Local Buyer Market Power and Horizontally Differentiated Manufacturers

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May 2010

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Abstract

In this paper we study a farmer-processor relationship, where market power is bidirectional: processors have buyer as well as seller market power. Farmers supply a homogeneous raw input to the processors, which, in turn, process it into a horizontally differentiated product. The analysis shows that the spread between prices that both parties receive can be decomposed into two components: one due to buyer market power in the agricultural input market and one due to seller market power in the differentiated processed market. Farmers receive a decreasing dollar share of the final price as concentration in the processed good market increases. On the other hand, the price spread due to processors' buyer (seller) market power decreases (increases) when farmers' transportation costs shrink and when consumers' strength for brand preference increases. We also examine welfare: while the surplus of farmers serving a specific processor is adversely affected in a more concentrated processed good market, the total surplus of farmers serving all processors is independent of the industry concentration. In addition, consumers are worse off when the processed good market is more concentrated and farmers' transportation costs are larger. While stronger brand preference implies a larger "travel cost" for consumers, it may encourage more processors to join the market and provide more varieties.

Keywords: buyer market power, horizontal differentiation

JEL Code: D43, L13, M31, Q13

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1. Introduction

In this paper we study the farmers-processors relationship conceptually. We consider a model of vertical and horizontal competition where market power is *bidirectional*: processors have buyer as well as seller market power. Farmers supply a homogeneous raw input to the processors, which, in turn, process it into a horizontally differentiated product. Supply in the raw input market, however, is not perfectly competitive because farmers are situated in different localities and transportation costs to any processor are non-zero. Processors are also scattered in different locations and buy from the nearest farmers. This spatial configuration grants the processors *buyer market power* as each of them becomes the sole buyer for a handful of farmers. Finally, the processors in the processed good market compete with each other by producing a differentiated product intended to attract consumers who have heterogeneous preferences (i.e., each consumer has a different "preferred brand"). This horizontal differentiation is the source of *seller market power* in our model.

There has been an increasing concern in several food industries, most notably in meat packing, about the farmers' dollar share of the final product, which has been continuously decreasing. This has often been attributed to increased processor concentration and the consequent increase in buyer market power, although product differentiation at the processor level may have a similar effect. The role of product differentiation as a factor in the declining dollar share of farmers is apparent when we look at how food processors have become more interested in advertising and promotional techniques that allow greater product differentiation and possibly larger margins.

Prior work has studied the effects of processors' market power in acquiring the raw product at a price below competitive levels. The typical assumption is that the final processed product is homogeneous and that processors are price takers. Because most food processing industries buy raw agricultural products and transform them into branded, differentiated products, we add this more realistic dimension into a model that captures several unique features of both raw agricultural product industries (upstream "farmers") as well as food processing industries (downstream "processors"). Our model is motivated by food manufacturing industries (e.g. canned food, packaged beef, etc.) where inputs markets are characterized by a homogeneous product with high transportation costs (or perishability) and processors compete with each other by offering a differentiated product to final consumers. In these industries, a highly debated issue has been whether (and how) downstream concentration, and its consequent enhanced buyer market power, has diminished farmers' profitability (measured by its share of the final price). A main feature of our model is that it allows us to decompose total market power ("the price spread") into the portion due to seller market power and the portion due to buyer market power, thereby informing the above mentioned debate.

We combine two models to capture the unique features of food producers and processors. The model in Rogers and Sexton (1994) is used to capture key characteristics of producers' markets and a variant on Salop's (1979) model of spatial product location is used to embed product differentiation at the processor's level. Under a Bertrand-Nash assumption, our results suggest that farmers receive a decreasing dollar share of the final price in a more concentrated processed good market. On the other hand, the price spread due to processors' buyer (seller) market power decreases (increases) with smaller farmers' transportation costs and with stronger consumers' brand preference. We also examine a welfare analysis: while the surplus of farmers serving a specific processor is adversely affected by a more concentrated processed good market, the total surplus of farmers serving all processors is independent of the industry concentration.

Moreover, consumers are worse off when the processed good market is more concentrated and farmers' transportation costs are larger. Consumers' brand preference has two effects on the welfare: while stronger brand preference implies more "travel costs" for consumers, it may encourage more firms to join the market and provide more varieties, which results in welfare gains. For a relatively small brand preference, consumer surplus increases in brand preference.

This paper helps us understand the farmers-processors relationship. By using more realistic assumptions that incorporate product differentiation in the processed good market, we study two components of the price spread (due to buyer market power in the raw input market and seller market power in the processed good market) and the corresponding welfare implications of market power. The results provide more complete figures about the effect of the concentrated food processing industry on the structure and performance of the agricultural and food markets and also inform the formation of public policy.

The remainder of this paper is organized as follows. We briefly review some related studies in section 2. In section 3 the model describing upstream and downstream markets is presented. Section 4 discusses the main results including the properties of price spreads and welfare analysis. Section 5 provides concluding remarks, limitations, and possible extensions.

2. Literature Review

The closest papers to our work are Sexton (1990) and Rogers and Sexton (1994). These two studies consider a model of a homogeneous good produced by a large number of farmers who produce in different locations. The farmers can sell their product to a few processors but in doing so incur transportation costs. Processors then sell the processed homogeneous goods in a perfectly competitive market. Their analysis of the processor-farmer price margin is relevant to our study. They show that farmers receive a decreasing dollar share of the processors' product price as transportation costs increase and as the number of processors decreases. An important finding is that, because farmers' output is costly to transport, positive margins are possible even under Bertrand competition and homogeneous products. In addition, Chen and Lent (1992) and Hamilton and Sunding (1997) study the unique comparative statics of a farmers' supply shock when the processors enjoy buyer market power and the farmers are price takers in the production of a homogeneous good.

Turning to empirical studies, an often studied topic has been the estimation of buyer market power. Hyde and Perloff (1994) conduct a Monte Carlo study to test the accuracy of a structural model and a nonstructural method for estimating the degree of buyer market power in a homogeneous product market with price-taker sellers. Raper, Love and Shumway (2000), and Schroeter, Azzam and Zhang (2000) extend New Empirical Industrial Organization methods to study the amount of market power enjoyed by sellers (farmers) and buyers (manufacturers / processors). Both studies reach a similar conclusion: manufacturers appear to have buyer market power whereas farmers lack seller market power. In a study that analyzes the type of buying behavior by processors, Just and Chern (1980) find evidence to reject the hypothesis of perfect competition in favor of that of oligopsonistic dominant firm-leadership.

Few studies analyze the simultaneous exertion of market power on both the selling and buying side of the market. Wann and Sexton (1992) find that pear processors enjoy market power in the purchase of the upstream raw product and in the sale of two downstream differentiated products: canned pears and fruit cocktail. Gohin and Guyomard (2000) estimate joint oligopoly-oligopsony market power of French retailers several food product categories.

They strongly reject the joint null hypothesis that French retail firms behave with no oligopoly-oligopsony market power.

None of the above studies explicitly model downstream product differentiation in the context of the welfare impact of market power in the purchase of an input. This is our contribution, which we present next.

3. Model

3.1 Spatial Competition in the Upstream Market

In Rogers and Sexton's model, farmers are uniformly distributed on the unit interval and a few processors are located at equally spaced intervals on the line.[1] Processors pay a mill price, W, which farmers receive after incurring a transportation cost, t, per unit of distance, d, to the farm. Hence, the further away a farmer is located from the processor, the lower the net price (W-td) s/he receives. Several characteristics of this model make it suitable for studying procurement of farmers' output by processors. First, by construction, the model reflects the higher concentration of the food processing industry with respect to that of the raw agricultural products industry. Second, even though farmers' products are homogeneous in nature, distance and transportation costs will prevent a given processor from undercutting a rival and gaining all farmers' output, making the model more realistic and appealing.

We present a modified version of Rogers and Sexton's model. Farmers' aggregate supply faced by a processor can be computed as

$$R(W) = 2\int_0^M \beta(W - td)\mathrm{d}d = M\beta(2W - tM), \qquad (1)$$

[1] While Rogers and Sexton (1994) motivate their model as competition on a line interval, their analysis corresponds to a circular model. We also use the circular model in our analysis below.

where R is the quantity of the raw product, M is the length of half the interval over which the processor is a sole buyer of the product, $\beta(W - td)$ is an individual farmer's linear supply curve, and β is an coefficient.

Moreover, processor's technology for production of Q units of the final good is one of fixed-proportions; i.e., $Q = R/\lambda$ and without loss of generality $\lambda = 1$. This gives the processors' cost function: $c(R) = W(R)R + F$, where F represents fixed costs. As a result, processor's profit expressed as a function of the input quantity R is given by $\pi = p \cdot R - W(R)R - F$, where p is the price of the processed good and $W(R)$ is the inverse supply function of the input faced by the processor. For Bertrand competition, processors' profits can be written as a function of the input price W: $\pi = p \cdot R(W) - WR(W) - F$.

3.2 Product Differentiation in the Downstream Market

To address imperfect competition via differentiated products in the downstream market, we consider a variant of Salop's (1979) circular model of product location. There are two reasons for choosing this model over other alternatives. The linear city model by Hotelling forces more competition only one side of the product space as a product moves to the extremes, which may not be a realistic assumption. This feature makes the Hotelling model less mathematically tractable. On the other hand, a representative consumer model does not allow for several key consumer heterogeneity issues that we deal with below.

Each consumer has a preferred brand location on a circle of circumference size equal to 1. Consumers' preferred brands are uniformly distributed on the circle and firms locate their brands at equally spaced intervals on the circle perimeter (for n firms, the length of the interval is $1/n$). Consumer i has a reservation value "A" and pays two "prices" for purchasing firm j's product (where j denotes the location of the product on the circle): the price of the product, p_j, and a total travel cost of $c|z_i - j|$, where c is the per unit travel cost and z_i is consumer *i*'s preferred brand location. A consumer purchases the product that yields the highest utility (i.e. purchase *j* if: $U_{ij} = A - p_j - c|z_i - j| > U_{ik}, \quad \forall k \neq j$).

Let us focus on two neighboring firms *j* and *j'* located at 0 and 1/*n*, respectively. Considering a consumer at *z* receiving equal surplus from these two firms, we have the following equation representing the location of the indifferent consumer:

$$A - p_j - cz = A - p_{j'} - c\left(\frac{1}{n} - z\right) \Rightarrow z = \frac{1}{2c}\left(p_{j'} - p_j + \frac{c}{n}\right). \qquad (2)$$

As a result, firm *j*'s demand is given by

$$Q_j = 2z = \frac{p_{j'} - p_j}{c} + \frac{1}{n}.$$

When all other firms charge $p = p_{j'}$, the maximization problem facing firm *j* is

$$\max_{p_j} \ \pi_j(p_j, p) = (p_j - W)\left(\frac{p - p_j}{c} + \frac{1}{n}\right) - F,$$

where *W* is the raw input price paid to farmers and *F* is the processor's fixed cost. The first-order condition for firm *j* is $p - 2p_j + W + c/n = 0$. In a symmetric equilibrium, $p = p_j = W + c/n$. In addition, with free entry each firm earns zero profits and therefore $p = W + nF$. The number of firms *n* can be endogenously determined and the equilibrium number of firms is $n = \sqrt{c/F}$. Hence, the equilibrium price is $p = W + \sqrt{cF}$. It is easy to see that processors charge higher prices when they incur higher marginal and fixed costs. For a given raw input price, it is also reasonable that the downstream price is higher when consumers have stronger brand preference (higher c).[2]

To solve for equilibrium W, we substitute $M = 1/(2n)$ and $R = Q = 1/n$ into equation (1). In equilibrium,

$$R = M\beta(2W - tM) = \frac{\beta}{2n}(2W - \frac{t}{2n}) = \frac{1}{n} = Q \text{, thus } W = \frac{1}{\beta} + \frac{t}{4n} = \frac{1}{\beta} + \frac{t}{4}\sqrt{\frac{F}{c}},$$

where t and F have a positive impact while β and c act inversely. Note that the second term $t/(4n)$ is served to compensate farmers' transportation costs (t). If farmers incur no transportation costs, processors' payments to farmers are based on the market input supply curve ($1/\beta$).

4. Main Results

4.1 Price Spreads

Now we consider the spreads between processed good prices and raw input prices. When Bertrand competition is assumed, processors' profits can be written as a function of the input price W: $\pi = p \cdot R(W) - WR(W) - F$. Since the processed good market is imperfectly competitive, the first order condition for π is:

$$\frac{\partial p(R)}{\partial R}\frac{\partial R(W)}{\partial W}R(W) + p\frac{\partial R(W)}{\partial W} = R(W) + W\frac{\partial R(W)}{\partial W}, \tag{3}$$

where the left-hand side represents the marginal revenue product of using the input and the right-hand side represents its marginal costs. Note that the second term on the right-hand side is the source of buyer market power and it takes this form because each processor is a monopsonist for farmers located in its market area of size $2M$. If the input market were a perfectly competitive

[2] However, when W is endogenously determined, the brand preference may have a positive or negative impact on downstream prices. See the welfare analysis below for details.

market with many buyers, the term $W\partial R(W)/\partial W$ would be equal to zero so that the marginal cost of the input that the processor faces is only given by the aggregate supply $R(W)$.

The key feature of this model, however, is that the term $\partial R(W)/\partial W$ is a function of both how much additional input can be acquired as a result of an increased input price, and how much the market area *M* is affected by such an increase. After rearranging terms, the price-cost margin (or spread between processors' and farmers' prices) can be expressed as:

$$
\begin{aligned}
&\frac{p-W}{W} = \frac{1}{\eta} - \frac{p}{W}\frac{1}{\varepsilon_D}, \\
&\eta = \frac{\partial R}{\partial W}\frac{W}{R} + \frac{\partial R}{\partial M}\frac{M}{R}\frac{\partial M}{\partial W}\frac{W}{M} = \eta_{R,W} + \eta_{R,M}\eta_{M,W}, \\
&\varepsilon_D = \frac{\partial Q}{\partial p}\frac{p}{Q}.
\end{aligned} \tag{4}
$$

It turns out that the price spread has two components: one due to *buyer market power* in the raw input market, $1/\eta$, and one due to *seller market power* in the processed good market, $-P/(W\varepsilon_D)$. The demand elasticity ε_D is negative in the imperfectly competitive processed good market. As a result, the price spread is usually larger than that of the competitive processed good market. In Rogers and Sexton (1994), this term is zero due to the assumption of a perfectly competitive processed good market.

The three elasticity terms $\eta_{R,W}, \eta_{R,M}, \eta_{M,W}$ are positive, and, in general, the higher η, the lower the price spread. The key term in this expression is $\partial M / \partial W$, which in turn is a function of how rivals' would react to changes in the mill price *W* (i.e. $\partial W^*/\partial W$, where W^* is rival's processor mill price). We will first examine the case of Bertrand competition in the analysis.[3]

[3] The different behavioral assumptions will be considered, including Bertrand ($\partial W^*/\partial W = 0$), collusion ($\partial W^*/\partial W = 1$) and Cournot competition ($\partial R^*/\partial R = 0$).

One of Sexton and Rogers (1994) findings is that transportation costs matter in how price-spreads are determined. For example, under Bertrand competition price-spreads are zero if transportation costs are ignored, but positive if they are taken into account. In general, price spreads increase as transportation costs increase, suggesting that farmers' dollar share of the final product's price is likely to be smaller than that of other industries where perishability and transportation are not important. In addition, as the number of processors increases, the price-spread decreases.

As mentioned previously, a critical assumption in Sexton and Rogers' approach is that the market for the processed good is perfectly competitive and hence its price *p* is taken as given by processors. The price spread is then solely a function of the equilibrium input price *W*. Thus a higher price spread (*p*-*W*)/*W* necessarily translates into a lower input price *W*, which need not be the case if *p* is endogenously determined by imperfect competition in the processed good market. Given farmers' frequent criticisms of how higher processor concentration has caused farmers to receive a smaller dollar share of the final product price, the interesting question that arises is what portion of this lower share is due to buyer market power as described by Sexton and Rogers, and what portion is due to higher prices of the processed good (*p*) as a consequence of imperfect competition in the downstream market.

Let us turn to the characteristics of price spreads in equation (4). From equation (1),

$$\eta_{R,W} = \frac{\partial R}{\partial W}\frac{W}{R} = 2M\beta\frac{W}{R} \text{ and } \eta_{R,M} = \frac{\partial R}{\partial M}\frac{M}{R} = 2\beta(W - tM)\frac{M}{R}.$$

To derive $\eta_{M,W}$, we apply a similar logic as in equation (2): an indifferent farmer between a processor and its adjacent rival receives equal net prices and the distance between the processor and the indifferent farmer (*M*) can be expressed as

$$W - tM = W^* - t\left(\frac{1}{n} - M\right) \Rightarrow M = \frac{1}{2t}\left(W - W^* + \frac{t}{n}\right),$$

where *W** is the mill price of an rival. Therefore,

$$\eta_{M,W} = \frac{\partial M}{\partial W}\frac{W}{M} = \frac{1}{2t}\left(1 - \frac{\partial W^*}{\partial W}\right)\frac{W}{M} = \frac{\alpha}{2t}\frac{W}{M},$$

where producer conduct α is defined by $1-(\partial W^* / \partial W)$. For example, $\partial W^* / \partial W = 0$ and $\alpha = 1$ in Bertrand competition. Hence,

$$\eta = \eta_{R,W} + \eta_{R,M}\eta_{M,W} = 2M\beta\frac{W}{R} + 2\beta(W - tM)\frac{M}{R}\frac{\alpha}{2t}\frac{W}{M} = \frac{W\left(2tM + (W - tM)\alpha\right)}{tM(2W - tM)}$$

Taking the expression for the price spread in equation (4), if we define $S_u = 1/\eta$ and $S_d = -p/(W\varepsilon_D)$, then the total price spreads $S = S_u + S_d$, where S_u is the component of price spreads due to buyer market power in the raw input market (upstream) and S_d is the one due to seller market power in the processed good market (downstream). As a result, two components of the price spreads can be expressed by

$$S_u = \frac{1}{\eta} = \frac{tM(2W - tM)}{W\left(2tM + (W - tM)\alpha\right)} = \frac{16\beta t\sqrt{c/F}}{\left(4\sqrt{c/F} + \beta t\right)\left(4\beta t + \left(4\sqrt{c/F} - \beta t\right)\alpha\right)} \qquad (5)$$

$$S_d = -\frac{P}{W}\frac{1}{\varepsilon_D} = \frac{c}{nW} = \frac{4\beta c}{4\sqrt{c/F} + \beta t} \qquad (6)$$

Since the price spreads come from market power in both upstream and downstream markets, they are influenced by the variables in these two markets. In other words, any exogenous variable in either upstream or downstream market (*c*, *F*, *t*, or β) has impacts on both spreads. Such a feature has not been fully explored in previous studies. To examine the characteristics of price spreads, we provide the following comparative statics[4]:

$$\frac{\partial S_u}{\partial c} < 0,\ \frac{\partial S_d}{\partial c} > 0;\ \frac{\partial S_u}{\partial F} > 0,\ \frac{\partial S_d}{\partial F} > 0;\ \frac{\partial S_u}{\partial t} > 0,\ \frac{\partial S_d}{\partial t} < 0;\ \frac{\partial S_u}{\partial \beta} > 0,\ \frac{\partial S_d}{\partial \beta} > 0.$$

We first discuss the impact of processor's fixed costs (*F*) on the price spreads. An increase in fixed costs, (e.g., R&D expense, capacity expansion, increased safety regulation), which results in a decrease in the number of firms, it is reasonable to see both components of the price spreads increase because of the resulting increase in market power of processors in both the buying and selling side of the market. A large coefficient of farmer's supply function (β) implies inputs supplied by farmers are more sensitive to the price received (*W*). For a given quantity supplied, farmers receive lower prices with a larger β, resulting in larger upstream and downstream spreads.

While the effects of farmer's transportation costs (*t*) and consumer's brand preference (*c*) are more complicated, they are generally unambiguous. When farmers incur more transportation costs (i.e., *t* increases), processors can exercise more buyer market power and the upstream component of the price spread (S_u) increases. In addition, the impact of *t* on the downstream component of the price spread (S_d) is by way of raw input prices (*W*). Increasing transportation costs should push up input prices and, in turn, result in smaller downstream price spreads. When consumers have stronger brand preference, they are willing to pay more for a preferred product and their brand selections are relatively restricted. The processors can enjoy more seller market power and the downstream component of the price spread (S_d) is larger. However, stronger

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[4] The results of S_u are based on an assumption that $n > \beta t\sqrt{(4-\alpha)}\,/\,(4\sqrt{\alpha})$. If Bertrand competition, $\alpha = 1$, is assumed, $n > \sqrt{3}\beta t / 4$. See the appendix for more details. The inequalities might be reversed as α decreases; for example, $\alpha = 0$ in a collusion case.

brand preference results in a smaller upstream component of the price spread (S_u) because the equilibrium number of firms increases and processors' buyer market power gets smaller.

4.2 Welfare

In this section, we illustrate the welfare of farmers and consumers while all processors receive zero profits due to free entry. We first look at farmers' surplus.

4.2.1 Farmers' Surplus

Since farmers' production costs are assumed to be 0 in the current model, farmer *i* at location d_i receives $\pi_{fi} = W - td_i$. Recall that $W = \frac{1}{\beta} + \frac{t}{4n}$ and maximal $d_i = M = \frac{1}{2n}$. We have

$$\pi_{fi} = W - td_i \geq W - tM = \frac{1}{\beta} + \frac{t}{4n} - \frac{t}{2n} = \frac{1}{\beta} - \frac{t}{4n} \geq 0 .^{5} \quad (7)$$

An individual farmer is worse off as the processing industry is more concentrated (small *n*). Surplus of farmers serving a processor is given by

$$2\int_0^M (W - t\mathrm{d})d\mathrm{d} = M(2W - tM) = \frac{1}{2n}\left(\frac{2}{\beta} + \frac{t}{2n} - \frac{t}{2n}\right) = \frac{1}{n\beta} .$$

Though the surplus of all farmers serving a specific processor is inversely affected by the number of processors, the total surplus of all farmers serving *n* processors is $1/\beta$; i.e., the total surplus is independent of the industry concentration. For a flatter input supply curve (larger β), farmers receive smaller total surplus. They may have no surplus when facing an infinite elasticity of supply (horizontal input supply curve).

The other interesting feature is that the farmers' total surplus has nothing to do with farmers' transportation costs (*t*). This is because a change in farmers' total surplus due to *t* is

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[5] Note that the circle of the upstream market can be larger than that of the downstream market (the downstream circumference size equals 1). According to equation (7), farmers located from a processor further than 1/*M* do not supply raw inputs because positive profits are not feasible to them. As a result, the upstream suppliers (farmers) to different processors are not connected in this case.

completely offset by a change caused by raw input prices (W). To see this, we differentiate π_{fi} with respect to t and get

$$\frac{\partial \pi_{fi}}{\partial t} = \frac{1}{4n} - d_i .$$

The effects of an increase in t include an increase of raw input prices ($1/(4n)$) and an additional transportation cost (d_i). When t increases, a farmer located close to a processor ($0 \le d_i < 1/(4n)$) has a welfare gain while one far away from a processor ($1/(4n) < d_i \le 1/(2n)$) has a loss. However, if we take all farmers serving a specific processor into consideration, the total effects of increasing t on the farmers' surplus are

$$2\int_0^{1/(2n)} (\frac{1}{4n} - d)\mathrm{d}d = 2\left(\frac{1}{2n}\frac{1}{4n} - \frac{1}{8n^2}\right) = 0 \text{, for all processors.}$$

The above expression explains why the farmers' transportation costs do not appear in farmers' surplus.

4.2.2 Consumer Surplus

We turn to consumer surplus in this section. Consumer surplus can be derived by

$$\begin{aligned} CS &= 2n\int_0^{1/(2n)} (A - p - cz)\mathrm{d}z = 2n\int_0^{1/(2n)} (A - W - \frac{c}{n} - cz)\mathrm{d}z \\ &= A - \frac{1}{\beta} - \frac{5c+t}{4n} = A - \frac{1}{\beta} - \frac{1}{4}\sqrt{\frac{F}{c}}\left(5c + t\right). \end{aligned}$$

In the above derivation, we have used $p = W + \frac{c}{n}$, $W = \frac{1}{\beta} + \frac{t}{4n}$, and $n = \sqrt{c/F}$. We then examine some properties of consumer surplus below.

$$\frac{\partial CS}{\partial F} = -\frac{1}{8\sqrt{cF}}\left(5c + t\right) < 0 ,$$

$$\frac{\partial CS}{\partial t} = -\frac{1}{4}\sqrt{\frac{F}{c}} < 0 ,$$

$$\frac{\partial CS}{\partial \beta} = \frac{1}{\beta^2} > 0 .$$

Through equilibrium price charged by processors (*p*), raw input price received by farmers (*W*), and number of processors (*n*), consumers receive less welfare with larger fixed costs (larger *F*) for the processors, larger transportation costs (larger *t*) for the farmers, and steeper farmer's supply curve (smaller β). For the impact of consumer's brand preference (*c*), there are two effects: stronger brand preference has 1) a direct effect that consumers have to pay more "travel costs" and 2) an indirect effect that stronger preference may encourage more firms (brands) to join the market and provide more varieties (larger *n*). From equilibrium *p*, *W*, and *n*, we can see how brand preference (*c*) affects *p* and *W* through *n* and ultimately through *t*. Let us examine the impact of brand preference on prices first:

$$\frac{\partial p}{\partial c} = \frac{\partial}{\partial c}\left(W + \frac{c}{n}\right) = \frac{\partial}{\partial c}\left(\frac{1}{\beta} + \frac{1}{4}\sqrt{\frac{F}{c}}\left(4c + t\right)\right) = \frac{1}{8c}\sqrt{\frac{F}{c}}\left(4c - t\right) .$$

That is, the equilibrium price charged by processors are decreasing in brand preference if farmers' transportation costs are sufficiently large ($t > 4c$). This reduction in prices of processed product is related to the decreasing input prices (*W*) through large enough farmers' transportation costs (*t*), which dominate the effect of stronger preference causing higher prices. Together with travel costs, the second component of the total prices facing consumers, the farmers' transportation costs (*t*) have to be even larger such that consumers have welfare gains due to their strong brand preference. The result can be seen in the following equation:

$$\frac{\partial CS}{\partial c} = \frac{1}{8c}\sqrt{\frac{F}{c}}\left(-5c + t\right) > 0 \quad \text{if } t > 5c .$$

The impact of brand preference on consumer surplus depends on relative magnitudes of brand preference to farmer's transportation costs. For a relative small brand preference ($c < t/5$), as a result, consumer surplus increases but price decreases in brand preference. On the other hand, for a relative large brand preference ($c > t/4$), consumer surplus decreases but price increases in brand preference. For a median case ($t/5 < c < t/4$), both consumer surplus and price decrease in brand preference. The result of the median case is because the reduction in price is not sufficient to cover the increase in the travel costs, which results in consumers' welfare loss.

4.3 Discussions of Price Spreads and Farmers' Surplus

In the previous sections we have discussed the characteristics and comparative statics of price spreads and welfare. It is interesting to compare price spreads and farmers' surplus as the welfare effects may not be necessarily implied by the price spreads.

Though the decreasing dollar share of the final product that farmers receive is a major concern in a more concentrated industry, our response to this concern is that we have to identify the source of the concentration first. The examination of the price spreads indicates that while the higher processor concentration due to increasing fixed costs may cause farmers to receive a smaller dollar share of the final product price, the impact of decreasing consumer brand preference is mixed. That is, if the increasing industry concentration is due to lower consumer brand preference, the total price spreads may or may not increase and the net effect depends on the relative magnitude of $\partial S_u / \partial c$ and $\partial S_d / \partial c$.

In general, farmers receive higher mill prices when there are fewer processors in the market. However, some of the farmers have to travel longer distances to deliver the inputs after the exit of some processors. While the surplus of all farmers serving a processor is increasing in the industry concentration, the total surplus of all farmers serving all processors is independent of the industry concentration. Therefore, while more concentration redistributes welfare among farmers, total farmer surplus remains unchanged.

Our model conforms with the commonly observed fact that industry concentration is directly related to price spreads and inversely related to farmers' dollar share of the final product price. However, we also find that the mill input prices increase with concentration. This means that farmers close to an operating processor have welfare gains when concentration increases, but there are other farmers that face a significant welfare loss as there are fewer (and more distant) processors to sell to. Our analysis suggests that while it is important to address the concern about the increasing price spreads with the concentration trend, it is more straightforward to look at the welfare implication.

5. Concluding Remarks

Motivated by the consolidation trend of food processing industries in past decades, in this paper we present a simple model to study the farmer-processor relationship that characterizes a key feature in these industries: the processors exercise increasing market power in both raw input markets as buyers and processed good markets as sellers. We develop a model that allows for homogeneous inputs with high transportation costs in the upstream market and differentiated processed products to final consumers in the downstream market. For a purpose of computational tractability, we make some assumptions to simplify the model: farmers are uniformly distributed on a circle of circumference and incur only transportation casts; processors have a fixed-proportion technology, interact with their competitors in a Bertrand-Nash fashion, and are free to enter the market. Though the model is simple, it performs reasonably well and captures several feature observations in food processing industries.

Given farmers' frequent criticisms of how higher processor concentration has caused farmers to receive a smaller dollar share of the final product price, we successfully decompose the spread between prices that both farmers and processors receive into two components: one due to buyer market power in the agricultural input market and one due to seller market power in the differentiated processed market. We show that farmers receive a decreasing dollar share of the final price in a more concentrated processed good market. The price spread due to processors' buyer (seller) market power decreases (increases) with smaller farmers' transportation costs and with stronger consumers' brand preference. We also complement our study with welfare effects as the welfare may not be necessarily implied by the price spreads. The welfare comparisons indicate that the total surplus of farmers serving all processors is independent of the industry concentration. The farmers' total surplus is also independent of their transportation costs because all changes in farmers' transportation costs are offset by the input prices. Consumers are worse off when the processed good market is more concentrated and farmers' transportation costs are larger. Consumers' brand preference has two effects: while stronger brand preference implies more "travel costs" for consumers, it may encourage more firms to join the market and provide more varieties, which results in welfare gains. When the brand preference is relative small, consumer surplus may increase in brand preference.

Moreover, processors receive zero profits because of the free entry assumption in our study. Though not captured by the model, potential entrants are allowed to enter the markets under this free entry assumption and it may take longer time for the transition of market structure as fixed costs can be a major portion of total costs in the food industries and the entry decision may be significantly delayed. As such, the incumbents may enjoy positive profits during the adjustment process.

For the future plan of this study, we will first consider other behavioral assumptions, including collusion and Cournot competition as mentioned in footnote 4. Collusion has $\eta_{M,W} = 0$ and hence yields the highest markup by making $1/\eta$ as small as possible. For Cournot and Bertrand competition, $\eta_{M,W} \neq 0$ and $\eta_{M,W}$ is larger for Bertrand competition. Therefore, the Cournot price spread is higher than the Bertrand price spread, but lower than the collusive spread. In addition, we may assume that consumers differ in their maximum willingness to pay for the product ("*A*" or reservation price) and their strength of brand preference ("*c*" or transportation cost). Following Borenstein (1985), consumers' preferences are bivariate normally distributed on the two-dimensional (*A*, *c*) space. In this extended model consumers who have a sufficiently large brand preference with respect to their reservation price are served "monopolistically" whereas consumers who have a relatively small brand preference (such that more than one product yields positive utility) are served "competitively". It would be interesting to examine two types of equilibrium and compare them with the current model.

Appendix

This appendix derives some comparative statics of price spreads. In equations (5) and (6) we have expressions for the price spread due to buyer market power in the raw input market (S_u) and the one due to seller market power in the processed good market (S_d). By taking derivatives on S_u and S_d with respect to consumer's brand preference (*c*), processor's fixed costs (*F*), farmer's transportation costs (*t*), and coefficient of farmer's supply function (β), we get

$$\frac{\partial S_u}{\partial c} = \frac{-8\beta t\left(16\alpha c-(4-\alpha)F\beta^2t^2\right)}{F^2\sqrt{c/F}\left(4\sqrt{c/F}+\beta t\right)^2\left(4\beta t+\left(4\sqrt{c/F}-\beta t\right)\alpha\right)^2}, \tag{A1}$$

$$\frac{\partial S_d}{\partial c} = \frac{4\beta\left(2c+\beta Ft\sqrt{c/F}\right)}{F\sqrt{c/F}\left(4\sqrt{c/F}+\beta t\right)^2} > 0; \tag{A2}$$

$$\frac{\partial S_u}{\partial F} = \frac{8\beta t\sqrt{c/F}\left(16\alpha c-(4-\alpha)F\beta^2t^2\right)}{F^2\left(4\sqrt{c/F}+\beta t\right)^2\left(4\beta t+\left(4\sqrt{c/F}-\beta t\right)\alpha\right)^2}, \tag{A3}$$

$$\frac{\partial S_d}{\partial F} = \frac{8\beta\left(\sqrt{c/F}\right)^{3/2}}{\left(4\sqrt{c/F}+\beta t\right)^2} > 0; \tag{A4}$$

$$\frac{\partial S_u}{\partial t} = \frac{16\beta t\sqrt{c/F}\left(16\alpha c-(4-\alpha)F\beta^2t^2\right)}{F\left(4\sqrt{c/F}+\beta t\right)^2\left(4\beta t+\left(4\sqrt{c/F}-\beta t\right)\alpha\right)^2}, \tag{A5}$$

$$\frac{\partial S_d}{\partial t} = \frac{-4\beta^2 c}{\left(4\sqrt{c/F}+\beta t\right)^2} < 0; \tag{A6}$$

$$\frac{\partial S_u}{\partial \beta} = \frac{16t\sqrt{c/F}\left(16\alpha c-(4-\alpha)F\beta^2t^2\right)}{F\left(4\sqrt{c/F}+\beta t\right)^2\left(4\beta t+\left(4\sqrt{c/F}-\beta t\right)\alpha\right)^2}, \tag{A7}$$

$$\frac{\partial S_d}{\partial \beta} = \frac{16\sqrt{c/F}}{\left(4\sqrt{c/F}+\beta t\right)^2} > 0\,; \tag{A8}$$

If we assume that $n > \beta t\sqrt{(4-\alpha)}/(4\sqrt{\alpha})$, it is easy to show that $16\alpha c-(4-\alpha)F\beta^2 t^2 > 0$ by using equilibrium $n=\sqrt{c/F}$. When Bertrand competition is assumed, $\alpha = 1$ and $n > \sqrt{3}\beta t/4$.

To see why this inequality is valid, we borrow some numbers from Durham and Sexton (1992). In Durham and Sexton's (1992) study on California's processing tomato market, total farm-to-processor shipping costs, *td*, are in the range of 25% of raw product value. That is, the maximal t^* is such that $t^*M=W/4$. As a result, $t \le t^* = W/(4M) = nW/2$. Recall that $W=\frac{1}{\beta}+\frac{t}{4n}$. If we assume that a farmer incurs $t = x\, t^*$, then $W=\frac{1}{\beta}+\frac{xt^*}{4n}$, where x is a ratio and $0 \le x \le 1$. It implies that $1/\beta = \left(1-x/8\right)W$ and $t = xnW/2$. It turns out that $\sqrt{3}\beta t/4 = \frac{4\sqrt{3}x}{8-x}n$ and it is easy to verify that $\frac{4\sqrt{3}x}{8-x} < 1,\ \forall 0 \le x \le 1$. In other words, under the Bertrand competition assumption and the observation that total farm-to-processor shipping costs are in the range of 25% of raw product value, $n > \sqrt{3}\beta t/4$ for any number of processors in the downstream market. Therefore,

$$\frac{\partial S_u}{\partial c} < 0\,,\ \frac{\partial S_u}{\partial F} > 0\,,\ \frac{\partial S_u}{\partial t} > 0\,,\ \frac{\partial S_u}{\partial \beta} > 0\,.$$

On the other hand, because $\beta t\sqrt{(4-\alpha)}/(4\sqrt{\alpha})$ is decreasing in α, the inequality might be reversed as α decreases; for example, α = 0 in a collusion case. We focus only on the Bertrand case for now.

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