Effect of Plant Location Decisions on Raw Material Input Prices

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Introduction

In processing industries, plant location decisions are costly and have consequences for firm profitability. When raw materials are heavy or perishable, transportation costs limit shipping distances and processors must compete locally for raw material inputs. Adding a new processing plant in the procurement area will increase raw material demand, likely raising input price and decreasing profit for all processors in the area. Important to the entry decision is the expected magnitude of input price change. To determine the expected profitability of a new plant, a processor must forecast the effect entry will have on local post-entry raw material price. This requires anticipating how entry will affect market structure and intensify competition for raw materials.

Through time and space, various numbers of processors can be observed competing for input supply within their procurement areas. These cross-sectional time-series variations potentially allow estimation of the relationship between number of processors competing for an input in a procurement area and the input price in that area. The probable effect on raw material price of a processor entering a procurement area can be inferred by contrasting procurement areas with n firms with those containing n+1 firms while controlling for differences between the procurement areas other than input price. The unique contribution of this study is development of a game-theoretic based empirical model that incorporates unique features typical of processing industries to forecast the magnitude of a raw material price response to processor entry. The method developed is widely applicable.

Model

Model development in this paper is most closely related to that of Corbett and Karmarkar (2001), where downstream players base entry decisions on expected outcomes of post-entry Cournot competition. Rather than focusing on theory as they do, the emphasis here is on development of a forecasting model that can be used to predict likely impact of entry on input costs. This paper also differs from their work in its focus on downstream entry effects on upstream input prices. The empirical work in this paper draws from Bresnahan and Reiss (1990 and 1991) and Berry (1992), but differs from these in that it uses a specific game setting, focuses on input rather than output markets, enhances model information through use of prices, and provides an ex ante price forecasting approach for entry effects.

The model is based on production technologies commonly observed in processing industries and is derived from game theory that explicitly accounts for processor competition in local input procurement areas.

Input supply of fed beef is derived from feeder profit maximization. Profit for raw material supplier j is:

$$\Pi^S_j = w\, y_j - c(y_j, v; l_j) - s\, l_j\,,$$

where Π^S_j is supplier j's profit, w is fed cattle price, y_j is cattle production for j, c(.) is variable cost assumed to be a normalized quadratic, v is a vector of variable factor prices (feeder steers, corn, farm inputs, and labor), l_j is quasi-fixed capital (capacity) for j, and s is the price associated with l_j.

Packer profit is modeled as revenues less unit marginal cost for noncattle inputs and a price for the fed cattle input which permits exertion of monopsony market power by packers. Packers are assumed to have identical linear unit (marginal) cost, so $C(\mu; k_i)$ is linear in μ and k_i.

$$\Pi^P_i = P'\beta\, x_i - C(\mu; k_i)\, e'\beta\, x_i - w(X)x_i - r\, k_i\,,$$

where Π^P_i is processor i's profit, P is a vector of wholesale and byproduct prices for processor output, μ is a vector of prices for processor production factors associated with variable inputs other than cattle (e.g., labor, energy, and materials), e is a vector of ones conformable with β,and r is the price of quasi-fixed capital input (capacity), k_i.

Letting N be the number of packers in a supply area and solving for Cournot-Nash equilibrium in packer procurement results in the estimation equation:

$$w = [P_1\, \beta_1 + P_2\, \beta_2 - (b_0 + b_\mu\, \mu + b_k\, k_i) - a_{Yv}\, v - a_{Yl}\, l\,]\, N/(1 + N) + a_{Yv}\, v + a_{Yl}\, l,$$

where N is the number of processors competing in the procurement area, a's and b's are parameters, and other variables are defined above.

Model Estimation and Data

Estimation results are obtained for the 43 of the largest steer and heifer packing plants in the US.Supply areas are bounded by a 300-miles radius around the plant. Number of processors in each circle is N varying between 1 and 11 or more packers.

Estimation results indicate that, with the exception of food processor wage, all estimated parameters have the expected signs. Further, with the exception of b_k, all parameters are statistically significant. The insignificant parameter estimate for b_k indicates that unit cost is not affected by scale of packer operations.

Results

(p-values)

N	Price ($/head)	Change in Price (%)	Cumulative Change in Price (%)
1	**690.17**		
	(7.15)		
2	**727.74**	**37.57**	**37.57**
	(4.35)	(3.87)	(3.87)
3	**746.53**	**18.78**	**56.35**
	(3.43)	(1.93)	(5.80)
4	**757.80**	**11.27**	**67.62**
	(3.47)	(1.16)	(6.96)
5	**765.31**	**7.51**	**75.14**
	(3.70)	(0.77)	(7.74)
6	**770.68**	**5.37**	**80.51**
	(3.94)	(0.55)	(8.29)
7	**774.70**	**4.03**	**84.53**
	(4.17)	(0.41)	(8.70)
8	**777.83**	**3.13**	**87.66**
	(4.37)	(0.32)	(9.71)
9	**780.34**	**2.50**	**90.17**
	(4.53)	(0.26)	(9.28)
10	**782.39**	**2.05**	**93.22**
	(4.67)	(0.21)	(9.50)
11	**744.10**	**1.71**	**93.92**
	(4.80)	(0.18)	(9.67)

Conclusions

Theory predicts that when a processor enters a procurement area, total input supply rises, amount purchased by each processor falls, profit per processor falls, and raw material input price rises. Estimation results confirm that statistically significant higher equilibrium input prices are associated with larger numbers of processors competing in a procurement area. Further, theory predicts that as the number of buyers in a procurement area increases, the incremental effect that each additional buyer has on equilibrium price diminishes; the model correctly forecasts this expected response as well. Importantly, the model predicts the magnitudes of price increases likely to result from entry. Whether entry is a good business decision will depend upon how much processor profits fall with entry, which is can be computed from the expected input price rise.

This method provides an approach for moving beyond the theoretical to evaluate both the direction and magnitude of price and profitability changes associated with downstream entry and provides enhanced information to decision makers.

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