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Completed Research Paper

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Abstract

We analyze how increased use of electronic channels affects geographic price variance by enabling buyers to shift demand across locations. Using data from the wholesale automotive market, we find that buyers use the reach of the electronic channels to shift purchases from high-price to low-price locations. This "arbitrage" reduces the variance of market prices, but not their means. Further, these relationships weaken with distance, due to transportation costs. The study contributes to the literature on how electronic trading affects geographic trade and price dispersion by: a) considering the role of geographic location in price dispersion, b) observing the behavioral mechanism (buyer arbitrage across locations) that leads to lower price dispersion, c) analyzing dispersion when prices are determined by auction rather than fixed price, and d) examining how reduced buyer search costs have led to lower price dispersion throughout the entire market, as opposed to only the online or offline components.

Keywords: search costs, transaction costs, electronic commerce, markets, price dispersion, variance.

Introduction

Electronic commerce has significantly lowered the costs of searching for products (Bakos 1997; Brynjolfsson and Smith 2000), particularly across large geographic distances. If prices are high in one geographic region, then buyers can use electronic channels to shift their purchases to another region where prices are lower. This shifting of demand should cause prices across regions to become more uniform, resulting in a "flatter" market. Prior research has examined the relationship between electronic commerce and price variance[1] (e.g., Brown and Goolsbee 2002; Ghose and Yao 2009). However, it has not considered the geographic location of buyers and products. Location is an important consideration because it has significant price implications for many products such as automobiles, industrial equipment, and other durable goods which have non-trivial transportation costs. One goal of this study is to address this gap by examining whether buyers use electronic channels to exploit pricing discrepancies across geographic locations and whether this results in greater price uniformity within the market.

We use the U.S. wholesale automotive market as the empirical context for the study. The products in this market (used vehicles) are located throughout the U.S., and the price of a vehicle has traditionally varied across locations. Over the last several years, electronic channels have made it easier for buyers to purchase automobiles outside their local geographies. Using data that spans 2003 to 2008, we pose four research questions and reach four interrelated conclusions. First, do buyers use the electronic channels to purchase from more locations across a wider geographic area? We find that they do; a buyer who shifts from making 0% of his purchases via electronic channels to 20% increases his geographical buying area by approximately 30%. Second, how do buyers use this expanded geographic reach? We find that buyers use it to shift their purchases from high-price locations to low-price locations; a location at which prices are 5% below average market value attracts approximately 5% more electronic transactions than a location at which prices are 5% above average market value. Third, are prices for approximately equivalent vehicles located in different geographic locations becoming more uniform as electronic trading becomes more prevalent? We find that they are; a 20% increase in electronic trading of a vehicle model is associated with an 18% reduction in its price variance across the U.S. We conclude that buyers' "arbitrage" between high and low price locations is the mechanism leading to this reduced price variance. The arbitrage and price variance reduction effects attenuate with distance, given the costs associated with vehicle transportation. Thus, the price "flattening" we observe is more pronounced on a regional basis, but the aggregate effects across regions are apparent for the U.S. as a whole. Fourth, does the increase in electronic trading affect the mean of prices in the market in addition to their variance? We find no evidence for this. Prices in our context are determined via auction, such that the demand shift between locations enabled by electronic trading causes prices to fall in some locations but to rise in others. This has a negative effect on price variance, but no significant effect on mean prices.

The study draws upon and contributes to two main research streams. The first research question relates primarily to the research stream on how electronic commerce affects geographic trade (e.g., Blum and Goldfarb 2006; Hortacsu et al. 2009). The third and fourth research questions relate primarily to the research stream on how information technology affects price dispersion for products within a market (e.g., Chellappa et al. 2009; Clemons et al. 2002). The second research question creates the linkage between these two research streams by asking how the shifting of demand across geographic locations facilitated by the electronic channels can explain the reduced price variance (but not reduced price levels) across locations.

We contribute to both research streams in several ways. First, to our knowledge, existing research on price dispersion has not considered the geographic location of products as a factor in influencing their price -- and therefore their price dispersion. This is because location has been irrelevant for the types of products that have typically been studied (e.g., books, consumer electronics, and tickets), because shipping costs do not vary with distance for these products. However, location has important effects on price and price dispersion for products in which shipping costs increase with distance, such as automobiles, agricultural commodities, and metals. Understanding electronic trade in these goods is important, because the dollar value of trade in these goods is substantially larger than that for goods more commonly studied.[2] We explicitly consider location and find that it influences buyer channel usage and moderates the effect of electronic trading on price dispersion. Thus, we extend the price dispersion literature by considering a factor that has heretofore largely been ignored, despite its relevance

[1] Price variance is often referred to as price dispersion. We use the two terms interchangeably.

[2] For example, U.S. retail sales for automobiles were approximately 30 times larger than that for books and CD's in 2002. Source: U.S. Census, http://www.census.gov/econ/census02/data/us/US000_44.HTM.

to many product categories of great economic significance.

Second, most of the empirical research in the price dispersion stream only measures the level of dispersion without considering the underlying buyer behavior which shapes prices. Observing this behavior is critical for continued research in this area, because different behavioral mechanisms can cause reduced search costs to lead to more *or* less price dispersion (Baye et al. 2006). We provide evidence that the empirical mechanism for lower price dispersion is buyer use of the electronic channel to engage in a form of arbitrage between high-price and low-price locations.

Third, most of the existing research on price dispersion has studied fixed price environments. A popular hypothesis in this stream is that the reduced buyer search costs available in electronic channels will force sellers to lower their prices towards marginal cost, resulting not only in a lower average price but also in lower dispersion of prices among sellers (e.g., Bakos 1997). By contrast, we study an environment in which prices are determined by auction. In our context, the lower buyer search costs associated with electronic trading result in lower price dispersion, but have no significant effect on average prices. This can be attributed to the auction mechanism, in which a shift in demand from one auction to another reduces prices in the first auction but raises them in the second. Although reduced buyer search costs are unlikely to lower seller revenue, the price uniformity across locations they create has implications for where sellers locate their products. A second distinction related to our studying an auction environment is that we observe the actual transacted prices in the market, rather than just the posted prices, which is unusual in this stream (but see Ghose and Yao (2009) for a recent exception.)

Fourth, most existing research has sought to demonstrate how electronic channels enable lower price variance by comparing price dispersion in online markets to that in offline markets, theorizing that dispersion should be lower online due to lower search costs. By contrast, due to the nature of our empirical context, we observe how increased use of the electronic channel affects prices in the market as a whole, regardless of any online/offline distinction. Also, our data spans a longer time period (5.5 years) than is typical within this stream, increasing our confidence that the results are not idiosyncratic to a particular time period.

Empirical Context

The empirical setting of the study is the wholesale automotive market. This is a business-to-business market in which buyers and sellers trade used vehicles. The buyers are used car dealers who purchase vehicles in the wholesale market for resale to retail customers. The sellers are either other dealers or institutional sellers such as rental car companies and banks. Traditionally, transactions have been conducted at physical facilities where buyers, sellers, and vehicles are collocated. Facilities are located throughout the U.S. On "sale day" at a facility, each vehicle offered for sale is driven – one at a time – into a warehouse-type building into the midst of a group of buyers. An auctioneer solicits bids from the buyers in an ascending, open outcry format, i.e., a traditional English auction. Once the auctioneer can solicit no additional bids, the seller indicates to the auctioneer whether he will accept the high bid. If so, the vehicle is sold to the high bidder. If not, the vehicle remains the property of the seller and may be auctioned again later. The vehicle is then driven away, and the next vehicle is driven into place and the process repeats. After purchasing a vehicle, the buyer is responsible for transporting the vehicle to his dealership. The cost of transportation is non-trivial and increases with distance.

In 2002, some of the facilities began using video cameras to simulcast via the Internet the vehicle auctions as they were occurring. They provided a web application that allowed buyers to experience the live streaming video and audio of the auction as well as to place bids on the vehicles in competition with the buyers who were physically present at the facility. This gave buyers a choice for how to participate in the bidding for a vehicle: they could either participate physically in the traditional fashion (we refer to these buyers as physical buyers) or online using the electronic "webcast" channel (we refer to these buyers as electronic buyers.) Electronic and physical buyers bid against each other for the same vehicles. Electronic buyers see bids placed by physical buyers both in the bid log that appears on the web application and via the video / audio stream. Physical buyers see bids placed by electronic buyers via a monitor mounted in the facility that flashes red and shows the name of the buyer who placed the bid.

Historically, prices in the market have varied by location. For example, a 3-year old Toyota Camry might fetch a high price in Cleveland and a low price in St. Louis. This price variance is partly due to the fact that no two 3-year old Toyota Camry's are exactly alike due to differences in usage history, option packages, etc. However, the price variance is also due to different demand across locations and to transaction costs that have effectively segmented the U.S. market into a series of smaller regional markets. For example, the historical need to be physically present at a location to purchase a vehicle has led to frictions which have limited the ability of buyers to shift their demand from high-priced locations (e.g., Cleveland in the above example) to low-priced locations (e.g., St. Louis.) A key motivation of this study is to examine whether electronic trading is reducing these frictions and leading to more uniform prices across locations.

Advantages of the Empirical Context: The empirical context is well-suited to investigating whether reduced buyer search costs lead to lower price dispersion.[3] This is because we study a single market in which buyers can participate either physically or electronically. Buyers participating physically have higher search costs than buyers participating electronically because of the need to travel to the facility. Thus, as more buyers participate electronically, average search costs in the market decrease. We use the percentage of electronic transactions as a proxy for the decline in average buyer search costs and test whether this is associated with a decrease in price dispersion. This approach differs from the more common empirical design in which the dispersion in online prices for a particular product is compared to that in offline prices (e.g., Ancarani and Shankar 2004; Brynjolfsson and Smith 2000). In our case, there are no "online" and "offline" prices, only a single price that is influenced by the demand of buyers who have different search costs due to whether they access the market physically or electronically.

Research Questions, Literature Review, and Hypotheses

We pose several research questions in which we examine whether use of the electronic channel leads to a decline in geographic price variance as well as the mechanism by which such a decline might occur. First, does the electronic channel extend buyer reach to more facilities across greater distances? Second, what factors, including price and location, influence which facilities buyers use the electronic channel to purchase from? Third, is use of the electronic channel associated with reduced price variance in the market overall? Given that vehicles are costly to transport, is the relationship between electronic channel use and reduced price variance more pronounced regionally than across the entire country? In other words, is the entire market "flat," or is it comprised of "flat" spots? Fourth, is use of the electronic channel associated with a change in the mean of prices as well as their variance?

Hypothesis 1: Several authors have argued that use of electronic channels will reduce the costs of trading across distance (e.g., Cairncross 1997; Friedman 2005). In our context, the electronic channel provides buyers with the ability to purchase vehicles from facilities without having to travel. This should expand buyers' reach by allowing them to purchase vehicles from more facilities across a larger geographic area. Surprisingly, this hypothesis has received limited empirical testing. Perhaps the closest tests have been in Sinai and Waldfogel (2004) -- who show that individuals who are geographically isolated will be more likely to use electronic commerce -- and Freund and Weinhold (2004) -- who show that an increase in a country's web hosts are associated with increased export growth. These papers do not test whether use of the electronic channel is associated with expanded buyer reach, as we do.

Although use of the electronic channel lowers the costs of distant trade, it is not obvious that buyers will necessarily purchase from more distant locations. Several studies have shown that online buyers tend to purchase most frequently from sellers and locations that are geographically proximate due to the importance of local content (Hortacsu et al. 2009) or geography-specific preferences (Blum and Goldfarb 2006). Other studies have shown that the online channel substitutes for local offline sellers (Brynjolfsson et al. 2008; Forman et al. 2009). Thus, buyers in our context may simply use the electronic channel as a substitute for physical attendance at the facilities they have traditionally used, as opposed to using the channel to expand their reach to additional facilities. However, using the electronic channel to access additional facilities increases the selection of vehicles available to buyers, which has been shown to be valuable to buyers in other contexts (Brynjolfsson et al. 2003). Thus, we posit:

H1: Buyer use of the electronic channel is positively associated with reach, as measured by the number of facilities from which he purchases and the average distance between the buyer and the facilities from which he purchases.

Hypothesis 2: Our next hypothesis explores the factors that affect how buyers use the expanded reach provided by the electronic channel. The literature on online price dispersion posits that buyers use electronic channels to facilitate price comparisons, searching for the lowest price for a given product (e.g., Brown and Goolsbee 2002). We hypothesize that behavior will be similar in our context. Buyers can compare prices for a given vehicle model (e.g., Chevrolet Malibu, Honda Civic) at different facilities by logging in and observing the bidding activity at each

[3] We use the term "buyer search costs" in the same fashion as Bakos (1997: p. 1677), who defined it as "the cost incurred by the buyer to locate an appropriate seller and purchase a product. This would include the opportunity cost of time spent searching as well as associated expenditures such as driving, telephone calls, computer fees, magazine subscriptions, etc."

facility. If bids at a facility are low relative to the overall market, then buyers can join the bidding and purchase vehicles from that facility. If bids at a facility are high, then buyers would be more likely to eschew bidding at that facility. Essentially, buyers will use the electronic channel to shift demand from high-price facilities to low-price facilities. Put differently (and in the form that matches our empirical tests), facilities where prices for a given vehicle model are low are more likely to attract electronic buyers than facilities where prices are high. Stated formally:

H2a: Prices at a facility for a vehicle model are negatively associated with the percentage of electronic transactions of the vehicle model at the facility.

The location of the facility relative to the other facilities should have a moderating effect on the relationship proposed in H2a. For example, if there are no facilities near a given facility, i.e., if the facility is remotely located, then prices at that facility should have little impact on electronic transactions there. This is because the relatively high cost of transporting vehicles from a remote facility reduces the likelihood that buyers will use the electronic channel to purchase from it, because any potential savings on price are likely to be offset by higher transportation costs. On the other hand, prices should play a significant role for facilities that are close to other facilities, i.e., for facilities that are centrally located. Low prices at central facilities will attract electronic buyers because transportation costs – although still important – will be relatively low and will not offset purchase price savings.

H2b: The relationship posited in H2a is moderated by the relative location of the facilities, such that the relationship is weaker for remotely located facilities.

Hypothesis 3: If buyers use the electronic channel to shift purchases from high-price to low-price facilities, a second-order effect of this shift should be reduced price variance in the market. To elaborate, recall that products in this context are sold through an English auction. Regardless of whether buyers are collocated at the physical auction or are participating via the electronic channel, they place bids in an English auction in competition with each other. In an English auction, price increases along with the number of bidders (McAfee and McMillan 1987). If buyers use the electronic channel to abandon high-price facilities in favor of low-price facilities, then prices at the high-price facility will drop while prices at the low-price facility will rise, ceteris paribus. Thus, an increase in electronic trading should lead to greater price uniformity for that vehicle model, which we refer to as price "flattening."

H3a: Electronic trading for a vehicle model is negatively associated with the price variance for that vehicle model.

Due to the costs of transporting vehicles, this price flattening should be less pronounced across greater distances. This is because the farther away a vehicle is, the higher the cost to transport it, and the more likely the transportation cost will offset any savings on the price. Thus, "long-distance" purchases are less likely to be motivated by price reasons than are "short-distance" purchases, and therefore should have a smaller impact on reducing price variance. This suggests that the relationship between electronic trading and price variance should be more pronounced on a regional basis than across the entire country.

H3b: The relationship between electronic transactions and price variance is moderated by distance, such that the price "flattening" is less pronounced across greater distances.

H2 and H3 are closely connected. H2 represents the underlying behavioral mechanism that is hypothesized to lead to lower price variance across locations (H3.) As Baye et al (2006) noted, it is important for empirical researchers of price dispersion to observe this mechanism, because different mechanisms can lead to different predictions about whether lower search costs lead to more or less dispersion. Different underlying behavioral mechanisms may explain the conflicting results in the price dispersion literature: some studies have found price dispersion to be higher online (Bailey 1998; Chellappa et al. 2009; Clay et al. 2002), while others have found it to be lower (Brown and Goolsbee 2002; Morton et al. 2001). It is also important to investigate buyer behavior -- rather than take it as given -- when there is a known variable that may influence it, such as the cost of vehicle transportation in our case.

Hypothesis 4: A popular hypothesis in the price dispersion literature is that the reduced search costs associated with electronic channels will lead not only to lower price dispersion but also to lower prices (Bakos 1997). This is because reduced search costs help buyers find the lowest price, forcing sellers to drop their prices towards marginal cost to remain competitive. Under this view, which was constructed for fixed price environments, reduced search costs force sellers to converge toward a lower price, thereby reducing both the mean and variance of prices. In our context, we expect the reduced search costs associated with the electronic channel to affect the variance of prices (for the reasons described in H3), but not the mean of prices. This is because the demand shifts attributable to the electronic channel will cause prices to fall at facilities which experience reduced demand but rise at facilities which experience increased demand, due to the properties of the auction mechanism discussed above. Ceteris paribus, these increases and decreases will balance out, such that mean prices should remain relatively constant regardless of the amount of electronic trading. We state both the null and alternative forms of this hypothesis below.[4]

H4 (null): There is no significant association between electronic trading and average vehicle prices.

H4 (alternate): There is a significant association between electronic trading and average vehicle prices.

Data

Data were provided by an intermediary in the wholesale automotive market that operates over 80 physical market facilities in the continental U.S., all of which are equipped with the webcast technology. The data consists of all transactions that occurred at those facilities between January 2003 and June 2008 for vehicles with between 15,000 and 21,000 miles. The mileage filter reduces heterogeneity in vehicle condition, so that prices for the same vehicle model across facilities may be more validly compared. The percentage of vehicles traded electronically increased from just over 0% to approximately 25% over this time. There are 2,077,601 physical transactions (88% of the total) and 280,533 electronic transactions (12% of the total) in the data set. Figure 1 illustrates the geographical distribution of the facilities where the vehicles were located. The size of the circles represents transaction volume.

Figure 1. Distribution of facilities throughout the country.

Table 1 describes the variables in the data. We used Facility Zip Code and Buyer Zip Code to calculate the distance between facilities and between buyers and facilities. We mapped each zip code to its latitude and longitude as recorded by the U.S. Census Bureau and calculated the distance between them using the Haversine formula.

Table 1: Variables in the raw data.

Variable	Description	Descriptive Statistics
Facility ID	Denotes the facility where the vehicle was located.	There are 84 facility ID's.
Facility Zip Code	Zip code of each facility.	n/a
Buyer ID	Denotes the buyer who purchased a vehicle.	There are 74,917 buyers.
Buyer Zip Code	Zip code of each buyer.	n/a
Seller ID	Denotes the seller of each vehicle.	There are 561 sellers.
Electronic	Dummy variable indicating whether the vehicle was purchased via the electronic (1) or physical (0) channels.	Mean: 0.119
Transaction Date	Date a transaction occurred.	From 1/1/2003 to 6/30/2008.
Vehicle Model	Model of each vehicle (e.g., Ford Focus, Nissan Maxima.)	There are 834 vehicle models.
Vehicle Price	Sales price of each vehicle.	Mean: 14,819 St. Dev.: 6,834
Vehicle Valuation	Market value estimate for each vehicle at the time of the transaction. Calculated by the intermediary.	Mean: 15,005 St. Dev.: 6,768

<u>Assigning buyers to facilities:</u> In order to conduct the tests of H1 and H3b discussed in the next section, it was necessary to assign each buyer to a facility in their geographic area, referred to as a buyer's "local" facility. We did this via the following procedure. First, we calculated the average distance each buyer traveled to make physical purchases. This statistic was 125 miles (s.d. 185.) We then determined which facilities were within 125 miles of

[4] Note that our arguments support the null hypothesis, rather than the alternate hypothesis, which runs counter to typical hypothesis testing. We qualify our conclusions accordingly.

each buyer. If a buyer had exactly one facility within a 125 mile radius, we assigned him to that facility. If a buyer had more than one facility within this radius, we calculated the facility from which they made the most physical purchases and assigned him to that facility. We assigned buyers who were located farther than 125 miles from the nearest facility to the facility closest to them.

Analysis and Results

This section describes the data structure and empirical models used to test each hypothesis, along with the results. For each hypothesis, we conducted two steps. First, we aggregated the raw data into a panel structure, using quarter-years as the time dimension. We structured the data differently based on the hypothesis we were testing, as described below. Second, we estimated the empirical model constructed for the hypothesis using a fixed effects within transformation with robust standard errors and time dummies. For robustness, we reran each model after instrumenting key variables that might be endogenous.

Table 2 describes the aggregate variables that we constructed for our panel models, along with which hypotheses each aggregated variable is used to test. Some variables are similar but differ based on how they are aggregated. We use a consistent subscripting notation throughout the paper: *i* indexes buyers, *j* indexes vehicle models, *k* and *l* index facilities, and *t* indexes time.

<u>Testing H1:</u> To test H1, we used the Buyer ID variable in the data to create a panel in which we observed each buyer's electronic and physical purchases from different facilities over time. We used specification 1 to test H1.

$$Dependent\_Variable_{i,t} = \alpha + \beta_1\, PctElecTrans\_Buyer_{i,t} + \beta_2\, TotalTrans\_Buyer_{i,t} + \sum_{t=2-2003}^{2-2008} \beta_t\, time_t + c_i + \varepsilon_{i,t} \quad (1)$$

where $Dependent\_Variable_{i,t}$ is either a) $NumberFacilities\_Buyer_{i,t}$ or b) $AvgDistance\_Buyer_{i,t}$.

A positive and significant coefficient for $PctElecTrans\_Buyer_{i,t}$ (β_1) would provide support for H1. $TotalTrans\_Buyer_{i,t}$ controls for each buyer's overall purchase volume. Because $NumberFacilities\_Buyer_{i,t}$ is a count variable, we estimated the model in which it is the dependent variable using a standard fixed effects model and a fixed effects Poisson model. Results of both models are similar. The Poisson results are withheld to conserve space. We also reran the models after replacing $PctElecTrans\_Buyer_{i,t}$ and $TotalTrans\_Buyer_{i,t}$ with $ElecTrans\_Buyer_{i,t}$ and $PhysTrans\_Buyer_{i,t}$. These results are also similar.

Potential endogeneity: A potential concern with specification 1 may be reverse causality; for example, if a buyer's increasing need to purchase from more facilities (for example, to obtain more vehicles) caused him to conduct more transactions electronically. To account for this, we instrumented $PctElecTrans\_Buyer_{i,t}$. As with all instrumental variables procedures, we required an instrument that is correlated with the endogenous variable but uncorrelated with unobservables influencing the dependent variable. The instrument we used is the percentage of electronic transactions for all buyers assigned to the same facility as the focal buyer, not including the transactions of the focal buyer. We refer to this as $PctElecTrans\_OtherBuyers_{i,t}$. Prior research has demonstrated that Internet use among users within a geographic region is correlated (e.g., Agarwal et al. 2009; Forman 2005). This may reflect demand-side spillovers, e.g., buyers learn how to use the electronic channel more efficiently when other buyers use it. Thus, $PctElecTrans\_OtherBuyers_{i,t}$ should be correlated with $PctElecTrans\_Buyers_{i,t}$; first stage regression results confirm this (see Table 3). However, there is little reason to believe that this variable will influence the focal buyer's choice of which facilities to use. We calculated this instrument for each buyer in each quarter by: a) summing the electronic and total transactions of all buyers assigned to the same facility as the focal buyer, b) subtracting the transactions for the focal buyer, and c) dividing the two. Results of specification 1, with and without instrumenting $PctElecTrans\_Buyer_{i,t}$, appear in Table 3.

The coefficient for $PctElecTrans\_Buyer_{i,t}$ (β_1) is positive and significant in all specifications, indicating that use of the electronic channel is associated with purchasing from a greater number of facilities and with purchasing across a wider geographic area, lending support for H1. β_1 is larger after instrumentation; we discuss the non-instrumented results below to be conservative. A one percentage point increase in electronic trading is associated with a 0.0032 increase in the number of facilities a buyer purchases from and a 0.75 mile increase in the distance between the buyer and the facilities. Thus, a buyer who shifts from purchasing 0% of his vehicles electronically to 25% uses 0.08 more facilities and buys across a 18.75 mile larger radius, on average. This represents an increase of approximately 6% in the number of facilities used and a 14% increase in the average distance between buyer and facilities. This 14% increase in the radius corresponds to a 30% increase in a buyer's purchasing area (area = $\pi * radius^2$.)

Table 2: Aggregate variables used in the panel models.			
Variable	**Description**	**Mean (St. Dev.)**	**Used For**
NumberFacilities_ $Buyer_{i,t}$	Number of facilities buyer *i* purchased from in time *t*.	1.70 (1.29)	H1
$AvgDistance\_Buyer_{i,t}$	Average distance between buyer *i* and the facilities where he purchased vehicles in time *t*.	135.95 (192.20)	H1
$ElecTrans\_Buyer_{i,t}$	Number of electronic transactions for buyer *i* in time *t*.	0.93 (4.76)	H1
$PhysTrans\_Buyer_{i,t}$	Number of physical transactions for buyer *i* in time *t*.	6.94 (18.36)	H1
$TotalTrans\_Buyer_{i,t}$	Number of transactions for buyer *i* in time *t*.	7.87 (19.35)	H1
$PctElecTrans\_Buyer_{i,t}$	Percentage of transactions for buyer *i* in time *t* that were electronic.	10.02 (26.52)	H1
PctElecTrans_ $Facility_{j,k,t}$	Percentage of transactions for vehicle model *j* at facility *k* in time *t* that were electronic.	6.87 (16.22)	H2
AvgNormPrice_ $Facility_{j,k,t}$	Average price divided by average valuation for vehicles of model *j* purchased at facility *k* in time *t*. Scaled by multiplying by 100.	95.38 (13.70)	H2
AvgValuation_ $Facility_{j,k,t}$	Average valuation of vehicles of model *j* purchased at facility *k* in time *t*. Scaled by dividing by 10,000	1.68 (0.99)	H2
$TotalTrans\_Facility_{j,k,t}$	Number of transactions for vehicle model *j* at facility *k* in time *t*.	18.71 (52.03)	H2
RelativeLocation_ DistanceTo $Others_k$	Average distance between facility *k* and all other facilities. Scaled by dividing by 100.	10.36 (2.67)	H2
RelativeLocation_ OthersWithin 251_k	Number of facilities within 251 miles of facility *k*. 251 is the mean distance between buyer and facility for electronic transactions.	8.62 (3.81)	H2
$Availability_{j,t}$	Number of facilities where a vehicle of model *j* was purchased in time *t*. Scaled by dividing by 10.	4.82 (1.96)	H2-H4
$CVPrice\_Vehicle_{j,t}$	Coefficient of variation of price for vehicle model *j* in time *t*.	0.26 (0.28)	H3
$AvgPrice\_Vehicle_{j,t}$	Average price for vehicle model *j* in time *t*.	17,854 (18,028)	H4
$PctElecTrans\_Vehicle_{j,t}$	Percentage of transactions for vehicle model *j* in time *t* that were electronic.	8.51 (11.55)	H3-H4
$TotalTrans\_Vehicle_{j,t}$	Number of transactions for vehicle model *j* in time *t*.	486 (1,236)	H3-H4
CVPrice_Facility $Pair_{j,k,l,t}$	Coefficient of variation of average price at facilities *k* and *l* for vehicle model *j* in time *t*.	0.16 (0.25)	H3
StDevPrice_Facility $Pair_{j,k,l,t}$	Standard deviation of average price at facilities *k* and *l* for vehicle model *j* in time *t*.	1,887 (2,471)	H3
TotalTrans_Local $Buyers_{j,k,l,t}$	Number of transactions for vehicle model *j* by buyers assigned to facilities *k* and *l* in time *t*.	44.59 (81.18)	H3
ElecTrans_Local $Buyers_{j,k,l,t}$	Number of electronic transactions for vehicle model *j* by buyers assigned to facilities *k* and *l* in time *t*.	4.88 (11.51)	H3
PhysTrans_Local $Buyers_{j,k,l,t}$	Number of physical transactions for vehicle model *j* by buyers assigned to facilities *k* and *l* in time *t*.	39.71 (74.54)	H3
$Distance\_FacilityPair_{k,l}$	Distance between facility *k* and facility *l*. Scaled by dividing by 100.	10.36 (6.25)	H3
TotalTrans_Facility $Pairs_{j,k,l,t}$	Number of transactions for vehicle model *j* at facilities *k* and *l* in time *t*.	48.41 (96.73)	H3
$Time_t$	Series of dummy variables indicating in which of the 22 quarter-year time periods *t* (1-2003, 2-2003, 3-2003, etc.) a transaction occurred.	n/a	H1-H4

<u>Testing H2:</u> To test H2, we used the Vehicle Model and Facility variables to create a panel in which we observed the physical and electronic purchases of each vehicle model (e.g., Ford Explorer, Hyundai Sonata) at each facility over time. We used specification 2 to test H2a and H2b.

$$PctElecTrans\_Facility_{j,k,t} = \alpha + \beta_1\ AvgNormPrice\_Facility_{j,k,t} + \beta_2\ AvgNormPrice\_Facility_{j,k,t} * RelativeLocation_k + \beta_3\ AvgValuation\_Facility_{j,k,t} + \beta_4\ Availability_{j,t} + \sum_{t=2-2003}^{2\text{-}2008} \beta_t\ time_t + c_{j,k} + \varepsilon_{j,k,t} \quad (2)$$

where $RelativeLocation_k$ is either $RelativeLocation\_DistanceToOthers_k$ or $RelativeLocation\_OthersWithin251_k$.

Table 3: Results of specification 1 for both dependent variables.				
	DV: NumberFacilities_ Buyer		**DV: AvgDistance_Buyer**	
	Coefficient	**Coefficient**	**Coefficient**	**Coefficient**
PctElecTrans_Buyer	0.0032 (0.0001) ***	0.0055 (0.001) ***	0.75 (0.02) ***	1.42 (0.17) ***
TotalTrans_Buyer	0.025 (0.005) ***	0.025 (0.005) ***	0.60 (0.12) ***	0.60 (0.12) ***
Time dummies	included	included	included	included
Buyer fixed effects	included	included	included	included
Intercept	1.40 (0.03) ***	--	133.03 (1.24) ***	--
PctElecTrans_Buyer Instrumented?	*no*	*yes*	*no*	*yes*
1st stage F-statistic	n/a	1064.52 ***	n/a	1038.08 ***
R^2, including the fixed effects	0.60	--	0.68	--
R^2 within	0.10	--	0.02	--
R^2 centered	--	0.10	--	0.01
N	442,990	442,990	442,990	442,990
Robust standard errors in parentheses.			*** p < 0.01, ** p < 0.05, * p < 0.10.	

The coefficient for $AvgNormPrice\_Facility_{j,k,t}$ (β_1) represents the test of H2a. As the price of a vehicle model -- relative to its market value -- rises at a facility, that facility should be less attractive to electronic buyers. Thus, if H2a is supported, then β_1 should be negative. The coefficient for $AvgNormPrice\_Facility_{j,k,t}$ * $RelativeLocation_k$ (β_2) represents the test of H2b. We estimated the models using two different measures of $RelativeLocation_k$. $RelativeLocation\_DistanceToOthers_k$ is the average distance between facility *k* and all other facilities. $RelativeLocation\_OthersWithin251_k$ is the number of facilities within 251 miles of facility *k*.[5] We could not include $RelativeLocation_k$ as a main effect because it does not vary over time. $AvgValuation\_Facility_{j,k,t}$ controls for the possibility that highly valuable vehicles attract more electronic buyers than cheap vehicles or vice versa. $Availability_{j,t}$ controls for the possibility that facilities offering vehicles which are widely available are less likely to attract electronic buyers than are facilities offering vehicles available at only select facilities (Overby and Jap 2009).

Because of differences in the number of transactions for vehicle models across facilities, we weighted the regressions by $TotalTrans\_Facility_{j,k,t}$. We did not include $TotalTrans\_Facility_{j,k,t}$ as an independent variable because it serves as the weighting variable, although including it does not affect the results. Also, fitting the regressions without weights does not affect the coefficients for $AvgNormPrice\_Facility_{j,k,t}$ or its interactions, although it does affect the $Availability_{j,t}$ coefficient.

Potential endogeneity: A potential concern with specification 2 may be reverse causality; e.g., if the average price of a vehicle model at a facility were affected by how often that vehicle model was purchased electronically. To account for this, we instrumented $AvgNormPrice\_Facility_{j,k,t}$. The instrument we used is the average normalized price for all vehicle models sold at facility *k*, not including the transactions for the focal vehicle model *j*. We refer to this as $AvgNormPriceOthers\_Facility_{j,k,t}$. We calculated this instrument for each vehicle model at each facility in each quarter by: a) counting the vehicles sold at that facility and summing the normalized price of those vehicles, b) subtracting from both the count and the sum the transactions involving the focal vehicle model, and c) dividing the remaining sum by the remaining count. $AvgNormPriceOthers\_Facility_{j,k,t}$: a) reflects local conditions at a facility that affect vehicle pricing, which should be correlated with the average price of the focal vehicle model, but b) should not influence the electronic trading activity of the focal vehicle model. To elaborate on the second point, consider that a buyer would not log into a facility's webcast to purchase vehicle model A (e.g., a Chevrolet Malibu) based on attractive prices for vehicle model B (e.g., a Nissan Titan) at that facility. Results without instrumentation appear in columns a, c, and e of Table 4; those with instrumentation appear in columns b, d, and f.

The negative and significant coefficient for $AvgNormPrice\_Facility_{j,k,t}$ (β_1) in the models without interactions (columns a and b) indicates that facilities with higher (lower) prices relative to the overall market attract a lower (higher) percentage of electronic transactions. This provides support for H2a. There is some evidence that the effect of $AvgNormPrice\_Facility_{j,k,t}$ is moderated by the $RelativeLocation_k$ measures. The interaction terms in the models appearing in columns c and d indicate that the coefficient of $AvgNormPrice\_Facility_{j,k,t}$ becomes less negative (i.e.,

[5] 251 is the mean distance between buyers and facilities for electronic transactions.

weaker) as the location becomes less central. The interaction terms in the models in the models appearing in columns e and f indicate that the coefficient of AvgNormPrice_Facility$_{j,k,t}$ becomes *more* negative (i.e., stronger) as the location becomes *more* central, although only the interaction term in the instrumented model is significant. Both of these effects are consistent with the hypothesized interaction effect, providing moderate support for H2b.

Table 4: Results of specification 2.

	a	b	c	d	e	f
	Coef.	**Coef.**	**Coef.**	**Coef.**	**Coef.**	**Coef.**
AvgNormPrice_Facility	-0.05 (0.01) ***	-0.10 (0.05) **	-0.15 (0.02) ***	-0.41 (0.16) **	-0.05 (0.02) ***	-0.00 (0.11)
AvgNormPrice_Facility * RelativeLocation_ DistanceToOthers	--	--	0.01 (0.00) ***	0.03 (0.01) **	--	--
AvgNormPrice_Facility * RelativeLocation_ OthersWithin251	--	--	--	--	-0.0001 (0.0017)	-0.03 (0.01) ***
AvgValuation_Facility	1.04 (0.24) ***	0.93 (0.25) ***	1.04 (0.24) ***	0.93 (0.25) ***	1.04 (0.24) ***	0.93 (0.25) ***
Availability	-1.31 (0.08) ***	-1.31 (0.08) ***	-1.31 (0.08) ***	-1.30 (0.08) ***	-1.31 (0.08) ***	-1.30 (0.08) ***
Time dummies	included	included	included	included	included	included
Vehicle model / facility fixed effects	included	included	included	included	included	included
Intercept	11.07 (0.81) ***	--	11.39 (0.83) ***	--	11.07 (0.82) ***	--
AvgNormPrice_Facility instrumented?	*no*	*yes*	*no*	*yes*	*no*	*yes*
1[st] stage F-statistic	n/a	84.05 ***	n/a	43.37 ***, 44.19 ***[a]	n/a	93.02 ***, 31.61 ***[a]
R^2, including fixed effects	0.54	--	0.54	--	0.54	--
R^2 within	0.05	--	0.05	--	0.05	--
R^2 centered	--	0.26	--	0.26	--	0.26
n	191,915	191,915	191,915	191,915	191,915	191,915

Robust standard errors in parentheses. * p < 0.01, ** p < 0.05, * p < 0.10.
[a] We instrumented both the main effect and the interaction effect (using AvgNormPriceOthers_Facility in place of AvgNormPrice_Facility when creating the interaction.) The first F-stat corresponds to the main effect; the second F-stat corresponds to the interaction effect.

Using the estimates reported in column a of Table 4, a 10 percentage point increase in AvgNormPrice_Facility$_{j,k,t}$ is associated with a 0.51 percentage point decrease in PctElecTrans_Facility$_{j,k,t}$. This represents a drop of almost 5% in the mean of PctElecTrans_Facility$_{j,k,t}$. Note that these estimates are based on the average for all facilities and will be stronger (weaker) for centrally (non-centrally) located facilities.

Testing H3: We developed one specification to test H3a and H3b and a second specification to test H3a only. We first provide the intuition behind our joint test of H3a and H3b, along with the empirical specification. The graphic shown in the left panel of Figure 2 enhances our textual description. Consider a group of buyers for whom Indianapolis is their "local" facility. This facility is represented by the black circle in Figure 2. The gray circles represent other facilities. Purchases made by the Indianapolis-area buyers are represented by the squares in Figure 2. White squares represent physical purchases, and black squares represent electronic purchases. Both physical and electronic purchases might be from either the local Indianapolis facility or from a different facility. Based on the results of the H1 tests, electronic purchases are, on average, conducted across greater distances than are physical purchases and thus are more likely to be from a non-local facility. Buyers choose which other facilities to purchase from based partly on price, as shown in the tests of H2. In essence, they use the electronic channel to shift their purchases from high-price facilities to low-price facilities. This should cause prices between the Indianapolis facility and the surrounding facilities to flatten, as buyers "arbitrage" away any price discrepancies. The flattening effect should weaken with distance, because the cost of transporting a vehicle a long distance may wipe out any savings on the purchase price. Thus, "long-distance" electronic purchases are unlikely to be motivated by price reasons, meaning they will have a smaller effect on price variance. This moderating effect is illustrated in Figure 2 via the concentric circles. The "flattening" attributable to the electronic purchases of the Indianapolis-area buyers should be greater within the inner circle than the outer circle. Next, consider an analogous situation in Columbus, which is illustrated in the right panel of Figure 2. An increase in electronic purchases by the Columbus-area buyers should have a similar flattening effect on prices at other facilities around Columbus, with the effect weakening with distance.

Figure 2: Graphical illustration of price flattening around a focal facility.

To test H3a and H3b, we used the Vehicle Model and Facility variables to create a panel containing the mean of prices, the variance of prices, and the electronic trading activity for distinct facility pairs over time. We constructed our empirical model to determine whether the price variance for a given vehicle model between any two facilities (such as Indianapolis and Columbus) was a function of: a) the electronic (and physical) purchases made by buyers local to the two facilities, and b) the distance between the facilities. The specification appears below.[6]

$$CVPrice\_FacilityPair_{j,k,l,t} = \alpha + \beta_1\, ElecTrans\_LocalBuyer_{j,k,l,t} + \beta_2\, ElecTrans\_LocalBuyer_{j,k,l,t} * Distance\_FacilityPair_{k,l} + \beta_3\, PhysTrans\_LocalBuyer_{j,k,l,t} + \beta_4\, PhysTrans\_LocalBuyer_{j,k,l,t} * Distance\_FacilityPair_{k,l} + \beta_5\, Availability_{j,t} + \sum_{t=2\text{-}2003}^{2\text{-}2008} \beta_t\, time_t + c_{j,k,l} + \varepsilon_{j,k,l,t} \quad (3)$$

We calculated the coefficient of variation for each vehicle model *j* between facilities *k* and *l* at time *t* ($CVPrice\_FacilityPair_{j,k,l,t}$) as follows. First, we calculated the mean price of each vehicle model at each facility. Second, we calculated the coefficient of variation of the two mean prices. For example, if the mean price of a Honda Accord was $10,000 at facility *k* and $11,000 at facility *l*, then the coefficient of variation was 0.067. The advantage of using the coefficient of variation as the variance measure is that it accounts for differences in value between vehicles and across time (Baye et al. 2006). To calculate the $ElecTrans\_LocalBuyers_{j,k,l,t}$ variable, we: a) counted the number of vehicles of model *j* that buyers assigned to facility *k* purchased electronically, regardless of where the vehicles were located, b) conducted the same calculation for buyers assigned to facility *l*, and c) summed the two. We constructed the $PhysTrans\_LocalBuyers_{j,k,l,t}$ analogously. We interacted $Distance\_FacilityPair_{k,l}$ with $ElecTrans\_LocalBuyers_{j,k,l,t}$ and $PhysTrans\_LocalBuyers_{j,k,l,t}$. Because $Distance\_FacilityPair_{k,l}$ does not vary over time, we could not include it as a main effect. We included $Availability_{j,t}$ as a control variable. The coefficient for $ElecTrans\_LocalBuyers_{j,k,l,t}$ (β_1) represents one test of H3a (we report another below), and the coefficient for the interaction of $Distance\_FacilityPair_{k,l}$ and $ElecTrans\_LocalBuyers_{j,k,l,t}$ (β_2) represents the test of H3b.

As in specification 2, we weighted the regression by $TotalTrans\_FacilityPair_{j,k,l,t}$. We also estimated the regressions without weighting; results are similar. $TotalTrans\_FacilityPair_{j,k,l,t}$ is not the sum of $ElecTrans\_LocalBuyers_{j,k,l,t}$ and $PhysTrans\_LocalBuyers_{j,k,l,t}$. The former measures the number of vehicles sold at the facilities in the pair, whereas the latter measures the total number of vehicles that buyers assigned to the two facilities purchased. The former may contain purchases made by buyers assigned to other facilities, and the latter may contain purchases from facilities other than those in the pair. This distinction relates to why we used the raw values of $ElecTrans\_LocalBuyers_{j,k,l,t}$ and $PhysTrans\_LocalBuyers_{j,k,l,t}$, on the right-hand side of the specification rather than the percentage of electronic transactions. $ElecTrans\_LocalBuyers_{j,k,l,t}$ and $PhysTrans\_LocalBuyers_{j,k,l,t}$ are both zero for an observation in the

[6] One way to conceptualize the logic behind specification 3 is as follows. Consider buyers local to Dallas, Houston, Miami, and Seattle who purchase Honda Civics. Dallas and Houston-based buyers who use the electronic channel are likely to purchase from each other's locations due to proximity, thereby flattening prices between the two facilities. By contrast, Miami and Seattle-based buyers who use the electronic channel are unlikely to purchase from each other's locations due to the distance. Thus, there should be a smaller (or perhaps no) flattening effect between these facilities.

panel in when: a) a vehicle model was traded at both facilities in the pair, but b) those trades were made by buyers assigned to other facilities. Using the percentage of electronic transactions would cause these observations to drop and consequently bias the panel.

Potential endogeneity: In contrast to the previous models, it is difficult to conceptualize the source of any potential endogeneity in specification 3, but we instrumented $ElecTrans\_LocalBuyers_{j,k,l,t}$ for robustness and consistency with the other specifications. The instrument we used is the count of electronic transactions for the focal vehicle model that were not affiliated with the facilities in the focal pair. We considered a transaction "affiliated" if it either: a) occurred at one of the facilities in the focal pair, or b) was conducted by a buyer assigned to one of the facilities in the pair. We refer to this instrument as $ElecTrans\_Unaffiliated_{j,k,l,t}$. We calculated the instrument for each vehicle model at each facility pair in each quarter by: a) counting the electronic transactions per vehicle model at all facilities, and b) subtracting the electronic transactions affiliated with either facility in the pair. $ElecTrans\_Unaffiliated_{j,k,l,t}$ should be correlated with $ElecTrans\_LocalBuyers_{j,k,l,t}$ because it reflects the general propensity of a vehicle model to be traded electronically. However, because the transactions that form $ElecTrans\_Unaffiliated_{j,k,l,t}$ are not affiliated with the focal facility pair, it should not influence the price variance between the pair. Results without instrumentation appear in columns a and c of Table 5; those with instrumentation appear in columns b and d.

Table 5: Results of specification 3.

	a	b	c	d
	Coef.	**Coef.**	**Coef.**	**Coef.**
ElecTrans_LocalBuyers	-0.00021 (0.00002) ***	-0.00088 (0.00005) ***	-0.00036 (0.00004) ***	-0.00097 (0.00004) ***
ElecTrans_LocalBuyers * Distance_FacilityPair	--	--	0.00002 (0.00000) ***	0.00001 (0.00000) *
PhysTrans_LocalBuyers	-0.00006 (0.00000) ***	-0.00007 (0.00000) ***	-0.00005 (0.00000) ***	-0.00006 (0.00000) ***
PhysTrans_LocalBuyers * Distance_FacilityPair	--	--	-0.00000 (0.00000) ***	-0.00000 (0.00000) **
Availability	-0.0085 (0.0003) ***	-0.0080 (0.0003) ***	-0.0085 (0.0003) ***	-0.0080 (0.0003) ***
Intercept	0.1998 (0.0018) ***	--	0.1998 (0.0018) ***	--
ElecTrans_LocalBuyers instrumented?	*no*	*yes*	*no*	*yes*
1st stage F-statistic	n/a	45,127 ***	n/a	24,102 ***, 20,735 ***[a]
Time dummies	included	included	included	included
Vehicle model / Facility pair fixed effects	included	included	included	included
R^2, including fixed effects	0.60	--	0.60	--
R^2 within	0.01	--	0.01	--
R^2 centered	--	0.01	--	0.01
n	3,969,742	3,969,742	3,969,742	3,969,742

Robust standard errors in parentheses. * p < 0.01, ** p < 0.05, * p < 0.10.

[a] We instrumented both the main effect and the interaction effect (using ElecTrans_Unaffiliated in place of ElecTrans_LocalBuyers when creating the interaction.) The first F-stat corresponds to the main effect; the second F-stat corresponds to the interaction effect.

Table 5 shows that electronic transactions have a negative relationship with price variance, supporting H3a. Of interest is that both physical and electronic transactions influence price variance, but the effect of electronic transactions is stronger. The coefficients for $ElecTrans\_LocalBuyers_{j,k,l,t}$ and $PhysTrans\_LocalBuyers_{j,k,l,t}$ are statistically different from each other in all specifications ($p < 0.01$), and the coefficient for the former is larger in absolute value. We attribute this to the following. Any transaction increases trading volume, which reduces price variance because it increases the amount of price information in the market. However, an electronic transaction has an additional effect attributable to reduced transaction costs which make it easier for buyers to shift their purchasing from high-price facilities to low-price facilities, accentuating the price flattening.

The coefficient for the interaction of $Distance\_FacilityPair_{k,l}$ and $ElecTrans\_LocalBuyers_{j,k,l,t}$ (β_2) is positive and significant, showing that the flattening effect of electronic transactions weakens with distance. This provides support for H3b. Using the estimates reported in column c of Table 5, if the distance between the facilities is assumed to be zero, results indicate that one additional electronic purchase by the buyers assigned to a facility pair decreases the coefficient of variation by 0.00036. The average distance between buyer and facility for electronic transactions is 251 miles (st. dev. 257). Setting this as the distance, the previous estimate becomes 0.00031. This indicates that a facility pair separated by 251 miles in which the buyers local to those facilities made 10 electronic purchases will have a coefficient of variation that is 0.003 lower than a corresponding facility pair in which the buyers made 0 electronic transactions. This equates to approximately a 1.5% reduction in price variance.

Additional test of H3a: We used specification 4 as an additional test of H3a.

$$CVPrice\_Vehicle_{j,t} = \alpha + \beta_1\, PctElecTrans\_Vehicle_{j,t} + \beta_2\, Availability_{j,t} + \sum_{t=2-2003}^{2\text{-}2008} \beta_t\, time_t + c_j + \varepsilon_{j,t} \quad (4)$$

Specification 4 permits examination of whether an increase in electronic trading of a vehicle model is associated with a decrease in price variance of that vehicle model across the entire U.S. The coefficient for $PctElecTrans\_Vehicle_{j,t}$ (β_1) represents the second test of H3a. $Availability_{j,t}$ is a control. Similar to specification 2, we weighted the regressions by $TotalTrans\_Vehicle_{j,t}$ because the number of transactions upon which many of the variables are based varies. We estimated specification 4 both with and without instrumenting $PctElecTrans\_Vehicle_{j,t}$. We used $PctElecTrans\_Vehicle_{j,t-1}$ (i.e., the first lag) as the instrument. $PctElecTrans\_Vehicle_{j,t-1}$ should be correlated with $PctElecTrans\_Vehicle_{j,t}$ because of likely persistence over time in the use of the electronic channel to purchase a vehicle model but uncorrelated with present period shocks that may be correlated with $CVPrice\_Vehicle_{j,t}$. Results appear in Table 6.

Table 6: Results of specification 4.

	a	**b**
	Coefficient	**Coefficient**
PctElecTrans_Vehicle	-0.002 (0.000) ***	-0.003 (0.000) ***
Availability	-0.01 (0.00) ***	-0.01 (0.00) ***
Intercept	0.22 (0.01) ***	--
Time dummies	included	included
Vehicle model fixed effects	included	included
PctElecTrans_Vehicle instrumented?	*no*	*yes*
1st stage F-statistic	n/a	653.03 ***
R^2, including fixed effects	0.70	--
R^2 within	0.04	--
R^2 centered	--	0.10
n	7,645	6,984
Robust standard errors in parentheses.		* p < 0.01, ** p < 0.05, * p < 0.10.

The negative and significant coefficient for $PctElecTrans\_Vehicle_{j,t}$ (β_1) shows that as the percentage of electronic transactions in the market increases, the coefficient of variation decreases. This provides support for H3a. Using the estimates reported in column a of Table 6, a 10 percentage point increase in $PctElecTrans\_Vehicle_{j,t}$ is associated with a 0.02 decrease in the coefficient of variation, which represents an approximately 9% drop. In the Discussion section, we reconcile the finding that prices are becoming flatter across the country with the previous finding that the flattening effect weakens with distance.

Testing H4: We used specification 5 to test H4. This is the same as specification 4, except we used $AvgPrice\_Vehicle_{j,t}$ instead of $CVPrice\_Vehicle_{j,t}$ as the dependent variable.

$$AvgPrice\_Vehicle_{j,t} = \alpha + \beta_1\, PctElecTrans\_Vehicle_{j,t} + \beta_2\, Availability_{j,t} + \sum_{t=2-2003}^{2\text{-}2008} \beta_t\, time_t + c_j + \varepsilon_{j,t} \quad (5)$$

We estimated specification 5 both with and without instrumenting $PctElecTrans\_Vehicle_{j,t}$. As above, we used $PctElecTrans\_Vehicle_{j,t-1}$ as the instrument. Results appear in Table 7.

The coefficient for $PctElecTrans\_Vehicle_{j,t}$ (β_1) is insignificant, indicating that an increase in electronic trading for a vehicle model is not significantly associated with a change in the mean price for that vehicle model. This is consistent with the null formulation of H4. We discuss this result more fully below.

Table 7: Results of specification 5.		
	a	**b**
	Coefficient	**Coefficient**
PctElecTrans_Vehicle	11.16 (8.70)	-25.74 (97.69)
Availability	146.43 (37.55) ***	256.96 (91.18) ***
Intercept	17957.42 (205.42) ***	--
Time dummies	included	Included
Vehicle model fixed effects	included	Included
PctElecTrans_Vehicle instrumented?	*no*	*yes*
1st stage F-statistic	n/a	653.03 ***
R^2, including fixed effects	0.97	--
R^2 within	0.05	--
R^2 centered	--	0.05
n	7,645	6,984
Robust standard errors in parentheses.		* p < 0.01, ** p < 0.05, * p < 0.10.

Discussion

A common conclusion about the effects of reduced search costs is that they will shift surplus from sellers to buyers (e.g., Bakos 1997). This is because reduced search costs help buyers find the lowest price, such that sellers must respond by lowering their price towards marginal cost. Buyers benefit from improved preference matching and lower prices, while sellers benefit from increased exposure but are harmed due to lower profit margins. However, the theoretical models upon which these conclusions are based assume fixed-price environments in which sellers set prices (e.g., Salop and Stiglitz 1977; Varian 1980). Because the price mechanism in our context is an auction, it is interesting to explore the implications of reduced buyer search costs for buyers and sellers.

First, we find evidence that reduced buyer search costs due to the electronic channel are associated with lower price variance, but no evidence that they are associated with lower mean prices. This is in contrast to most theoretical models of reduced search costs, which predict lower price dispersion and lower prices. Although a formal proof is beyond our scope, the intuition behind this difference is as follows. In our context, the reduced buyer search costs of the electronic channel help buyers find auctions where prices are relatively low. However, the buyers' subsequent participation in those auctions causes prices to rise, due to the properties of the auction mechanism. Thus, "bargain" prices are not sustainable. Prices move toward a uniform price, but the price is not marginal cost.

Implications for buyers: Intuitively, it would seem that the electronic channel benefits buyers by providing them with more options, including easier access to facilities where prices are good. However, an electronic buyer's newfound access to a low-price facility harms the buyers who were already using that facility, because the new buyer represents bidding competition. These "incumbent" buyers can use the electronic channel to purchase from other facilities, but this shuffling of demand will ultimately eliminate below-average prices that might otherwise be available at facilities in the market. Thus, buyers are unlikely to benefit from lower prices. However, they should benefit from improved preference matching, because the electronic channel provides access to more vehicles. They may also benefit from the elimination of transaction costs associated with physical participation in auctions.

Implications for sellers: Because prices are becoming more uniform but not necessarily lower, reduced buyer search costs may not impact seller revenue. However, they do have implications for where sellers locate their vehicles. This is because the price for a vehicle has traditionally varied based on its location, which has given sellers an incentive to strategically locate their vehicles at different facilities (Du et al. 2009). This incentive is becoming weaker as prices in the market flatten, suggesting that sellers may use fewer facilities to save on operational costs. However, because the price flattening effect weakens with distance due to transportation costs, sellers should still use facilities in different geographic regions, as opposed to, for example, centralizing all vehicles at one facility. Thus, we would expect sellers to use fewer facilities over time, but for these facilities to be spread across the country.

We examined these predictions by calculating the gini coefficients for each time period for: a) the distribution of vehicles across facilities, and b) the distribution of vehicles across regions defined by the U.S. Census Bureau. A gini coefficient of 1 would indicate that sellers were locating all vehicles at one facility (or region), while a gini coefficient of 0 would indicate that sellers were distributing their vehicles equally among all facilities (or regions.) The left panel of Figure 3 plots the gini coefficients by time period. The upward trend for the gini coefficient by facility indicates that sellers are concentrating more of their vehicles at fewer facilities. However, the flat trend for the gini coefficient by U.S. Census Region indicates that sellers have maintained a consistent geographic distribution of vehicles. Both results are consistent with the predictions.

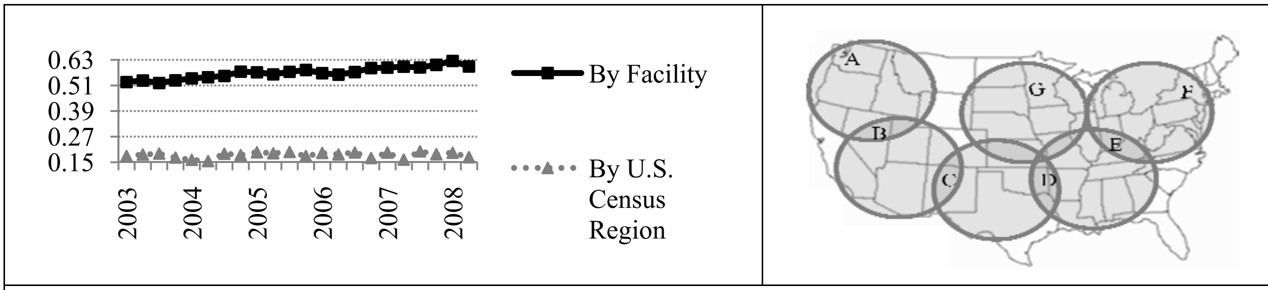

Figure 3: Left panel: Gini coefficients for the distribution of vehicles across facilities and U.S. Census regions per time period. Right panel: Illustration of how individual "flat" regions overlap to yield a "flat" country.

<u>Is the entire market flat, or it comprised of a series of flat spots?</u> The results of our second test of H3a show that prices across the U.S. are becoming flatter as electronic trading increases. However, the results of H3b show that the flattening effect of electronic trading weakens with distance. This presents a paradox: how can prices across the entire country be flattening when the flattening effect operates primarily on a regional basis? We reconcile this by concluding that the reduced buyer search costs of electronic trading is creating a series of flat regions throughout the country. These regions overlap, which causes prices across the entire country to flatten via transitivity. The right panel of Figure 3 illustrates this. Each gray circle represents a flat region, and letters represent locations. Prices at locations A and B are flat because they are in the same flat region, as are prices at locations B and C. By transitivity, this means that prices at locations A and C are flattening, as are, by extension, prices at locations A and F.

Conclusion

We analyzed over 2.5 million wholesale transactions for vehicles with between 15,000 and 21,000 miles from 2003 to 2008. There has been a steady increase in the percentage of electronic trading over these years, growing from approximately 0% to approximately 25%. This increase represents a net decrease in buyer search costs, leading to important changes in buyer behavior and price dispersion in the market. The results of our analysis show that buyers are using the electronic channel to purchase across a larger geographic area and to shift their demand from high-price to low-price facilities. This "arbitrage" is causing prices to become more uniform, although the flattening effect weakens with distance. Although electronic trading affects geographic price variance, it does not affect the mean level of prices in the market due to the properties of the auction mechanism.

<u>Intended Contributions:</u> Our study extends the research streams on how electronic commerce affects geographic trade and price dispersion in several ways. First, we consider how location affects the relationship between electronic trading and price dispersion, concluding that location affects buyer channel usage and that the relationship between electronic trading and price variance weakens with distance. Second, by showing empirically that buyers engage in a form of arbitrage between high-price and low-price locations, we observe the behavioral mechanism by which reduced search costs affect price dispersion. Illustrating this mechanism is critical to understanding how reduced search costs influence price dispersion (Baye et al. 2006). Third, we study price dispersion in an auction rather than a fixed price context. Reduced search costs should lead to lower price dispersion in both contexts, but for different reasons. In a fixed price context, the lower price dispersion arises as a result of all sellers lowering prices toward marginal cost. I.e., lower price dispersion is the result of lower price levels. In an auction context, the lower price dispersion arises due to buyers shifting their demand from high-price auctions to low-price auctions, effectively "arbitraging" away the price variance. In this case, lower price variance is the result of this arbitrage, not of lower price levels. We find support for this distinction; increased electronic trading, which proxies for a reduction in buyer search costs, is negatively associated with price variance, but unassociated with price levels. Fourth, we use panel data spanning 5.5 years to study how overall prices within a market – regardless of channel – are becoming more uniform as electronic trading increases. This extends the empirical research in this stream, which typically compares dispersion in online prices to that in offline prices.

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