also allocate pigs to privately negotiated sales, which occur throughout the year and account for the bulk of their sales. For example, 75% of Seller K's pigs are sold via bulk private treaty sales to distributors in other states (personal communication, 2010). Sellers engage in an initial quality sorting process where lower quality pigs are slated for private treaty sales and higher quality pigs are selected for auction, where the auction venue for these

For example, in table 1, we see that Seller K had 87 pigs born between December 4, 2009 and February 28, 2010 that were approaching market age in early March, 2010. The available sale dates were an Internet auction on March 18 and a live auction on April 8, 2010. The farmer chose to sell those born prior to January 1 at the first sale, which happened to be an Internet sale, and those born after January 1 at the latter sale, which happened to be the traditional auction. Had the birthdates of the pigs overlapped between those sold in Internet auctions and live auctions, we would suspect that the farmer was sorting pigs across auction venues.[5] Instead, we see a separation of birth dates between pigs sold in Internet and live auctions for each seller. Hence, the natural variation in sale date and pig age determines which channel receives each pig.

Prices and Net Revenues by Channel

As an initial exploration of the data, we present the box plot of net revenues by channel in figure 1 and of buyer prices by channel in figure 2. In figure 1 we notice several differences between the net revenues generated in the two channels. First, the median net revenue generated per pig at the traditional auction is $128 (about 26%) higher than at the Internet auction site. This difference between venues is larger for higher percentiles ($637 or 79% for the 75th percentile) and smaller at lower percentiles ($49 or 16% at the 25th percentile). Finally, the far right tail of the traditional auction features one pig sold that generated an extremely high net revenue (greater than $8000 where as the next highest net revenue is just over $4000). However, we verify that the qualitative results of regressions hold even when omitting this particular observation. Finally, we find that the net revenue floor for pigs sold on the Internet is around

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higher quality pigs is assigned according to the process described in the text. Higher quality pigs go to auction because these prices provide favorable, publicly observed prices upon which to base private negotiations.

[5] There was overlap in birthdates for pigs sold by Seller M at two auctions in April. However, these were both live auctions, and the methodological focus is sorting across Internet and live auction formats and not potential endogenous selection among different auctions within the same format.

$150 while for pigs sold at traditional auctions nearer to $70. All together this suggests that net revenues are larger for traditional auctions and a nonparametric test confirms this (Kruskal-Wallis test, $\chi^2(1) = 5.55$, $p = 0.02$). A similar visual (not shown to conserve space) and statistical comparison holds for raw sale prices between the two venues, though the nonparametric test of differences is only marginally significant (Kruskal-Wallis test, $\chi^2(1) = 3.11$, $p = 0.08$). Buyer prices (figure 2), which differ from sale prices due to a 10% buyer's premium for Internet sales, are similar between the two channels (Kruskal-Wallis test, $\chi^2(1) = 0.53$, $p = 0.48$).

However, the observable characteristics of pigs and sales events systematically differ across venues (see table 2), suggesting that the raw difference in prices may instead be a function of observable characteristics rather than due to the auction platform. For example, pigs sold at the Internet auctions are older and less likely to male.

Therefore, in table 3 we present Ordinary Least Squares (OLS) regression results that explain the log of raw sale price and the log of net revenue as a function of observables and including robust standard errors clustered on the sale event. The explanatory variables of the regression model consist of dummy variables for auction format and gender, categorical variables for seller and breed, and continuous variables for age and time trend. The model specification also features interaction terms between the auction format and other observable characteristics to allow for distinct hedonic surfaces across sale channel.

Note that we express the continuous variables as a deviation from their sample medians (age = 2.33 months, time = 44 days from the first sale date) so that intercept term can be interpreted more easily. Specifically, the intercept term represents the average log price or log net revenue for male, crossbred pigs of median age sold by Seller S through an Internet auction held on April 10 (44 days after the first sale). Further, this allows us to interpret the coefficient on the dummy variable for the traditional auction format as the change in log price or log net revenue that would occur had this same pig been sold in a traditional auction format.

In table 4, we convert this change in log price and log net revenue to its corresponding change in levels such that, for example, $\Delta price = \exp(\beta + MSE/2)$ where $\Delta price$ is the change in price levels due to switching a pig from an Internet to a traditional auction sale, exp(.) is the exponential function, β is the coefficient on traditional auction format estimated as part of the regression, MSE is the mean square error of the regression and the logs-to-levels conversion expression is adapted from Newman (1993).

We also estimate an identical model for the log of buyer's price. However, as the buyer's price and the sale price differ only in that Internet buyer's are charged a 10% premium over sale price, the results are identical except for the coefficient on the dummy variable for traditional auction format, which is reported in the footnote section of table 3.

We choose regression over matching estimators because we find a strong time trend where sale prices decline later in the season. Furthermore, we only observe traditional auctions during one narrow period on the time frame of our data (April). Had we chosen a matching estimator, we would have to match pigs sold via Internet in winter or summer to pigs sold in traditional auctions in spring, which would not allow for a satisfactory match. Regression allows us to better exploit the variation in sale dates in both Internet and live auctions to compare prices and net revenues received across venues. We choose to model the dependent variable in logs rather than levels as this provides a better regression fit and is supported by Box-Cox transformation diagnostics.[6]

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[6] The estimated Box-Cox transformation parameter is -0.162 with a 90% confidence interval of [-0.258, -0.067]. While we reject restricting this parameter to 0 to meet the logarithmic case ($\chi^2 = 7.88$, $p = 0.005$), restricting the parameter to 1 to meet the linear case is rejected more strongly ($\chi^2 = 380.81$, $p < 0.0001$).

The regression results confirm that pigs sold in traditional auctions yield distinct hedonic surfaces for both price and net revenue. First the intercept shifter for the traditional auction format is positive and significant for sale price, net revenue and buyer price, i.e., holding all else equal, prices and net revenues were higher at traditional auctions. Furthermore, the terms interacting pig, sale and seller characteristics with auction format are jointly significant for all models (see the first line in the bottom panel of table 3 for the test statistics). Individual interaction terms are significant for seller dummies, breed and the time trend across the two models.

To understand the magnitude and robustness of these results in table 4 we convert the traditional auction format coefficient for each model (sale price, buyer price and net revenue) to levels for each model presented in table 3 and for several other variations of the model. These variations include OLS regression where the continuous variables of age and time are normalized to their means (age = 2.41, time = 52.35) rather than their medians and quantile regressions for the 25th, 50th and 75th percentiles.

Resutls from table 4 suggest modest thought statistically significant impacts of auction format. For example, for the models presented in table 3, we find a net revenue effect of the traditional auction format of about $9, which translates to a 1.6% of the net revenue generated by the median pig in the sample. Price effects were smaller – about $5.50 for sale price and about $5 for buyer price – which translates to less than 1% of median values.

The second set of values in table 4 revolve around OLS regression results when age and time of sale are normalized on mean values, which are larger than the median values used in the first set of values. Here the impact of auction format is even smaller, with significance levels dropping for each dependent variable considered and with the significance of auction format on buyer price becoming insignificant at the 10% level. This suggests that for sales later in the season and for older pigs, format exerts less of an impact upon outcome variables of interest.

The final three groupings of results from table 4 present results from 3 quantile regressions. The key pattern in these results is that the impact of auction format increases for more expensive pigs. For example, at the 25^{th} percentile the impact of auction format is less than 1% for net revenue and the price variables. At the 50^{th} percentile, these impacts grow to be between 1% and 2% while at the 75^{th} percentile, effects range from nearly 2% for buyer price to nearly 4% for net revenue. This pattern is not surprising given the raw data plots in figures 1 and 2, where the bottom of the box (which represents the 25^{th} percentile of the raw distribution) are quite similar but the top of the box (representing the 75^{th} percentile) are visually distinct.

The detailed regression estimates in table 3 also reveal some basic tenants of how pigs are valued in the club-pig market. For example, younger pigs are valued more highly than older pigs despite the fact these animals are smaller and prices are expressed per pig and not per pound. This is driven by weight penalties common at many shows, i.e., pigs are penalized if they exceed a maximum weight threshold, where pigs that are heavier at purchase are more likely to be penalized at the show and be eligible for fewer shows during a given season. Females (gilts) are valued more highly than barrows (castrated males), which is expected as they may provide offspring while the barrows cannot. Finally, there is a strong downward trend in prices as the season progresses, which makes sense given that animals purchased earlier in the year may be eligible for more summer shows while pigs purchased late in the season will only be available for late summer and fall shows.

Internet and Traditional Auction Co-existence

Prior to the Internet, the Midwestern show pig sale season was largely concentrated to large weekend auctions that stretched from mid-March to early May where Midwestern buyers purchased pigs for the dominant summer show season. Buyers with demands for the few early or late season shows would engage in private negotiations directly with buyers to meet demand.

To better understand how traditional auctions co-exist with Internet auction in this market since the advent of Internet platforms, we gathered data about the number, size and timing of Internet auctions held by sellers from one state (Ohio) during the 2010 sales season (January – July). We choose to focus on Ohio as we have additional information about the number of traditional auctions conducted during this same time period that was published in a sale calendar distributed by a state-wide agricultural trade publication (Ohio's Country Journal, Spring 2010 Livestock Directory) and from an authoritative web site that documents club-sales throughout Ohio (PrimeTime Agri-Marketing Network, Inc., Spring 2010 Showman's Handbook). The sources report the date and, in many instances, the number of pigs sold per auction.

In figure 3 we graph the number of sale events held each month in Ohio during the first part of 2010 and, in the legend, we list the mean number of pigs offered at each event. Clearly Internet sales involve fewer animals per event (16.3) than traditional auctions (104.1, Kruskal-Wallis test, $\chi^2(1) = 23.2$, $p < 0.001$). Furthermore, Internet sale event sizes get smaller during the traditional sales season months, though tests suggest this dip in sale size during peak months is not statistically distinct (18.6 for January, February, June and July vs. 15.3 for March, April and May, Kruskal-Wallis test, $\chi^2(1) = 0.35$, $p = 0.55$).

Traditionally live auctions sales in the Midwest still occur from late March through early May (light bars, figure 3). Advertisements in the sales calendars we consulted confirm that individual sellers offer to privately negotiate sales with individual buyers to meet offseason demand, though discussions with Seller K suggest that such sales entail greater transactions costs than auctions. The advent of Internet auctions provides another means to tap into offseason local demand as well as a means for attracting buyers from outside the Midwest who might have different seasonal demand as the show season differs throughout the United States. Furthermore, Seller K noted that Internet auctions provide a means to extract higher prices for top quality animals sold offseason.[7]

Within Ohio there were nine Internet auctions outside of the traditional spring sale months as well as 19 Internet auctions during traditional sales months (dark bars, figure 3). This suggests that Internet auctions have stolen some market share away from traditional auctions during the peak sale season, while simultaneously broadening auction season. Furthermore, none of the 19 Internet sales that occur during March, April and May were held on a weekend, while nearly all of the traditional auctions were on weekends. This suggests differentiation according to time, with Internet auctions reaching buyers with previous weekend commitments or buyers that were dissatisfied with offerings at weekend sales.

Interestingly, Internet sale sizes are larger in months when traditional sales are infrequent (figure 3, line graph) and, according to reports by the owner of the Internet auction platform, many buyers during these sales are located in states outside the Midwest. This suggests that the Internet platform is helping Midwest sellers meet the demand of buyers from other regions who have a different seasonality to their show season than do local buyers. Internet sale events

[7] Seller K noted that private treaty buyers often pressure him to sell top quality animals before other competing buyers have a chance to purchase (personal communication, 2010). The advent of Internet auctions provided a means for him to let the auction determine which buyer would gain access to these highest quality off-season pigs so he would not be seen as choosing favorites among frequent buyers.

become smaller during peak months for traditional auctions, however, suggesting that live auctions dominate in terms of total volume of sales.

These results paint a picture of how the two channels co-exist in the Ohio club pig market. Large traditional auction events predominate during the spring sale season centered around April, though Internet auctions attempt to plug holes by offering smaller offerings during the week between the larger weekend live auction events. The smaller scale of Internet auctions is logical as transactions costs for Internet auctions feature lower fixed costs and hence, allow sellers to efficiently move smaller lots with little penalty. Furthermore, sellers can monitor the sale while attending to regular duties at home or work, which may be critical as spring planting season requires considerable labor effort during this time of year.

However, Internet auctions are unlikely to fully supplant traditional auctions because these auctions feature stronger interactions between the sellers and potential buyers that facilitate industry discussions and networking opportunities that are difficult to duplicate via the Internet interface. Within such a niche market, it might be unwise for sellers to fully disengage with traditional auction sales.

Discussion

Comparisons of prices and net revenues generated by competing online and offline marketing channels are complicated in most settings because there may be substantial sorting or adverse selection that occurs between the two channels. Often this sorting occurs in terms of unobservable quality differences in the items offered in the two channels. Some past work has circumvented this problem by focusing on new, homogeneous products (e.g., new DVDs (Chiou 2009), new books (Forman, Ghose and Goldfarb 2009), women's apparel (Brynjolffson, Hu and

Rahman 2009), computer memory (Ellison and Ellison 2009), computers (Goolsbee 2001). However, items of heterogeneous quality form a non-trivial portion of commerce and inherently increase the disadvantage of Internet channels as quality verification by buyers must be surmounted (Kazumori and McMillen 2005). Most past comparison of sales prices of goods with heterogenous quality involve products where the average quality between channels is likely to differ (Kazamori and McMillen, 2005; Overby and Jap, 2009; Wolf and Muhanna, 2005; Diekmann, Roe and Batte 2008), though Hendel, Nevo and Ortalo-Magne (2009) overcome this challenge by using repeat sales data from existing homes. We overcome this difficulty by using data collected from sellers who allocate items to both channels based on an exogenous factor – the birth date of animals.

Unlike in Hendel, Nevo and Ortalo-Magne (2009), sellers in our market do not offer a single unit of the good and therefore, are not restricted to single-homing (selling through a single channel), though any particular pig can only be offered on one platform at a time. Also, unlike Hendel, Nevo and Ortalo-Magne (2009) and Overby (2010), where many items are first offered in one channel and then, contingent upon lack of sale, are moved to the alternative channel, we deal with items that are generally offered for sale only once.

Our results challenge and confirm several concepts in the literature on two-sided markets. For example, Armstrong (2006) claims there is little incentive for multi-homing on both sides of a particular market. His argument is that, for example, once all sellers offer product on all platforms, there is little incentive for buyers to frequent all platforms because the seller’s product is available at all locations already (why should the buyer need to visit multiple platforms?). However, this might not be the case in instances like ours where both sides of the market deal in multiple units that are heterogeneous in quality and where product tends to be offered in one platform at only certain points in time (seasonally).

While challenging this concept, we confirm another insight provided by Armstrong (2006). We note that the Internet auction platform in this paper charges a tariff contingent upon a successful sale to both sides of the market (a commission for sellers and a premium to buyers). Armstrong notes that such a pricing structure minimizes cross group (buyer-seller) externalities in a setting that features competing platforms. Specifically, compared to say, a lump sum entry fee that is charged regardless of a successful transaction, the sale-contingent tariff revenue grows with the success of the platform in attracting more buyers and sellers and means that the platform itself harvests the benefits of successfully expanding interest on both sides of the market.

Our analysis is also subject to several limitations. One limitation is the lack of information concerning the pool of buyers available at each venue or even information concerning the winning bidders for the pigs sold. Such information would provide for greater insight into whether buyers in this market are multi-homing or single-homing. As others have shown (Armstrong 2006), this can have implications for equilibrium platform pricing and network size. Also, while we as researchers are aware of the random allocation of quality between the auction channels by the three sellers included in this study, buyers may not be aware of this and may think there is quality sorting by sellers. Furthermore, other sellers not involved in this study may engage quality sorting with lower quality pigs going to the Internet auctions, which could dilute the perceived value of items in this channel and dissuade buyer attendance at the Internet auctions.

These limitations suggest several avenues for future research. For example, Ambrus and Argenziano (2009) suggest that when two platforms do exist in equilibrium, then one will be larger and cheaper on one side of the market while the other will be larger and cheaper on the other side of the market. We do not have enough information about the effective price buyers face when attending traditional auctions nor do we have enough information about the relative size of seller and buyer pools for the two markets in our study to verify if this holds in our case. Furthermore, we cannot yet say if the Internet platform in our market has reached maturity, which further hampers our ability to make such an assessment.

Also, while both venues are auctions with soft endings, other auction specific differences may contribute to the observed price differences. More risk-averse buyers may predominate at the traditional auctions, particularly as attendance provides a live view of the pig and greater confidence in the surety of the sale, which may attract such buyers. As Klemperer (2000) notes, open-outcry first-price auction prices tend to be shaded upward in the presence of risk-averse buyers. Second-price auctions are not subject to this upward influence by risk-averse buyers, and the Internet auction in this study features second-price elements in its construction. Roe, Batte and Diekmann (2010) note that risk-averse buyers tend to eschew Internet platforms for heterogeneous goods in favor of brick and mortar alternatives. However, without an analysis of buyers in this market, we are unable to determine if this is a contributing factor within our data.

Conclusions

We find that sale prices and net revenues are significantly higher for pigs sold in traditional auction markets than in a competing Internet auction market. The magnitude of the median effect (about 1% for prices and nearly 2% for net revenue) is substantially smaller than the 30% median Internet discount identified by Diekmann, Roe and Batte (DRB, 2008) for used U.S. farm equipment but similar to the magnitude identified by Banker, Mitra and Sambamurthy (forthcoming) when comparing online and offline sales of coffee in India.

The smaller effect than DRB might stem from a number of differences, including data differences, seller reputation differences and auction design differences. First, our data overcomes problems of endogenous quality sorting by leveraging exogenous assignment of animals to market channel that arises due to the nature of the market for show pigs. DRB and other cross-channel comparisons using non-homogenous goods likely suffer from endogenous sorting of goods where goods with lower unobservable quality sort into the Internet channel. Second, differences may arise from the fact that our analysis uses three reputable sellers while DRB's data involves a broad array of sellers with no controls included for seller reputation. If DRB could have restricted their sample to only a few reputable sellers, the Internet discount may have been smaller. Indeed, Overby (2010) finds that the quality of used cars offered on the Internet is higher than the quality of cars offered in physical auctions, particularly for sellers who have established deep repeated-trading relationships with buyers. Finally, the Internet auction mechanism in our study more closely mimics the structure of the standard auction than does the eBay mechanism generating DRB's Internet data sample. The eBay 'hard ending' feature is known to induce sniping, which shades down final sale prices (Roth and Ockenfels, 2002), while the Internet auction in our study features a soft ending.

We also chart out the timing and relative size of Internet and traditional auction events for one state within our data and infer that the introduction of the Internet auction platform has likely stolen some market share from traditional auctions during the seasonal peak in demand via the use of smaller online sales events held during weekdays between the large weekend live sales. It also appears that the Internet channel has extended the auction season for Midwestern sellers to reach Midwestern buyers with off-season demand and allowed Midwestern sellers to reach buyers in other regions who demand show pigs at different times of the year.

The advent of Internet auctions for club pigs has likely shifted the options available to Midwestern sellers. There is a long tradition of traditional (face-to-face) spring auctions in this sector to meet the chief demand for the summer fair season. Sales of pigs born too early or late for this key market would chiefly be made via private treaty sales in the era prior to Internet auctions. However, the advent of Internet auctions may be replacing these private treaty sales with a potentially more efficient mechanism and replacing some of the traditional auctions during peak season.

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Table 1. Pig Birth Dates and Sale Venue by Seller.

Sale Date	Pig Birth Dates	Sale Type	# Sold	Mean Age (d)	Sales Cost per Animal
Seller M					
2/25/2010	11/10/09 – 12/24/09	Internet	31	75.3	$22.43 + 10%
4/10/2010	12/24/09 – 2/23/10	Live	79	64.4	$24.53 + 2%
4/18/2010	2/7/10 – 2/23/10	Live	9	61.3	$129.00 + 2%
6/1/2010	3/25/10 – 4/1/10	Internet	10	64.4	$22.43 + 10%
7/12/2010	4/20/10 – 5/3/10	Internet	11	72.6	$22.43 + 10%
Seller S					
2/25/2010	12/1/09 – 12/18/09	Internet	14	79.0	$22.43 + 10%
4/18/2010	2/6/10 – 2/26/10	Live	15	64.9	$62.22 + 2%
6/1/2010	3/24/10 – 4/1/10	Internet	15	64.7	$22.43 + 10%
7/12/2010	4/21/10 – 5/3/10	Internet	12	78.7	$22.40 + 10%
Seller K					
3/18/2010	12/4/09 – 1/1/10	Internet	31	93.3	$22.43 + 10%
4/8/2010	1/1/10 – 2/28/10	Live	56	77.7	$29.94 + 2%
6/24/2010	3/22/10 – 4/17/10	Internet	21	75.4	$20.00 + 10%

Notes: N = 305. Sales costs for Internet sales include a $20 listing fee, $2.43 of labor costs per pig + 10% commission. Live auctions feature no listing fee, but the fixed cost includes seller-specific costs detailed in the text.

Table 2. Means (Standard Errors) of Observable Characteristics by Auction Type

Seller	Traditional Auction	Internet Auction	All
Sale Price ($/pig)	1081.0*	838.6*	965.0
	(85.5)	(65.1)	(54.7)
Buyer's Price ($/pig)	1081.0	922.4	1005.1
	(85.5)	(71.6)	(56.3)
Seller Net Revenue ($/pig)	1023.5**	730.3**	883.1
	(84.0)	(58.6)	(52.6)
Age (Months)	2.3***	2.6***	2.4
	(0.03)	(0.03)	(0.02)
Breed = Duroc (Dummy)	0.06	0.08	0.07
	(0.02)	(0.02)	(0.01)
Breed = Crossbred (Dummy)	0.86	0.79	0.82
	(0.03)	(0.03)	(0.02)
Breed = Hampshire (Dummy)	0.05	0.08	0.06
	(0.02)	(0.02)	(0.01)
Breed = York (Dummy)	0.04	0.06	0.05
	(0.02)	(0.02)	(0.01)
Male (Dummy)	0.69***	0.47***	0.58
	(0.04)	(0.04)	(0.03)
Time (Days after earliest sale)	44.5	60.9	52.3
	(0.3)	(4.7)	(2.3)
N	159	146	305

Notes: *, **, *** denotes differences between Internet and traditional means at the 10, 5 and 1% levels according to a non-parametric Kruskal-Wallis test for continuous variables and according to a Fisher's Exact test for dummy variables.

Table 3. OLS Regression Results

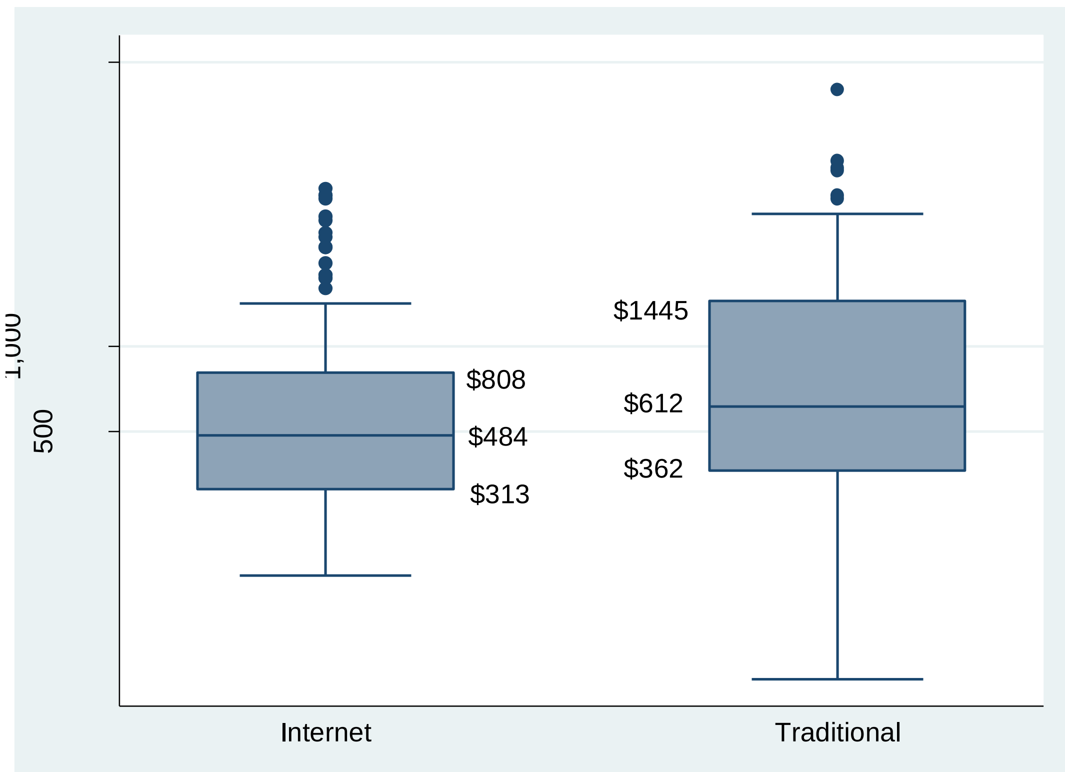
Variable	Ln(Sale Price)	Ln(Net Rev.)
Traditional Auction Format	1.352***	1.801***
	(0.185)	(0.195)
Seller K	-0.140	-0.153
	(0.216)	(0.227)
Seller M	-0.044	-0.052
	(0.218)	(0.230)
Age	-0.365*	-0.382*
	(0.176)	(0.183)
Female	0.434**	0.456**
	(0.140)	(0.146)
Breed = Duroc	-0.230*	-0.244*
	(0.118)	(0.123)
Breed = Hampshire	0.548***	0.570***
	(0.079)	(0.083)
Breed = York	-0.290	-0.300
	(0.262)	(0.280)
Time	-0.005***	-0.005***
	(0.001)	(0.001)
Traditional * Seller K	-1.800***	-2.307***
	(0.226)	(0.237)
Traditional * Seller M	-0.869***	-1.207***
	(0.220)	(0.232)
Traditional * Age	-0.005	-0.023
	(0.216)	(0.214)
Traditional * Female	-0.211	-0.233
	(0.182)	(0.194)
Traditional * Duroc	-0.325**	-0.349**
	(0.129)	(0.139)
Traditional * Hampshire	-0.120	-0.081
	(0.258)	(0.286)
Traditional * York	-0.409	-0.428
	(0.287)	(0.306)
Traditional * Time	-0.110***	-0.159***
	(0.003)	(0.002)
Constant	6.428***	6.198***
	(0.183)	(0.200)
F-test statistic that all interaction terms = 0	17.54***	639.23***
N	305	305
R^2	0.35	0.36

Notes: Age and time measured as absolute deviation from sample median. Robust standard errors clustered on sale event reported in parentheses. *, **, *** denotes statistical significance levels at the 10, 5 and 1 percent levels. An additional regression of the log of buyer's price yields identical results as the log sale price model except for the coefficient on the dummy for traditional auction formal, which is 1.257 with a robust standard error of 0.185, which is significant at the 1% level.

Table 4. Predicted Differences Between Auction Channels in Levels

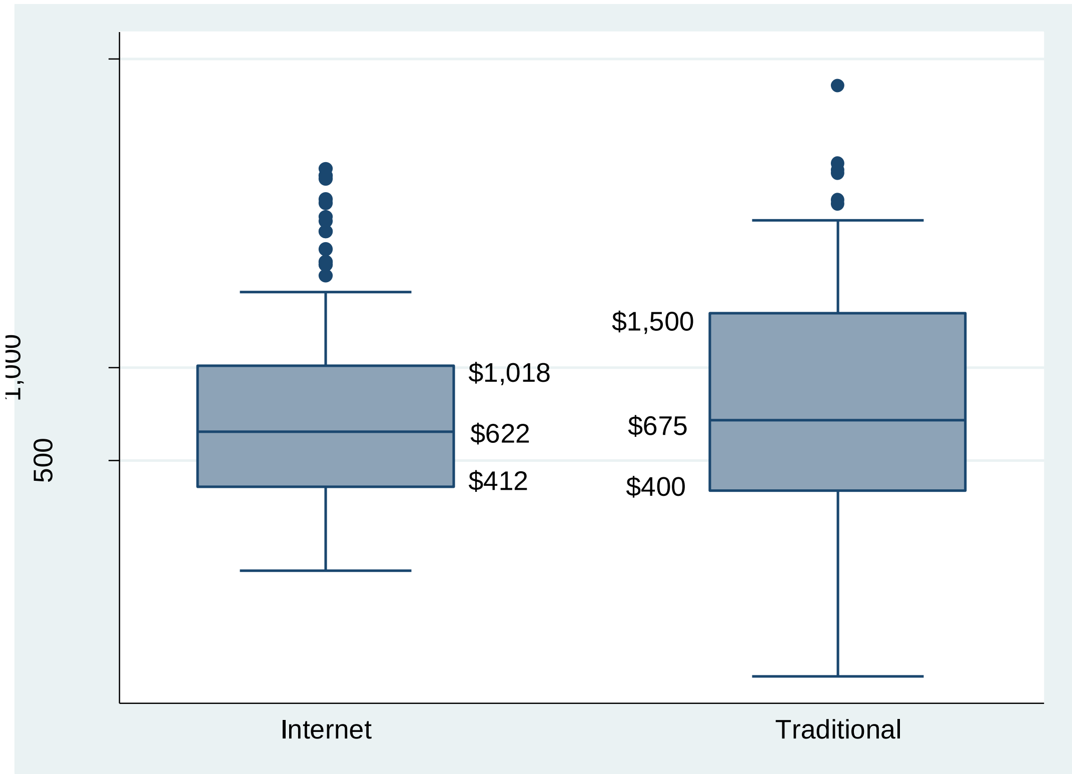
Variable	Effect: Traditional – Internet	As a % of Overall Median Value
OLS: Median Age & Time		
Seller Net Revenue	$8.75***	1.63%
Sale Price	5.46***	0.91
Buyer Price	4.96***	0.76
OLS: Mean Age & Time		
Seller Net Revenue	2.31*	0.43
Sale Price	2.18*	0.36
Buyer Price	1.99	0.31
Quantile Regression of 25th %: Median Age & Time		
Seller Net Revenue	3.36***	0.62
Sale Price	2.15*	0.36
Buyer Price	1.96	0.30
Quantile Regression of 50th %: Median Age & Time		
Seller Net Revenue	10.92***	2.03
Sale Price	7.38***	1.23
Buyer Price	6.71***	1.03
Quantile Regression of 75th %: Median Age & Time		
Seller Net Revenue	20.11***	3.74
Sale Price	13.62***	2.27
Buyer Price	12.38***	1.90

*,**,*** denotes significance of the coefficient on the dummy for traditional auction format from model estimated using the method described in italics in the table. *Mean (Median) Age & Time* means the continuous age and time trend variables used in the regression are expressed as deviations from the sample mean (median).



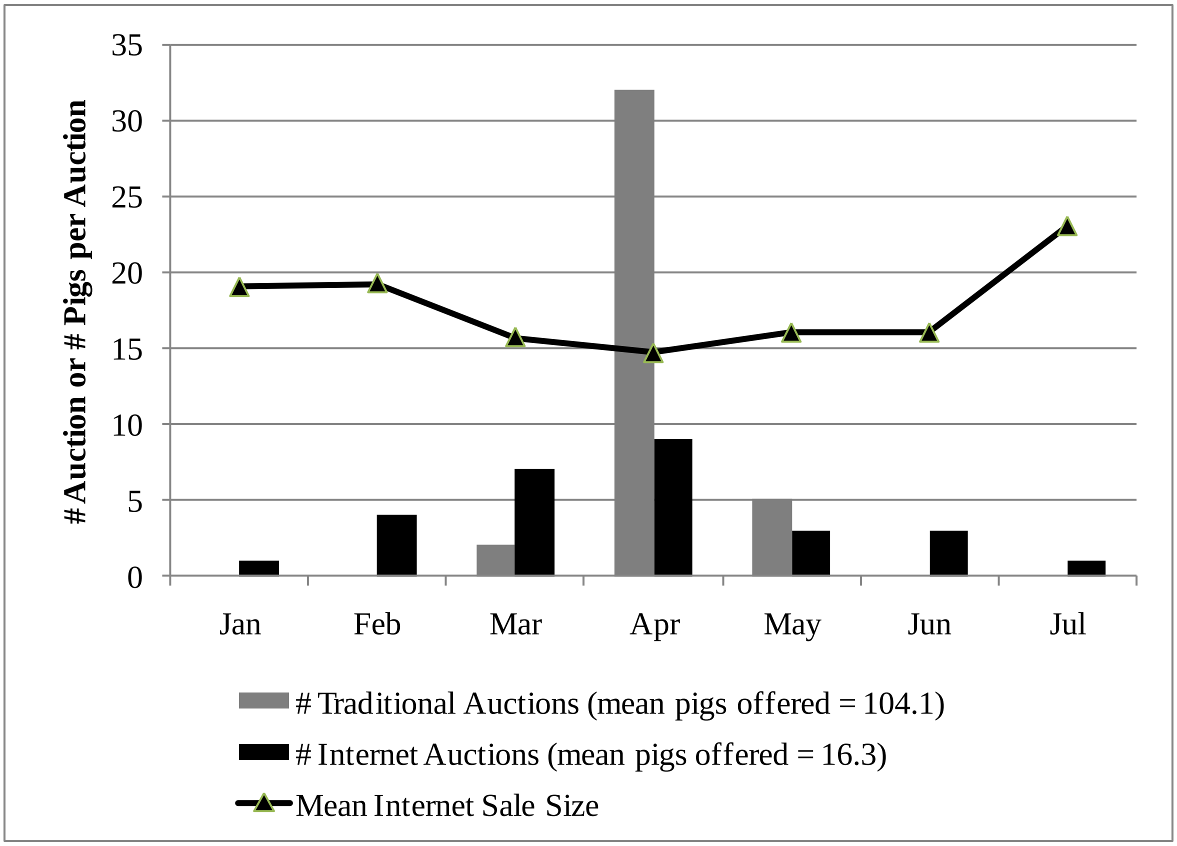
Notes: The top (bottom) of each box is the 75th (25th) percentile of the distribution of net revenue for the venue noted below the diagram. The solid line in the interior of the box is the median. Dollar figures reported correspond to the 75th, 50th and 25th percentile of the net revenue distribution by venue.

Figure 1. Box plot of net revenue by sale venue



Notes: The top (bottom) of each box is the 75th (25th) percentile of the distribution of net revenue for the venue noted below the diagram. The solid line in the interior of the box is the median. Dollar figures reported correspond to the 75th, 50th and 25th percentile of the net revenue distribution by venue.

Figure 2. Box plot of buying prices by auction channel



Notes: Based all Internet sales events using the platform detailed in the text by sellers in Ohio during the first seven months of 2010 and all traditional sales events reported in Ohio agricultural trade publications for the same period.

Figure 3. Sale events by month and auction type

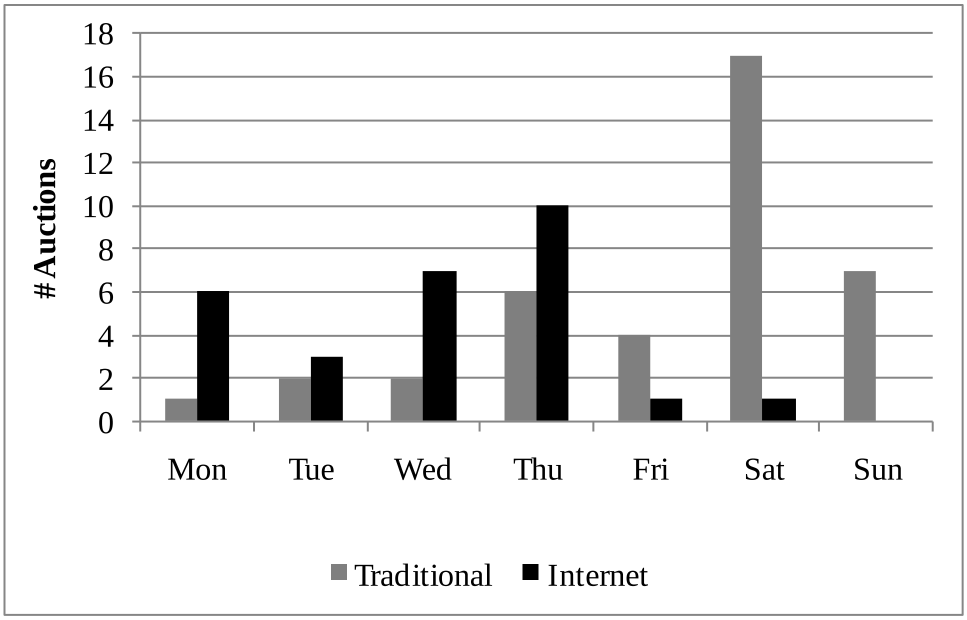


Figure 4. Sales events by day of week and sale type