Title: The Role of Spatial Density and Technological Investment on Optimal Pricing Strategies in the Grain Handling Industry

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Abstract: Shuttle-loading elevators are an investment that may lower grain-handling costs through improved rail rates, guaranteed railcar availability, and attracting grain from further distances. If shuttle-loading facilities reduce the marginal costs of handling a bushel of wheat, then it is possible that they pass some portion of those savings on to wheat farmers in the form of higher cash prices. We model and hypothesize how the decision of a profit-maximizing firm to pass through those savings is affected by differences in grain handling technology and spatial density of market competition. We exploit a natural, historical difference in Kansas and Montana wheat markets to empirically test these hypotheses using cross-sectional, temporal, and spatial variation in weekly wheat price levels from 2005 to 2013. Findings indicate that, relative to conventional grain elevators in Kansas, newer, more technologically advanced shuttle-loading facilities offer a $0.13 per bushel premium. In Montana, pass-through marginal cost savings from shuttle loading elevators are only $0.04 per bushel. These results indicate that adoption of variable cost reducing technology and the density of existing elevators both influence the degree to which grain farmers benefit from efficiency gains at grain-handling facilities.

Keywords: basis, grain elevator, prices, pass-through, spatial competition, spatial difference-in-difference, wheat

JEL Codes: Q13, L11, Q11

The Role of Spatial Density and Technological Investment on Optimal Pricing Strategies in the Grain Handling Industry

In competitive grain commodity markets, agribusinesses are price takers of globally-determined prices. As such, improvements in profit margins are largely dependent on technologies and management strategies that improve cost-side efficiencies of handling grain. Shuttle train-loading elevators—high capacity, high-speed grain loading facilities—are a recent example of agribusinesses responding to these incentives by adopting technologies that improve efficiency and attempting to capture market share through cost reductions.

Shuttle train-loading elevators are designed to quickly load approximately 380,000 bushels of wheat onto dedicated shuttle-unit trains in 15 hours or less (Kenkel, Henneberry, and Agustini 2004; Bekkerman 2013).[1] Through these operational efficiencies, grain handling facilities are able to reduce costs with improved rail rates and guaranteed railcar availability. For example, between 2010 and 2015, rail tariffs across numerous U.S. origins and destinations for wheat delivered by shuttle trains were, on average, 23.3% lower than delivery using non-shuttle trains (USDA Agricultural Marketing Service, 2016). These comparative advantages have spurred agribusinesses to upgrade existing elevators and build new shuttle-loading facilities across the U.S. Great Plains (Bekkerman 2013; Kowalski 2014).

If shuttle-loading facilities reduce the marginal costs of handling a bushel of grain, then it is possible that some portion of those savings will be passed through to grain farmers in the form of higher cash prices. Pass-through seems especially plausible because these facilities must meet strict shuttle train capacity requirements and, therefore, have higher demand for grain than smaller, conventional elevators. Additionally, technological advances and firms' historical location choices can result in local monopsony power, which can also pass-through behaviors. This study characterizes and measures systematic differences in elevators' pricing and pass-through behaviors and examines variation in these differences that may be associated with the spatial competitiveness of a local market for wheat.

We develop a model of spatial competition among elevators to characterize optimal pricing strategies and pass-through behavior. We then empirically assess these behaviors within and

[1] Shuttle-unit trains are typically 100 cars long and operate on fixed, predetermined schedules. Smaller, non-unit trains are typically comprised of 25-50 cars.

between elevators in Kansas and Montana, two large wheat-producing states where historical differences in the spatial marketing competition structures provides for empirical identification. We model cross-sectional and temporal variation in local wheat prices using daily cash price bids at grain elevators between January 2, 2004 and July 12, 2013. Specifically, we use a spatial basis model to estimate and test for evidence of differences between cash price bids across elevators that have different variable costs due to their grain handling technology.

The estimation results of the spatial basis model indicate that price bids at shuttle-loading elevators are higher than at conventional elevators by \$0.13 per bushel (22% higher) in Kansas and \$0.04 per bushel (6.0% higher) in Montana. These results indicate that costs savings from a technology that reduces variable grain handling costs is passed through to agricultural producers, but that in less spatially competitive markets (Montana), the pass-through is significantly lower. We also show that a greater degree of local spatial competition leads to pressure on firms that do not have the cost-saving technology to also raise their price bids (thus reducing profit margins) in order to remain competitive with their more efficient neighbors. These results represent the first set of empirical estimates quantifying the observed pricing behaviors in the grain handling industry and the extent to which these are impacted by the competitive structure of the industry.

Background on Grain-Handling Facilities' Pass-Through

We examine grain-handling facilities' pricing and pass-through behaviors using basis. Basis measures the spread between a cash price offered by a grain-handling facility and the associated futures contract price. In theory, basis represents the transportation costs associated with moving grain from the local elevator (source of the cash price) to the delivery location (source of the futures price). This makes it an appropriate measure for a study of the impacts of a transportation cost-reducing technology such as shuttle loading capabilities.

Basis is also commonly used in the grain marketing industry to evaluate changes in market conditions because, unlike either of its two separate components (cash price and futures price), variation in basis levels incorporates information about both the broad market conditions (through the futures prices) and more localized conditions (through the cash price). As such, knowledge about basis is important to both farmers and grain merchandizers, helping inform them of market information such as returns to storage, local and downstream demand, and changing costs of transportation. Within the context of this study, grain-handling facilities can increase the pass-through amount by strengthening their basis bid (i.e., increasing the cash price that they offer to farmers relative to the futures price) or weakening the bid.

A limited amount of research has focused on quantifying pass-through to the farm level of the grain production sector as a result of changes in grain handling costs. The studies that do exist exploit market structure changes prompted by the 1980 Staggers Act, which deregulated the railroad industry and shifted grain shipping away from single car loads and toward multi-car and unit-train (shuttle-train) shipments in response to rate reductions for larger shipments (MacDonald 2013). One result of the deregulation was a rapid increase in the number of shuttle-loader facilities in large U.S. corn and soybean production regions, which began to take advantage of lower freight rates.

Modeling basis levels in sixteen Corn Belt states between 1980 and 1992, Fortenbery, Zapata, and Kunda (1993) estimated a spatio-temporal error component model that used elevator concentration measures to determine whether grain companies were capturing decreased transportation savings rather than passing them on to farmers. The authors found that shuttle-loading facilities largely did not pass through the transportation cost savings to farmers.

Hauser, Jeffrey, and Baumel (1984) similarly analyzed the period following the Staggers Act focusing on shuttle-loading facilities in Iowa and Nebraska. In Iowa, the marketing landscape was relatively saturated with large capacity, 25- and 50-car loading facilities prior to the Staggers Act deregulation, while Nebraska had relatively few of these facilities and presented greater entry opportunities. Using a mathematical programming model to estimate the implicit (shadow) prices of shuttle-loader facilities, the authors estimated larger shadow prices for Nebraska than Iowa, suggesting possible improvements in local basis were likely to occur in areas with fewer existing shuttle-loading facilities.

The Hauser, Jeffrey, and Baumel (1984) study provided suggestive evidence that differences in grain-handling market competitive structures could affect elevators' decisions to pass on their cost savings upstream to farmers. However, the first wave of shuttle-loader entry did not provide an opportunity to empirically test this hypothesis because the new technology was adopted in markets with relatively homogeneous characteristics. That is, Corn Belt markets are largely characterized by having many farmers who produce high-yielding crops with little on-farm storage and they deliver much of their output soon after harvest to local elevators, of which there are a large number located within a geographic region.

During the late 1990s and early 2000s, a second entry wave of shuttle-loading, grain-handling facilities occurred in major wheat production regions. This entry occurred as a result of market-based changes rather than policies. For example, technological adoption during the late-20th century that led to higher wheat yields and faster harvest times translated to a greater demand for efficiency at elevators, which can be achieved by the higher capacity, higher loading speed shuttle-loading facilities (Kowalski 2014). Shuttle-loaders have also expanded into the northern Great Plains and Pacific Northwest as international agribusiness firms continue to invest in facilities to assure a steady supply of grain to Asian markets (Bekkerman 2013).

The second entry wave is unique because it occurred simultaneously in wheat producing regions that have historically had distinctly different spatial competition arrangements, farmer storage structures, and marketing channels (e.g., Northern Great Plains versus Central/Southern Great Plains). The existence of shuttle-loading facilities into these markets provides an opportunity to understand and measure differences in pass-through behaviors and how these differences are affected by the market structure heterogeneity that existed well before new grain handling technologies were adopted. Because the existence of more efficient firms as well as historical decisions about elevator location can affect the level of competition for grain procurement, the extent of pass-through could be influenced by the degree of local monopsony power. Evidence of such behavior would be analogous to widely documented asymmetric price setting under imperfect competition (for example, see Fisher, 1989; Neumark and Sharpe, 1992; Kim and Cotterill, 2008).

Pass-through under Alternative Spatial Competition Structures

The efficiencies attainable by shuttle train-loading elevators may be passed on to farmers in the form of stronger basis bids (i.e., higher cash price bids). However, a profit-maximizing elevator will only choose to pass on higher prices to farmers when market conditions require such pricing strategy adjustments. These conditions include the market structure and degree of spatial competition among nearby elevators within which a shuttle-loading elevator operates.

To model elevators' pass-through behavior, we first consider farmers' decisions to deliver grain to an elevator. These decisions are determined by the elevator at which farmers can receive the highest net farm gate price, which is the difference between the cash price farmers receive from an elevator and the cost of hauling the grain from the field to that elevator. The hauling costs are dependent on the distance between a farmer and an elevator. Without loss of generality, but as a modeling simplification, we assume farmers are uniformly distributed along a unit line (distance from 0 to 1), the distance between two successive farmers is identical across all farmers in a delivery region, and each farmer has one unit of grain to deliver. A shuttle-loading elevator (S) is located at one end and a conventional elevator (C) is at the other end of the unit line.

Under the assumption that both the shuttle-loading and conventional elevator can offer a sufficiently high price to attract at least one farmer, the market will be spatially separated with farmers delivering to the closest elevator. The marginal farmer, located at the outermost edge of the market boundary for each elevator, will be indifferent between delivering to the two elevators; that is,

$$w_s - tr = w_c - t(1-r). \tag{1}$$

The term w_s is the cash price offered by the shuttle-loader, w_c is the cash price offered by the conventional elevator, t is the per-unit transportation cost incurred by the farmer, and r is the distance the farmer must travel to reach the shuttle-loading elevator.[2] The location of the marginal farmer along the unit line is calculated by solving equation (1) for r^*. The resulting market boundary is,

$$r^* = \frac{(w_s - w_c)}{2t} + \frac{1}{2}. \tag{2}$$

The shuttle-loader maximizes profit in this market by choosing a cash price, w_s. This choice is conditional on the price they will receive after marketing the grain (e.g., the futures price), P, the marginal costs of handling the grain, m_s, and the dynamic relationship with the competing conventional elevator that determines the market boundary. Specifically, the shuttle-loader's profit maximization function is,

$$\max_{\{w_s\}} \Pi_S = (P - w_s - m_s)r^* = (P - w_s - m_s)\left[\frac{(w_s - w_c)}{2t} + \frac{1}{2}\right]. \tag{3}$$

We determine the profit-maximizing price setting behavior by setting the derivative $\frac{d\Pi_S}{dw_s} = 0$, and solving for $w_s{}^*$. The resulting optimal price response function for the shuttle-loader is,

$$w_s^* = \frac{1}{2}(P + w_c - m_s - t). \tag{4}$$

Similarly, the conventional elevator maximizes the profit function

[2] The assumption that each farmer has one unit of grain to sell implies that r is equivalent to the volume of grain that will be delivered to the shuttle-loader, while $(1-r)$ is the total volume of grain delivered to the conventional elevator.

$$\max_{\{w_c\}} \Pi_C = (P - w_c - m_c)(1 - r^*) = (P - w_c - m_c)\left[\frac{(w_c - w_s)}{2t} - \frac{1}{2}\right], \quad (5)$$

where m_c is the constant marginal cost of handling grain. The conventional elevator's optimal price response function is

$$w_c^* = \tfrac{1}{2}(P + w_s - m_c - t). \quad (6)$$

The optimal price response functions represent a Bertrand oligopsony solution, which characterize a market where each firm sets their prices assuming the other firm's prices are known. Because each of the two elevators' prices depend on the price-setting behavior of the other elevator, the Nash equilibrium prices are determined by simultaneously solving equations (5) and (6) for w_s and w_c. The resulting prices are

$$\widetilde{w_s} = P - \tfrac{2}{3}m_s - \tfrac{1}{3}m_c - t \quad (7)$$

and

$$\widetilde{w_c} = P - \tfrac{2}{3}m_c - \tfrac{1}{3}m_s - t\,. \quad (8)$$

Hypothesis 1: Cost Savings Pass Through

The optimal pricing equations can be re-characterized as functions of basis. Basis is typically defined as the cash price offered to farmers minus the futures contract price. Thus, the basis level at the shuttle-loader and conventional elevator are $b_s = \widetilde{w_s} - P$ and $b_c = \widetilde{w_c} - P$, respectively.[3] After substituting these relationships into equations (7) and (8), the partial derivative of the basis with respect to the marginal cost of grain handling for each type of elevator type is

$$\frac{\partial b_s}{\partial m_s} = \frac{\partial b_c}{\partial m_c} = -\frac{2}{3} < 0\,. \quad (9)$$

The comparative statics of equation (9) indicate that reductions in an elevator's marginal grain handling costs will increase (strengthen) the basis and, consequently, increase the farm gate price received by a farmer. For example, if shuttle-loaders receive more favorable (i.e., lower) rail tariff rates, then, in a baseline perfectly competitive marketing scenario, these elevators will pass through a portion of their cost savings to farmers in the form of stronger basis.[4] As such, equation

[3] Observed basis levels in Kansas and Montana are typically negative, reflecting the need for elevators to account for transportation costs between their physical location and the delivery location represented by the futures price, and the fact that these are major producers (and, thus, regional exporters) of wheat.
[4] The term strengthen, with respect to basis, means it is less negative because the cash price has increased. Similarly, a weaker basis is more negative due to a lower cash price.

(9) provides the first testable hypothesis from this model: if the shuttle-loader receives a rail tariff discount or can otherwise realize efficiencies through technologies that lower their marginal grain handling cost, then the shuttle-loader will offer higher cash prices ($b_s > b_c$) to farmers than a conventional elevator.

Hypothesis 2: Pass-Through Under Spatial Competition Due to Transportation Costs

Our first hypothesis describes the broad impacts of marginal cost reductions, but it does not provide insights about how basis levels are affected in response to changes in spatial competitiveness among grain handling facilities. The effects of an increase in elevator density can be simulated by decreasing the value of t. For example, a transportation cost of \$0.30 per mile is equivalent to \$0.15 per half mile. Therefore, a reduction in t from 0.30 to 0.15 is equivalent to changing the unit of distance from miles to half miles, implying the distance between elevators is halved. According to equation (7), a decline in the value of t increases the farmgate price

$$\frac{\partial b_s}{\partial t_s} = \frac{\partial b_c}{\partial t_c} = -1 < 0 \,. \tag{10}$$

The second testable hypothesis generated by the model is that a decline in transportation costs for farmers to deliver grain to an elevator will increase the price received by farmers (i.e., strengthen the basis level). That is, in markets where grain elevators are more densely populated and, as such, more spatially competitive, pass-through is expected to be higher. Using equations (7) and (8), it also follows that $(\widetilde{w_s} - \widetilde{w_c}) = (m_c - m_s)/3$. Elevator density, as measured by t, does not affect the difference between the equilibrium prices, implying that measuring the degree to which spatial competition affects pass-through would not be possible in markets where elevator density has remained historically constant. As such, identification of the competition–pass-through interaction and a test of the second hypothesis requires pass-through estimation in markets with historically different spatial competition structures such as Kansas and Montana.

Hypothesis 3: Pass-Through Spillovers Due to Spatial Competition

Following the re-characterization strategy that led to the relationship between marginal costs and basis defined in equation (9), we can also define the effect on basis due to changes in marginal costs of competing elevators. That is,

$$\frac{\partial b_s}{\partial m_c} = \frac{\partial b_c}{\partial m_s} = -\frac{1}{3} < 0\,. \tag{11}$$

This result is used to frame the third hypothesis: decreases in marginal costs of handling grain by competing elevators will increase basis at the elevator of interest, but to a lesser degree than if the marginal cost reduction occurred at that elevator. For example, if a nearby shuttle-loading facility geographically competes with a conventional elevator, then the lower marginal costs at the shuttle-loading facility (and resulting pass-through at that shuttle-loader in the form of higher basis) will lead to the conventional elevator also strengthening their basis. However, because this would represent an indirect spatial competition effect, rather than a direct impact on basis due to lower marginal costs, the basis increase at the conventional elevator is expected to be lower than the increase at the shuttle-loading facility.

Data Description and Empirical Modeling Strategy

The market structure heterogeneity among U.S. wheat markets provides the ability to test the three hypotheses about savings pass-through in spatially competitive markets. We focus on two major wheat producing states, Kansas (the largest U.S. wheat producing state) and Montana (the third largest U.S. wheat producing state), which also have distinctly different marketing landscapes. Similar to the Corn Belt, Kansas markets are characterized by having many farmers and many grain-handling facilities that are situated geographically close to one another. Montana, however, has fewer farmers and even fewer elevators, both of which are spatially dispersed. These fundamental market structure differences have been solidly established for numerous decades, and most certainly prior to the most recent wave of entry by shuttle-loading grain handling facilities.

Data Description

We construct a pooled cross-section of daily cash and futures prices for 297 locations in Kansas and Montana over the period January 2, 2004 to July 12, 2013.[5] Cash prices were obtained from the Kanas State University's historical database for all Kansas elevators and for the majority of elevators and days in Montana (Kansas State University 2017). The remaining prices for Montana were obtained from GeoGrain, Inc. (2017). Cash prices represent hard red winter wheat with a

[5] Within the data, there are days when elevators do not report their basis information. However, the missing data are missing-at-random, so the likelihood of the missing data affecting model estimates is low.

protein content of 11% for Kansas and ordinary (10% or less), 11%, 12%, and 13% protein content for Montana wheat. To ensure a similar comparison across states, Montana grain prices were averaged across the protein levels to calculate a single winter wheat price for each day and elevator.[6]

Futures prices for the nearby (closest contract to expiration at a given point in time) hard red winter wheat contracts traded on the Kansas City Board of Trade (KCBT), as well as implied volatilities for the nearby contracts, were collected from Bloomberg.[7] Using the cash and futures prices, the nearby basis levels were calculated by subtracting the futures price from the cash price.[8]

Additional information about the elevators in the dataset was gathered from a variety of sources. The ability of an elevator to load shuttle trains was determined by directly contacting individual elevators and from state and federal elevator licensing records, railroad websites, news releases, and the Kansas Grain and Feed Association's Annual Directory. For each elevator reported to be a shuttle-loader, the year in which they began loading shuttle trains was also recorded. Other elevator characteristics were similarly collected and include information about rail line access, business structure (cooperative or investor-owned firm), licensed grain holding capacity, and the name of the ownership firm.

Table 1 shows the descriptive statistics of select variables by state and shuttle-loading capability for the 483,709 daily observations in our sample. The descriptive statistics provide insights about market structure differences in Kansas and Montana, showing that Montana has fewer elevators than Kansas, but the proportion of shuttle-loaders to conventional elevators is higher in Montana than in Kansas. Although in both states the grain storage capacity of shuttle-

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[6] While Kansas State University historical databases only report prices for 11%, 12%, and 13% protein level winter wheat marketed in Montana, GeoGrain, Inc. reports prices for these protein levels and the ordinary protein level. Because elevators discount lower protein content wheat, the average price is expected to be higher when the ordinary protein level wheat price is excluded. However, the difference is expected to be relatively constant across time and elevators within a common marketing environment (Bekkerman, unpublished data representing Montana elevator protein discount schedules for 22 locations between 2011 and 2016) and can be accounted for using an indicator variable in an empirical specification.

[7] The rollover date for the nearby contract was defined as the first day of the month that the nearby contract was due to expire.

[8] It should be noted that cash bids collected in this manner represent offer prices to buy grain and do not necessarily imply that grain was transacted at these prices for every elevator on every day. While a significant proportion of winter wheat produced in Kansas and Montana is shipped west to export terminals in the Pacific Northwest, KCBT hard red winter wheat futures contracts—for which delivery locations are not on the west coast—represent the only consistently reported instrument for evaluating future price expectations. Furthermore, significant convergence problems that occurred in KCBT winter wheat futures markets (for example, see Garcia, Irwin, and Smith, 2014) would similarly affect basis values in all winter wheat production locations.

loaders averages five times more than conventional elevators, the average capacity of Kansas elevators is approximately 2.5 times larger than the capacity of Montana elevators. This additional storage capacity in Kansas elevators could largely be explained by the fact that for every 1 bushel of wheat stored at a Kansas grain-handling facility, only 0.08 bushels of wheat are stored on-farm. In contrast, over 4 bushels are stored on-farm in Montana for every 1 bushel stored at an elevator (USDA NASS, 2015). Interestingly, shuttle-loading facilities in both states are largely privately owned, while conventional elevators are more likely to be operated by a farmer-owned cooperative.

Figure 1 provides a visual representation of the differences between Kansas and Montana grain-handling market structures. The figure shows the location of grain elevators that procure wheat in each state. Shuttle-loader elevators are represented by darker circles and conventional elevators are lighter. The size of each circle corresponds to an elevator's licensed grain storage capacity, with larger circles representing greater capacity relative to other elevators in the sample. The lines on the map represent rail lines in each state. A visual comparison of the two states' grain marketing landscapes clearly indicates differences in market structures. For example, there are, on average, 25 other elevators within a 50-mile radius of any particular elevator in Kansas.[9] In Montana, an elevator has, on average, only 3 other competing facilities within a 50-mile radius. These spatial density differences could have unequal impacts on elevators' pricing strategies, depending on the state in which an elevator is located and the grain loading technology of that elevator.

Spatial Basis Model

The distinctions between the Kansas and Montana wheat marketing landscapes provide an opportunity to empirically identify if within- and between-state variation in grain elevators' pricing strategies are affected by grain handling technology and differences in spatial competition structures. To do so, we model cross-sectional and temporal variation in basis levels across competing elevators and the differential in that variation across the two markets. This modeling approach is informed by an extensive literature that examines local basis behavior and which has found that it can typically be categorized as having intertemporal and spatial determinants as well

[9] Clark, Jessup, and Casavant (2003) show that the majority of wheat—approximately 85%—is delivered within a radius of less than 20 miles of a grain elevator, and 97% of wheat is delivered within a radius of 50 miles.

as being affected by changes in public policy and the marketing environment (for example, see Garcia and Good, 1983; Dykema, Klein, and Taylor 2002; Martin, Groenewegen, and Pigeon 1980; Jiang and Hayenga 1997).

We use a spatial model of wheat basis that exploits the marketing landscape differences between Kansas and Montana. Specifically, we model the variation in nearby basis, b_{it}, at elevator i on date t as,

$$b_{it} = \beta_0 + \beta_1(Shuttle_{it}) + \beta_2(Shuttle_{it} \times MT_{it}) + \boldsymbol{\theta Z} + \varepsilon_{it} . \quad (12)$$

where $Shuttle_{it}$ is a binary variable indicating if an elevator is a shuttle train-loader and MT_{it} is a binary variable indicating if an elevator is located in the state of Montana. In this spatial difference-in-difference specification, the coefficients of interests are β_1, which represents the difference in basis at Kansas shuttle-loading facilities relative to Kansas conventional elevators, and β_2, which is the basis differential between Kansas and Montana shuttle-loading facilities. The sum, $(\beta_1 + \beta_2)$, therefore, represents the difference in basis at Montana shuttle-loading facilities relative to Montana conventional elevators.

The term $\boldsymbol{Z}$ represents additional controls, which include: a binary indicator for whether an elevator is in Montana; the implied volatility of the nearby Kansas City Board of Trade winter wheat futures contract[10]; a binary indicator for whether the cash price data were obtained from the Kansas State University historical database; binary indicators for whether an elevator has access to a rail line, whether there is access to a rail line owned by Union Pacific (UP), whether there is access to a rail line owned by Burlington Northern Santa Fe (BNSF), whether the elevator is privately owned or has a cooperative ownership structure, and whether the elevator has a federal or state operating license[11]; the elevator's storage capacity, in millions of bushels; and binary indicators for the name of the firm that owns the facility. Additionally, we include a binary indicator for whether an observation occurs in 2009 or later, because in response to a significant commodity futures market dysfunction event that occurred in 2008 (see Irwin et al., 2011 for an in-depth discussion of these issues), futures markets altered their trading policies and

[10] Implied volatility of the nearby futures provides a plausible control for grain elevators' knowledge about market uncertainty and risk. Taylor, Dhuyvetter, and Kastens (2014), for example, show that increased market uncertainty affected elevators' pricing (and thus, basis) behaviors, as these grain handling facilities pass down increased market uncertainty in the form of weaker basis.

[11] A federally licensed elevator has the ability to more easily move grain from one elevator to another to cover shipping obligations across state lines. As such, larger grain merchandizing companies with multi-state locations tend to be federally licensed.

contract specifications (Garcia, Irwin, and Smith, 2014). This required all grain handling facilities to make some change in their marketing and pricing behavior (Taylor, Tonsor, and Dhuyvetter 2014).

Lastly, we include year and month fixed effects to control for unobserved annual and seasonal heterogeneity in production and marketing conditions affecting all elevator locations; county fixed effects that control for unobservable location-based heterogeneity; and county-by-month and county-by-year fixed effects that control for additional spatial-temporal variability.

An important concern with interpreting the estimated standard errors of the model is that the estimates could be affected by spatial autocorrelation that exists across linked spatially separated grain markets and serial correlation across time. Numerous studies provide empirical evidence of price linkages in spatially separated agricultural markets (for example, see Brorsen et al. 1985; Goodwin and Holt 1999; Bekkerman, Goodwin, and Piggott 2013). These spatial dependencies could also exist in nearby wheat basis levels, especially in light of the grain transportation interconnectedness that exists in both states (McNew and Griffith, 2005). As such, to adjust for spatial and temporal correlation in the errors, we estimate county-level clustered standard errors that are adjusted for heteroscedasticity and serial autocorrelation following the Newey-West procedure.[12]

Estimation Results for the Spatial Basis Model

Table 2 presents the results of six specifications of the spatial basis model. Every specification includes the elevator-level control variables. The six specifications differ in the alternative spatial, temporal, and spatio-temporal fixed effects that are included in the model. These fixed effects are added iteratively to assess the stability and consistency of the estimated pass-through marginal effects in response to controls for regional dynamics, seasonality and marketing year differences, and interactive effects.

The estimation results in Table 2 show that across all model specifications, the data indicate a consistent price premium offered at shuttle-loading facilities in Kansas and Montana. However, the parameter estimates do not seem to stabilize until county, yearly, monthly, and county-by-year fixed effects are included in the model specification (Model 5). Adding county-by-month fixed effects (Model 6) increases overall model fit, but does not appear to significantly alter the marginal

[12] Following Greene (2003), we specify a 6 period lag length for the Newey-West adjustment.

effect estimates. Pairwise log-likelihood ratio and Vuong tests indicate that each model is statistically different from all others and that models with additional fixed effects are preferred.[13]

The parameter estimates associated with the variables of interest in the full specification (Model 6) indicate that, relative to prices offered by conventional elevators in Kansas, shuttle-loading facilities in Kansas offer an average premium of approximately $0.13 per bushel, which represents a 22% higher basis at shuttle-loading facilities relative to conventional elevators. This result supports the first hypothesis represented in equation (9). That is, reductions in an elevator's marginal grain handling costs will, in part, be passed on through the supply chain, which in the case of grain markets is reflected in higher basis and, consequently, higher prices received by farmers. The results also show that the premium offered by Montana shuttle-loading facilities is, on average, 4 cents per bushel or a 6.0% improvement in basis relative to conventional facilities.

During the period 2004 to 2013, the average Kansas farm produced approximately 14,700 bushels and an average Montana farm produced approximately 32,585 bushels of wheat (USDA NASS, 2017). As such, our empirical results suggest that even small improvements in basis resulting from savings pass-through by shuttle-loading facilities can result in economically significant revenue changes for farmers. For example, an average Kansas farm who benefited from the $0.13 per bushel pass through would have observed nearly an additional $2,000 in revenues simply by delivering to a shuttle-loading facility. In Montana, additional revenues for an average farm would have been approximately $1,300.

The difference between pass-through amounts in Kansas and Montana (approximately $0.08 per bushel higher in Kansas) provides evidence in support of the second hypothesis, represented by equation (10). In more "crowded" markets (in our application, the Kansas market), farmers' transportation costs to elevators decline and, thus, prices offered by grain handling facilities are higher. Our results, therefore, provide empirical evidence that supports the theoretical insights in Hauser, Jeffrey, and Baumel (1984), who show that there can be significant differences in the pricing opportunities for shuttle-loading facilities in different regions. More importantly, we show that these differences are driven by disparities in spatial density, which affects firms' pass-through behaviors.

[13] Test results are omitted for brevity but available upon request from the authors.

Robustness Analysis

The spatial basis model estimation results provide empirical evidence in support of the first two hypotheses that cost savings pass through occurs and that differences in firm density affect the extent to which those cost savings are passed on to agricultural farmers. To ensure that these results are not potentially due to factors other than the technological differences in grain handling facilities or other unobserved variables between grain marketing locations, we conduct a number of robustness checks. In each case, we estimate the fully specified spatial basis model, which includes all spatial and temporal fixed effects and fixed effect interactions (i.e., Model 6 in Table 2). Table 3 presents the results of the robustness analyses.

The first robustness check is a placebo analysis. In this analysis, we want to ensure that the differential basis values observed between shuttle-loading and conventional grain handling firms are not due to other unobservable firm characteristics that may differentiate prices across grain elevators and across states. The placebo analysis involves first removing all counties with a shuttle-loader, then randomly assigning shuttle-loader status to 9% of the remaining observations (which corresponds to the proportion of shuttle-loading facilities in the full sample), and finally re-estimating the model using the new sample. We repeat this procedure 1,000 times with a different assignment of placebo shuttle-loader status in each iteration.

Table 3 shows the average estimated coefficient for the variables of interest. Statistically significant marginal effects for the placebo analysis would suggest that there could be other firm or region-related factors—in addition to or correlated with shuttle-loading capabilities—that lead to differential pricing decisions between shuttle-loaders and conventional elevators. The results, however, indicate that the estimated marginal effects are not statistically different from zero. This implies that the basis differential estimated when actual (rather than placebo) shuttle-loaders were included in the sample is not likely due to a firm characteristic other than its shuttle-loading technology.

Second and third robustness checks seek to assess whether unobserved spatial data noise might be influencing the regression results. We include county-level fixed effects to control for unobservable regional variation and cluster standard error estimates to attenuate potential spatial autocorrelation biases. However, the strong spatial relationships in price transmission behavior may cause the differential pricing effect estimated for shuttle-loading grain elevators to be biased due to idiosyncrasies in nearby regions. To determine the extent to which the original results may be affected by these regional idiosyncrasies, we re-estimate the spatial basis model using two subsamples. The first subsample includes only counties that have at least one shuttle-loading facility and at least one conventional facility. The second subsample includes all counties from the first subsample as well as all adjacent counties. The subsample marginal effect estimates in Table 3 are similar in statistical significance and magnitude to the full model results, suggesting that unrelated market conditions in nearby regions influenced cost savings pass-through decisions by shuttle-loading firms.

The fourth robustness analysis is a sensitivity analysis to the particular composition of the sample. That is, if only a few of the shuttle-loading grain facilities or a few counties were disproportionately influencing the marginal effect estimates, then the model results could be unrepresentative of the market as a whole and the pricing decisions of average shuttle-loading and conventional elevators. To investigate the merits of this concern, we estimate 1,000 bootstrapped instances of the spatial basis model. Specifically, for each bootstrap iteration, we randomly sample with replacement counties from the original sample. For each selected county, prices for each elevator in the county are included for the entire 2004–2013 sample period. The total number of selected counties for each bootstrap sample is the same as the count in the original dataset, which helps preserve the original data structure.

Table 3 presents the average estimated marginal effects from the bootstrapping analysis. The results are quantitatively and qualitatively very similar to the estimated coefficients when using the original data sample. This suggests that it is unlikely that the original estimation results were disproportionately affected by one or a few elevators, regions, or some other factor that is unrepresentative of the broader marketing landscape and elevators' pass-through decisions.

The last analysis considers the extent to which pricing behavior by grain elevators located near state borders may be affected by basis at elevators in a bordering state, beyond what is already controlled for in our model using county-level fixed effects. Ideally, this robustness check would be performed by adding basis information for elevators located in nearby states and examining the impacts of variation in those data on Kansas and Montana elevators. However, elevator-level basis data are almost never publicly available and are very costly to obtain. As such, we test robustness to state-border effects by estimating the preferred basis model using a subsample of data that includes only counties that are not on a state border. Results in table 3 show that there are no qualitative and only trivial quantitative changes. As such, it is unlikely that our main findings are impacted by spatial spillovers from neighboring states.

Spatial Competition Analysis

We further assess the local spatial competition landscape and its potential impact on elevators' pricing behaviors by developing measures that characterize these marketing conditions. These assessments help provide further empirical evidence to test the second and third hypothesis posed above. Specifically, we develop three measures for each elevator in our dataset: the number of other nearby elevators; the total capacity of nearby elevators; and for conventional elevators only, the number of nearby shuttle-loading facilities. Following Clark, Jessup, and Casavant (2003), we specify three possible definitions of nearby for each measure: 5-mile, 20-mile, and 50-mile radii. Using these measures, we estimate nine additional regressions by including each of the local competition variables to the full baseline specification (Model 6), which includes all county and time fixed effects and interactions of those indicators.

Table 4 presents the results for the regressions that include the number of nearby elevators and the total capacity of nearby elevators. First, the results show that regardless of the local competition measure or radius, the consistency of the shuttle-loader basis differential in both Kansas and Montana is maintained at $0.13 and $0.04 per bushel, respectively. Second, we conduct pairwise comparisons across the six models in Table 4 using Vuong's non-nested tests, and find that models that define the nearby region as a 5-mile radius always provide a better fit to the data relative to models with larger radii. This suggests that in the grain handling industry, impacts of local spatial competition on pricing behaviors are particularly relevant within a relatively small geographic area, but dissipate as the radius increases. Additionally, the pairwise model comparison test results indicate that the model using the 5-mile radius total nearby capacity variable is preferred to the one using the number of nearby elevators in a 5-mile radius.

The regression results in Table 4 show that increased local spatial competition—regardless of whether it is measured using the nearby elevators or nearby capacity—increases (strengthens) the basis at an elevator. This almost certainly represents a localized response to increased demand for wheat. As such, the larger magnitude of the estimated total capacity marginal effect relative to the estimated nearby elevators coefficient as well as the Vuong test result seems to suggest that total quantity demanded, rather than simply the number of competitors, is the more pertinent spatial competition influence.

Table 5 presents the results of regressions that model conventional elevators' pricing strategies in response to nearby shuttle-loading facilities. This analysis investigates the third hypothesis defined in equation (11): increased local competition from technologically-advanced shuttle-loading facilities will affect basis not only at shuttle-loading facilities but also at competing conventional elevators. Similar to before, pairwise comparison tests indicate that the model of nearby shuttle-loading facilities within a 5-mile radius is statistically preferred to the competition measures defined using larger radii. The regression results show that conventional Kansas elevators that face competition from additional nearby shuttle-loaders have, on average, \$0.10 per bushel higher basis when the shuttle loader competition is within a 5-mile radius, and a \$0.07 per bushel higher basis when competition is farther away. In Montana, conventional elevators with shuttle-loading facilities within a 5-mile radius price wheat \$0.03 per bushel higher than conventional elevators that do not face competition from shuttle loaders; however, this impact dissipates in Montana if shuttle loaders are located farther away.

The results in Table 5 provide the closest direct test of the third hypothesis. Specifically, the presence of a shuttle-loading facility—which has lower marginal costs of handling wheat—within a spatially-competitive geographic region results in upward pressure on basis at nearby conventional elevators that may not have the same cost advantages. However, the magnitude of the basis increase at a conventional elevator is less than the direct basis increase at a shuttle-loading facility. That is, indirect effects of cost-saving pass-through by shuttle-loaders are muted relative to the direct effects on basis observed at shuttle-loading facilities.

Conclusion

A more complete understanding of how changes in the efficiency of grain handling affect elevators' willingness to bid for grain facilitates several practical outcomes. Agribusinesses and grain farmers can increase their understanding of relative basis bid behaviors by shuttle-loading and conventional grain facilities, as well as the impact of elevator density on transportation costs borne by the farmers. Another practical use of this research is the additional information it provides in determining the return on such a technology investment. Many farmer-owned cooperatives are considering investment in shuttle loading elevators. This research assists in understanding how the efficiencies of a shuttle loader accrue to farmers as owners and customers of the elevator as well as how the relative proximity of other elevators impacts cash price levels.

Results of this study indicate that an average of $0.13 per bushel premium is passed on to Kansas farmers by shuttle loading elevators as a result of efficiency-improving technology. In Montana, the premium is $0.04 per bushel to farmers. The primary difference between the two states is the density of elevators to which farmers can deliver. The relative sparsity of elevators in Montana reduces competition and leads to a lower amount of cost savings pass-through by shuttle loading elevators.

This research provides a framework for assessing differences in marketing behaviors in existing agricultural markets and increases understanding of future pricing strategies as competitive marketing structures continue to evolve. For example, while there is likely to be continued consolidation in the grain-handling industry and construction of larger, more efficient elevators, the potential benefits for farmers are likely to be determined by older conventional elevators' ability to make alternative arrangements to maintain their competitive viability. According to conversations with market experts, a hub and spoke marketing system often develops whereby conventional elevators serve as remote storage for shuttle-loading elevators and deliver grain to the shuttle-loaders via truck, rather than compete directly on rail rates (Kowalski 2014)[14]. Consequently, the level of pass-through that shuttle-loading facilities provide will depend on the extent to which these elevators spatially compete with the new role of conventional facilities.

Future research in this area may include further analysis of the nature of the rail service available between the two states and how rail competition affects grain basis. Montana is served by only one railroad, while Kansas has two national rail companies and several short line railroads. These differences are likely to affect transportation costs and the availability of shuttle trains for loading.

[14] Personal communication with a representative of the Montana rail grain transportation advisory group, November 2015.

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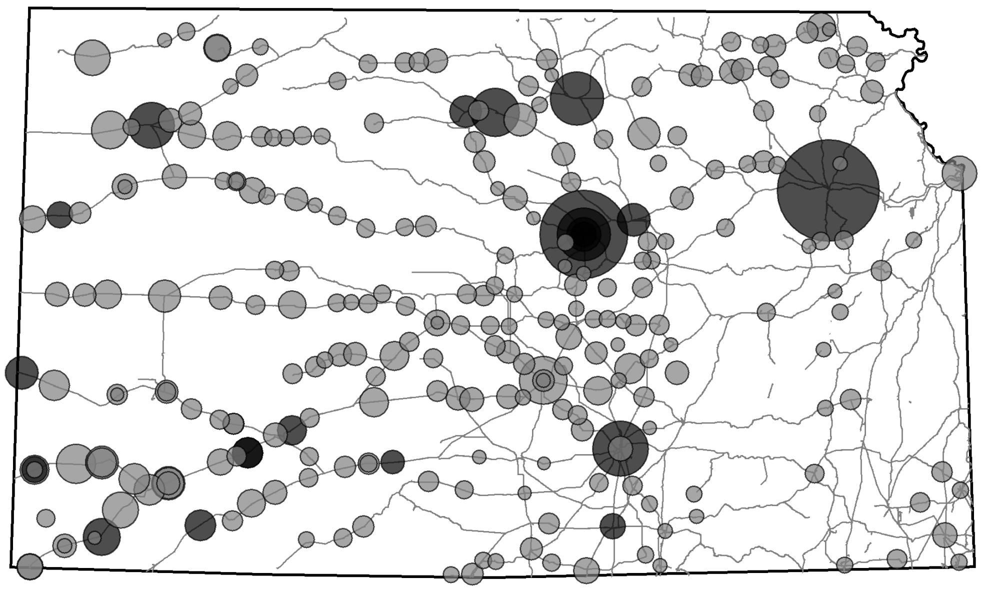
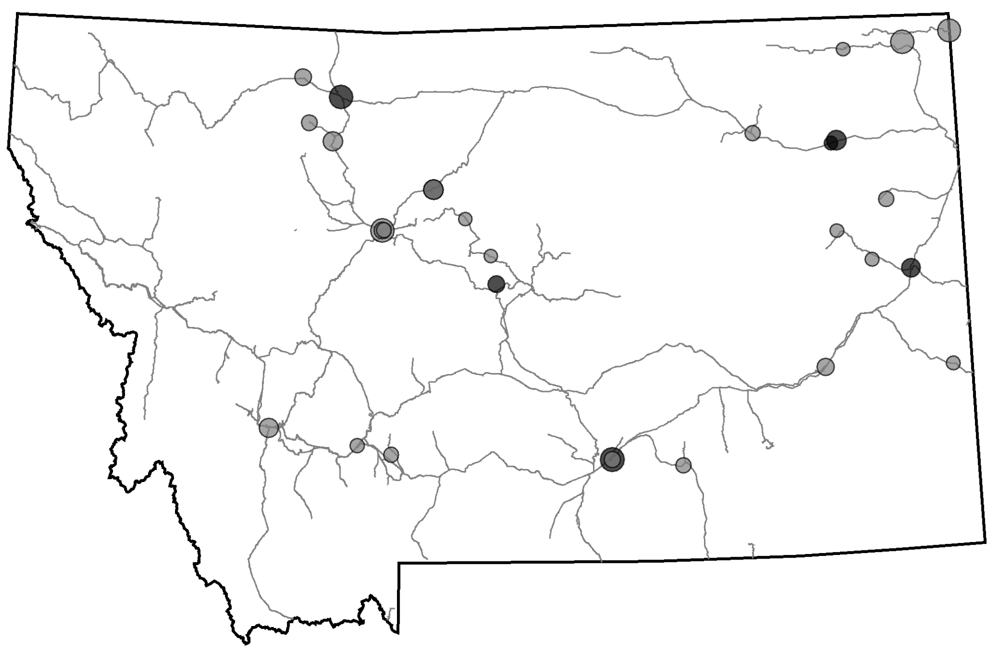


(a) Grain handling facilities and rail lines in Kansas



(b) Grain handling facilities and rail lines in Montana

Figure 1. Elevator Locations and Rail Lines in Kansas and Montana

Notes: Circles represent the location of a grain handling facility. Darker circles represent facilities with shuttle train-loading capabilities and lighter circles represent conventional elevators. The size of each circle represents the total storage capacity at the location relative to other elevators across the two states. Because several elevators may operate within a small geographic region, some circles overlap. Black lines characterize rail lines.

Table 1. Summary Statistics of Select Variables by State and Shuttle-Loading Features

	Conventional Elevators				Shuttle-Loader Elevators			
	Kansas							
	Mean	Std Dev	Min	Max	Mean	Std Dev	Min	Max
Nearby basis (dollars per bushel)	-0.59	0.35	-3.48	2.91	-0.48	0.37	-2.56	0.80
Proportion of elevator type	0.91				0.09			
Proportion, any rail access	0.67				1.00			
Proportion, access to UP	0.22				0.62			
Proportion, access to BNSF	0.21				0.62			
Proportion, owned by co-operative	0.70				0.17			
Proportion, federal license	0.43				0.45			
Storage capacity (million bushels)	1.31	1.12	0.09	8.86	7.74	9.31	1.76	42.54
KCBT futures contract implied volatility	32.89	8.08	0.00	74.35	32.89	8.08	0.00	74.35
	Montana							
	Mean	Std Dev	Min	Max	Mean	Std Dev	Min	Max
Nearby basis (dollars per bushel)	-0.67	0.64	-4.97	9.83	-0.60	0.44	-2.16	1.86
Proportion, elevator type	0.74				0.26			
Proportion, any rail access	0.64				1.00			
Proportion, access to UP	0.04				0.00			
Proportion, access to BNSF	0.46				1.00			
Proportion, owned by co-operative	0.50				0.75			
Proportion, federal license	0.77				1.00			
Storage capacity (million bushels)	0.52	0.38	0.23	1.63	1.04	0.40	0.25	1.71
KCBT futures contract implied volatility	32.89	8.08	0.00	74.35	32.89	8.08	0.00	74.35
	Overall Characteristics							
Total elevator locations	297							
Kansas	267							
Montana	30							
Date range	January 2, 2004–July 12, 2013							
Total daily observations	483,709							

Notes: Standard deviations are presented only for continuous variables. KCBT denotes the Kansas City Board of Trade futures contract for hard red winter wheat.

Table 2: Estimates of the Spatial Basis Model

	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
KS SL differential (B1)	0.132***	0.170***	0.139***	0.141***	0.128***	0.130***
MT SL relative to KS SL (B2)	-0.080***	-0.125**	-0.099***	-0.103***	-0.086***	-0.089***
MT SL differential (B1+B2)	0.052***	0.045***	0.040***	0.038***	0.042***	0.041***
Joint F-test, H0: (B1+B2)=0	[615.00]***	[341.53]***	[362.24]***	[412.64]***	[356.08]***	[424.35]***
Model R-square	0.444	0.463	0.693	0.722	0.766	0.783
County controls	No	Yes	Yes	Yes	Yes	Yes
Year controls	No	No	Yes	Yes	Yes	Yes
Month controls	No	No	No	Yes	Yes	Yes
County-by-Year controls	No	No	No	No	Yes	Yes
County-by-Month controls	No	No	No	No	No	Yes
Elevator-level characteristics						
MT indicator	-0.384***	0.039	-0.125***	-0.157***	-0.151***	-0.153***
Implied futures price volatility	-0.016***	-0.016***	-0.004***	-0.007***	-0.007***	-0.006***
Data source control (0/1)	0.427***	0.404***	0.253***	0.258***	0.328***	0.361***
Elevator has rail access?	-0.011***	-0.003***	0.005***	0.005***	0.007***	0.007***
Elevator has access to UP?	0.020***	0.003	0.005***	0.005***	-0.002	-0.002
Elevator has access to BNSF?	0.052***	0.023***	0.021***	0.021***	0.019***	0.020***
Elevator is owned co-operatively?	0.008***	0.001	-0.001	-0.002***	-0.010**	-0.010***
Elevator capacity (in 1 mil bu)	0.012	0.138***	0.044*	0.037*	0.051**	0.048**
Elevator has a federal license?	0.020***	0.014***	-0.001	-0.002	-0.001	-0.001
Indicator for post-2008 period	-0.294***	-0.294***	-0.249***	-0.156***	-0.155***	-0.175***
Ownership indicators (joint F-stat)	[612.57]***	[120.75]***	[140.06]***	[160.02]***	[167.56]***	[181.92]***
F-tests of joint fixed effects						
County FE	--	214.68***	338.94***	379.94***	404.34***	413.99***
Year FE	--	--	47,020.10***	49,545.00***	27,132.20***	29,625.40***
Month FE	--	--	--	5,422.42***	6,417.18***	3,095.21***
County-by-Year FE	--	--	--	--	155.39***	116.60***
County-by-Month FE	--	--	--	--	--	28.62***

Notes: "SL" represents shuttle-loading grain handling facility. Standard errors are clustered at the county level and adjusted for heteroskedasticity and autocorrelation using the Newey-West procedure. ***, **, and * represent statistical significance at the 1%, 5%, and 10% levels, respectively. Pairwise log-likelihood ratio tests indicate that each model is statistically different from others at the 1% level and Vuong tests indicate that in every case, the model with additional controls is preferred to models with fewer controls.

Table 3: Robustness Estimates of the Spatial Basis Model

	Placebo	Counties w/SL	Counties w/SL + Adjacent Counties	Bootstrapping	Not On State Border
KS SL differential (B1)	0.015	0.133***	0.128***	0.141***	0.134***
MT SL relative to KS SL (B2)	-0.017	-0.093***	-0.089***	-0.113**	-0.080***
MT SL differential (B1+B2)	-0.002	0.040***	0.039***	0.028***	0.054***
Joint F-test, H0: (B1+B2)=0	[0.20]	[256.96]***	[356.08]***	[219.18]***	[591.90]***
Model R-square	0.720	0.786	0.766	0.767	0.770
County controls	Yes	Yes	Yes	Yes	Yes
Year controls	Yes	Yes	Yes	Yes	Yes
Month controls	Yes	Yes	Yes	Yes	Yes
County-by-Year controls	Yes	Yes	Yes	Yes	Yes
County-by-Month controls	Yes	Yes	Yes	Yes	Yes
Elevator-level characteristics					
MT indicator	-0.186***	-0.181***	-0.159***	-0.190***	-0.182***
Implied futures price volatility	-0.006***	-0.006***	-0.007***	-0.007***	-0.006***
Data source control (0/1)	0.389***	0.331***	0.328***	0.341***	0.361***
Elevator has rail access?	0.007**	0.006***	0.007***	0.006***	0.007***
Elevator has access to UP?	-0.003	0.059***	-0.002	-0.003	-0.002
Elevator has access to BNSF?	0.018***	0.031***	0.020***	0.019***	0.020***
Elevator is owned co-operatively?	-0.012***	0.009	-0.010***	-0.012***	-0.010***
Elevator capacity (in 1 mil bu)	0.044**	0.177***	0.051**	0.028***	0.048**
Elevator has a federal license?	-0.001	-0.061*	-0.001	-0.001	-0.001
Indicator for post-2008 period	-0.192***	-0.162***	-0.155***	-0.161***	-0.175***
Ownership indicators (joint F-statistic)	[6,589.33]***	[210.74]***	[181.92]***	[181.92]***	[195.62]***
F-tests for joint fixed effects					
County FE	265,867***	723.34***	404.34***	317.66***	392.28***
Year FE	6.02E6***	6,003.66***	27,132.20***	17,019.91***	17,812.60***
Month FE	3.06E7***	953.09***	6,417.18***	4,117.35***	5,088.01***
County-by-Year FE	7.84E17***	101.92***	155.39***	136.16***	111.07***
County-by-Month FE	1.64E17***	33.46***	28.73***	26.89***	29.09***
Observations	--	131,079	415,169	--	353,669

Notes: "SL" represents shuttle-loading grain handling facility. Observation counts are provided only for subsample regressions. Observations in the "Placebo" and "Bootstrapping" analyses are dynamically determined in each iteration. Standard errors are clustered at the county level and adjusted for heteroskedasticity and autocorrelation using the Newey-West procedure. ***, **, and * represent statistical significance at the 1%, 5%, and 10% levels, respectively.

Table 4: Results of the Spatial Basis Model with Measures of Spatial Competition

	Near, 5 mi	Near, 20 mi	Near, 50 mi	Capacity, 5 mi	Capacity, 20 mi	Capacity, 50 mi
KS SL differential (B1)	0.129***	0.131***	0.131***	0.135***	0.132***	0.132***
MT SL relative to KS SL (B2)	-0.090***	-0.091***	-0.090***	-0.098***	-0.091***	-0.091***
MT SL differential (B1+B2)	0.039***	0.040***	0.041***	0.037***	0.041***	0.041***
Joint F-test, H0: (B1+B2)=0	[347.39]***	[424.42]***	[418.92]***	[346.63]***	[430.63]***	[433.72]***
Model R-square	0.783	0.783	0.783	0.784	0.783	0.783
County controls	Yes	Yes	Yes	Yes	Yes	Yes
Year controls	Yes	Yes	Yes	Yes	Yes	Yes
Month controls	Yes	Yes	Yes	Yes	Yes	Yes
County-by-Year controls	Yes	Yes	Yes	Yes	Yes	Yes
County-by-Month controls	Yes	Yes	Yes	Yes	Yes	Yes
Elevator-level characteristics						
Spatial competition variable	0.019***	-0.001***	-0.001***	0.409***	0.036***	-0.046***
MT indicator	-0.152***	-0.158***	-0.153***	-0.148***	-0.151***	-0.152***
Implied futures price volatility	-0.006***	-0.006***	-0.006***	-0.006***	-0.007***	-0.006***
Data source control (0/1)	0.363***	0.361***	0.361***	0.361***	0.361***	0.361***
Elevator has rail access?	0.008***	0.007***	0.006***	0.007***	0.007***	0.005***
Elevator has access to UP?	-0.002	-0.001	-0.002	-0.002	-0.002	-0.002
Elevator has access to BNSF?	0.017***	0.021***	0.021***	0.013***	0.020***	0.020***
Elevator is owned co-operatively?	-0.012***	-0.010***	-0.010***	-0.016***	-0.010**	-0.010***
Elevator capacity (in 1 mil bu)	0.056**	0.040*	-0.007	-0.368***	0.047**	0.037*
Elevator has a federal license?	-0.001	-0.001	-0.001	-0.001	-0.001	-0.001
Indicator for post-2008 period	-0.178***	-0.173***	-0.173***	-0.180***	-0.175***	-0.173***
Ownership indicators (joint F-statistic)	[164.08]***	[181.92]***	[183.31]***	[151.09]***	[182.68]***	[184.87]***
F-tests for joint fixed effects						
County FE	346.74***	338.47***	307.39***	293.53***	348.51***	397.66***
Year FE	29,618.40***	29,628.60***	29,618.80***	29,742.30***	29,625.30***	29,636.10***
Month FE	3,095.43***	3,095.32***	3,096.23***	3,095.54***	3,095.22***	3,096.02***
County-by-Year FE	115.79***	116.63***	116.48***	116.95***	116.71***	116.64***
County-by-Month FE	28.61***	28.68***	28.52***	28.65***	28.61***	28.70***

Notes: "SL" represents shuttle-loading grain handling facility. In all regressions, basis is the dependent variable. Column names represent the spatial competition variable used in the regression model. "Near" represents spatial competition variables that account for the number of other grain handling facilities within a 5, 20, and 50-mile radii. "Capacity" represents total capacity at other grain handling facilities with a 5, 20, and 50-mile radii. Standard errors are clustered at the county level and adjusted for heteroskedasticity and autocorrelation using the Newey-West procedure. ***, **, and * represent statistical significance at the 1%, 5%, and 10% levels, respectively. Pairwise Vuong non-nested tests indicate that each model is statistically different from all others at a 1% level.

Table 5: Results of the Spatial Basis Model for Conventional Elevators with Spatial Competition

	Shuttle, 5 mi	Shuttle, 20 mi	Shuttle, 50 mi
KS conventional w/nearby SL (B1)	0.106***	0.073***	0.079***
MT conventional w/nearby SL relative to KS conventional w/nearby SL (B2)	-0.074***	-0.073***	-0.080***
MT conventional w/nearby SL (B1+B2)	0.032***	8.79E-5*	-0.001**
Joint F-test, H0: (B1+B2)=0	[151.28]***	[3.13]*	[4.96]**
Model R-square	0.784	0.785	0.785
County controls	Yes	Yes	Yes
Year controls	Yes	Yes	Yes
Month controls	Yes	Yes	Yes
County-by-Year controls	Yes	Yes	Yes
County-by-Month controls	Yes	Yes	Yes
Elevator-level characteristics			
MT indicator	-0.190***	-0.193***	-0.193***
Implied futures price volatility	-0.006***	-0.006***	-0.006***
Data source control (0/1)	0.409***	0.409***	0.410***
Elevator has rail access?	0.004***	0.006***	0.001
Elevator has access to UP?	-0.012**	-0.014***	-0.004*
Elevator has access to BNSF?	0.015***	0.014***	0.016***
Elevator is owned co-operatively?	-0.018***	-0.010***	-0.010***
Elevator capacity (in 1 mil bu)	0.040***	0.034**	0.038**
Elevator has a federal license?	0.001	0.007	0.005
Indicator for post-2008 period	-0.216***	-0.218***	-0.218***
Ownership indicators (joint F-statistic)	[123.39]***	[128.35]***	[130.68]***
F-tests for joint fixed effects			
County FE	303.27***	399.66***	415.13***
Year FE	26,016.40***	29,625.30***	29,635.70***
Month FE	2,842.70***	3,095.22***	3,095.20***
County-by-Year FE	112.44***	116.56***	116.61***
County-by-Month FE	26.83***	28.61***	28.75***
Observations	439,597	439,597	439,597

Notes: In all regressions, basis is the dependent variable. Column names represent the spatial competition variable used in the regression model. "Shuttle" represents spatial competition variables that account for the number of shuttle-loading elevators within a 5, 20, and 50-mile radii of a conventional elevator. The data are restricted to represent only conventional elevators in the sample. Standard errors are clustered at the county level and adjusted for heteroskedasticity and autocorrelation using the Newey-West procedure. ***, **, and * represent statistical significance at the 1%, 5%, and 10% levels, respectively. Pairwise Vuong non-nested tests indicate that each model is statistically different from all others at a 1% level.