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PART ONE: Vertical Market Coordination and Power

2. A Rationale for Captive Supplies

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A Rationale for Captive Supplies

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The academic and legal debate over the costs and benefits of vertical integration is both well known and lengthy (Perry 1989, Williamson 1989). On one side, economists see firms' decisions to vertically integrate as nothing more than a means of reducing transactions costs, assuring supply, or as a means of alleviating efficiency losses that result from under-utilization of resources (McGee and Bassett 1976; Williamson 1975, 1985). On the other side, economists see vertical integration as a means for firms to reduce competition or extract market rents (Scherer 1980; Perry 1978a, 1989). To date, most of the discussion has focused on the effects of a monopolist integrating forward into a competitive downstream intermediate product market. Little work exists on the reverse case of a monopsonist integrating backward into a competitive input market (Perry 1978b; McGee and Bassett 1976). However, this case is of growing importance in many agricultural and natural resource industries, including poultry processing, beef processing, and forest industries.

In many industries, backward integration occurs either through acquiring input suppliers, establishing long-term contracts with existing suppliers, or investing in new input production capacity through internal corporate growth. In some industries, there is increasing concern about the effects of these arrangements on the remaining unintegrated input suppliers. Perhaps the most vocal are fed cattle producers. According to the Kiplinger Agriculture Letter:

> [There is] plenty of grumbling about captive beef supplies these days . . . complaints that too many cattle are tied up by the packers themselves, either through outright ownership or through contractual arrangements. Critics see the cattle industry heading down the poultry pathway: highly integrated, with packers and processors controlling all aspects of production . . . from the supply of feeders through slaughter and processing. They point to intensified concentration of the packing business and fret that the trend leaves [the] market vulnerable to price manipulation (June 9, 1995).

These concerns are reflected in the recent decision by Congress to initiate a $500,000 study (through USDA Packers and Stockyards Administration (PSA)) to investigate the effects of increasing packer concentration in the red meat packing industry. Seven projects were identified as priority research, including studies on price determination in slaughter cattle procurement and the role of captive supplies in the beef packing industry.

The Congressionally mandated Packers and Stockyards Administration study reports that, during the April 5, 1992 to April 3, 1993 interval, the 43 largest steer and heifer slaughter plants procured 82 percent of cattle through the spot market, 8 percent of fed cattle through marketing agreements, and 7 percent through forward contracts. The PSA study defined forward contracting as contracts to purchase specific lots of cattle at any time from placement of cattle on feed up to two weeks prior to the kill date. In contrast, marketing agreements were defined as long-term arrangements between a packer and a seller under which the packer agrees to purchase a specific number of cattle per specified time period (week, month, year). During the same 1992-1993 interval, the PSA study found packers obtained 3 percent of fed cattle through custom feedlot arrangements or through wholly-owned feed lot operations where cattle were packer-owned while they were fed for slaughter (p. 170).

Captive supplies in the beef industry are typically defined as "cattle owned by packers, forward contracted by them, and/or formula-priced cattle bought by the packers" (Uvacek 1995). This definition includes both procurement and pricing methods. A narrower definition of captive supplies, more closely aligned with the concepts of vertical integration, includes cattle that are packer-owned or fed and cattle procured through forward contracts or long-term marketing agreements (Ward 1990). This definition conforms more closely to the industrial organization tradition that defines an upstream or downstream firm as vertically integrated if it controls either directly or indirectly the decisions made within the vertical structure. Thus, a firm can be backward integrated without actually owning its input suppliers. Under this definition, vertically integrated profit is the maximum aggregate profit that the vertical structure can obtain (Tirole 1988: 170). In this paper, we follow this narrow definition, suggesting that the PSA procurement categories packer-owned and marketing agreement most closely fit the model developed below.

The PSA study found large firms are more likely to use marketing agreements and forward contracts to purchase cattle than are other firms. For example, Williams et al. (1996) report, "ConAgra, Excel, and IBP account for 73 percent of spot market transactions, but 88 percent of marketing agreements and 95 percent of forward contract transactions" (p. 16). They also found smaller firms in California and Arizona accounted for 42 percent of packer-fed lots. In another study of the Plains feeding area, Ward (1990) found that IBP, ConAgra, and Excel accounted for 98 percent of cattle procured as captive supplies during June 1989 (p. 31).

Many natural resource markets exhibit similar characteristics. Typically, processing mills are spatially distributed and transportation costs associated with moving raw products to mills are high, limiting competition among natural resource buyers. In the forest industry, large processing firms own or lease vast tracts of timberland, but also purchase timber from outside suppliers. In 1994, 31 forest products firms in the U.S. and Canada owned 45 million acres of industrial timberlands and controlled another 162 million acres through lease arrangements with nonindustrial landowners who own no processing facilities (Mies et al. 1994). These holdings represent roughly 34 percent of total U.S. and Canadian commercial-grade timberlands. The remaining two-thirds of productive timberlands are owned and controlled by either nonindustrial landowners or by governments.

Industrial owners internally supply a large proportion of their wood inputs. In 1991, industrially-owned forests in the U.S. accounted for 14 percent of timberland and 13 percent of timber inventory volume, but supplied 33 percent of volume harvested (Powell et al. 1993). Industrially-owned softwood forests contain about 16 percent of total standing inventory volume, but accounted for 38 percent of 1991 softwood harvest volume. The amount of wood internally supplied continues to increase. Harvests from U.S. industrial lands increased 6 percent between 1986 and 1991 and 62 percent between 1952 and 1991 (Powell et al. 1993).

In addition to harvesting from their own lands, forest products firms control additional acreage through lease arrangements with nonindustrial private landowners. These nonindustrial owners hold 59 percent of the timberland but only 46 percent of U.S. standing timber inventory volume (Powell et al. 1993). These lands are typically less productive than industrially-owned forests. The largest identifiable group of nonindustrial landowners is farmers. Ninety percent of nonindustrial landowners have less than 100 acres.

Some additional supply is provided by government. These lands are owned by the federal government, state governments, municipalities, and other public entities. While publicly-owned forests in the U.S. constitute 27 percent of the timberland and 41 percent of timber inventory volume (Powell et al. 1993), much acreage is reserved for parks, does not produce commercial timber, or is set aside for other uses. Federal lands are primarily in the western U.S., while state and other public lands are in the northeast and northcentral regions. Harvesting from public lands is also dependent on a complex policy structure and, in recent years, has not been a reliable or continuous source of timber in many regions. In 1991, harvest from public lands represented only 18.5 percent of volume harvested.

Clearly, firms use various mechanisms to achieve backward integration into input markets. There is ample evidence, at least in the beef processing market, that large firms, more than small firms, use these mechanisms to achieve at least partial backward integration. In this paper, we develop one plausible economic rationale for this behavior. While in reality firms may use vertical integration for a number of reasons, including achieving increased efficiency, reducing transactions costs, reducing price risk or assuring supplies, we follow Perry (1978a) and focus on firms' strategic use of vertical integration to achieve higher profits.

We utilize a number of simplifying assumptions. First, we assume that a market is defined by a dominant processing firm , a competitive fringe of smaller processors and competitive suppliers of a raw input and that the number of firms is fixed. Both processors' output and the raw input are assumed homogeneous. These assumptions simplify analysis and are realistic in natural resource and agricultural processing industries where firms possess scale economies over some range of operations and where transportation costs associated with assembling the raw input are high. Under these conditions, processors have an incentive to be spatially distributed so that each firm dominates its local input market area with distant firms in various directions representing a competitive fringe. Second, we assume that processors are competitive in their output markets. This is reasonable when numerous firms dominating their respective input supply areas compete in a homogeneous output market. Third, we assume that processing firms produce a single output employing a quasi-fixed proportions technology that allows no substitution between the raw input and a vector of other production inputs. This assumption allows us to focus the analysis on the interaction of upstream and downstream firms in an input market and is reasonable in natural resource or agricultural processing industries where final outputs contain specific proportions of raw inputs. Fourth, we assume the dominant firm enjoys falling average production costs as output expands toward optimal capacity utilization. As output rises above the optimum, average cost rises. This assumption is consistent with a short- or intermediate-run model of an agricultural or natural resource processing industry where capital costs are high and where plant capacity is fixed.

Using these assumptions, we demonstrate both graphically and analytically some important implications of backward integration that may be achieved through vertically controlling a portion of the raw input production sector either through establishing long-term exclusive contracts with raw input suppliers or through acquiring upstream firms. Contrary to the competitive notion that vertical integration is a purely "internal affair" that does not affect third parties (Tirole 1988: 170), we find that processors who integrate backward into their input supply industries can potentially benefit from at least two sources of increased profitability. First, a backward integrated dominant firm benefits from efficiency gains of expanded production. Second, partial backward integration may result in a reduction in the dominant firm's acquisition price for externally supplied raw inputs. We also show a number of important comparative statics results relating to backward integration.

The Model: A Graphical Approach

Consider a market with identical competitive input suppliers and a downstream processing industry characterized by a dominant firm and a competitive fringe. Total upstream market supply is $x_s = x_s(w_m)$, where w_m is market price. Without backward integration into the input producing sector, the dominant processing firm acts as a price leader in purchasing input quantity x_m. Acting as price takers, fringe processing firms follow by setting their optimal input levels so that aggregate fringe input demand is $x_d = x_d(w_m)$.

This market situation is depicted in Figure 2.1. The left quadrant presents upstream aggregate supply $x_s = x_s(w_m)$ and fringe processors' aggregate demand $x_d = x_d(w_m)$. The residual supply facing the dominant processor is shown in the right quadrant as $x_{rs} = x_{rs}(w_m) = x_s(w_m) - x_d(w_m)$. In the absence of vertical control, the dominant firm acts as a monopsonist with respect to residual supply, maximizing profit by setting value marginal product for raw input x, VMP_x, equal to marginal outlay for that input, MO_{rs}. In Figure 2.1, this occurs at quantity x_m^m and price w_m^m.

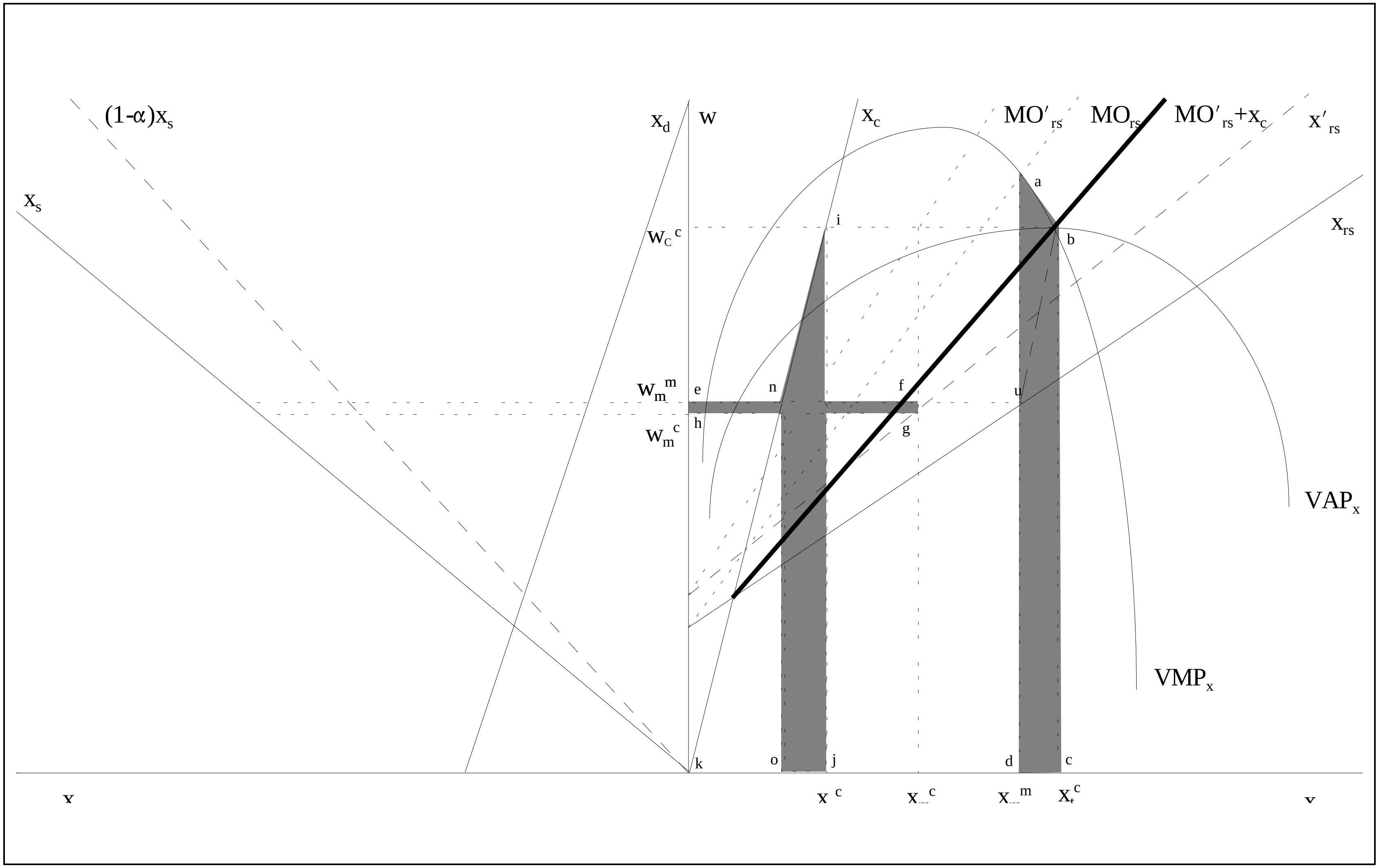
At the monopsony solution defined in Figure 2.1, the dominant firm underemploys the raw input. Assuming a constant raw input price, the firm could reduce average cost per unit of output by expanding production. However, unless the firm is able to price discriminate among input suppliers, this alternative is not profitable. Without price discrimination, the dominant firm must pay input suppliers a higher price for all units purchased to expand output, wiping out cost savings from increased production. However, by backward integrating into its input market at least partially, the dominant firm can increase production to achieve both increased technical efficiency and higher profits.

The dominant firm can achieve backward integration either through acquiring a fraction of the upstream firms in the raw input industry or by entering into exclusive long-term contracts with input suppliers who control a portion of total supply. For the moment, assume that integration is achieved through acquisition. Suppose the dominant firm purchases fraction α of raw input suppliers so that it internally produces amount x_c of the raw input. It then purchases quantity x_m from the spot market. In this case, the dominant firm is able to segment its input market, internally supplying raw input at one transfer price and externally purchasing raw input in the spot market at another price. In the right quadrant of Figure 2.1 the dominant firm's internal supply (marginal cost) of raw input is given as $x_c = \alpha\, x_s(w_c)$ and its residual spot market supply is given as $x_{rs}' = x_{rs}'(w_m) = (1-\alpha)x_s(w_m) - x_d(w_m)$, where w_c is the internal transfer price the dominant firm "pays" its internal input supply subsidiary. To maximize profit, the dominant firm will continue to act as a monopsonist with respect to its external residual input supply, but now it will operate its internal raw input producing facilities at the quantity that equates VMP_x to the marginal factor cost of the raw input, i.e., $MFC = w_c = x_s^{-1}(x_c/\alpha)$ (Perry 1978b). With partial integration in the input market, the dominant firm will set total raw input use to equate its marginal outlay for externally purchased input plus marginal factor cost for self-produced input, $MO_{rs}' + x_c$ in Figure 2.1, equal to VMP_x. To achieve this result, the dominant firm chooses the amount of input produced internally, x_c, and the price it pays in the spot market, w_m. Total input quantity for the dominant firm is $x_t = x_c + (1-\alpha)x_s(w_m) - x_d(w_m)$. In Figure 2.1, optimal total input use is x_t^c, with quantity x_m^c purchased in the spot market and quantity x_c^c produced internally. Equilibrium spot market price is now given by w_m^c and the internally supplied raw input transfer price is w_c^c. As a result of backward integration, total input use has expanded from x_m^m to x_t^c and the equilibrium spot market input price has fallen from w_m^m to w_m^c.

The dominant firm reaps two benefits from partial backward integration into its input market. First, it benefits from efficiency gains of expanded production. In Figure 2.1, this gain is measured as area *abcd* under the dominant firm's input demand function for x. Second, the dominant firm benefits (in this particular example) from paying a lower market price for externally supplied raw input. This gain is given by area *efgh* in Figure 2.1. That is, partial backward integration results in a reduction in the price for external raw input purchases amounting to $w_m^m - w_m^c$. This benefit is case specific and depends, among other things, on the slope of the dominant firm's input demand for x (the slope of VMP_x). If, for example, the dominant firm's input demand was flatter near the equilibrium point (input price w_m^c, input quantity x_t^c), then the equilibrium dominant firm monopsony price w_m^m would be less than the equilibrium external input price w_m^c. In this case, the dominant firm would suffer a loss from having to pay a higher price for externally supplied inputs after backward integration.

To obtain these benefits, the dominant firm must bear additional costs. The integrated firm produces x_c^c of raw input internally. Total variable cost of this production is area *ijk*. However, the costs to the dominant firm of acquiring this upstream production capacity are not covered. Acquisition costs are

FIGURE 2.1 Economics of Vertical Integration



related to rents accruing to input suppliers before they are purchased. There are many possibilities, but for simplicity, we follow Perry (1978b) and assume that any fraction of upstream firms can be acquired by paying them the present value of the stream of per-period initial rents so that acquired suppliers are never paid less for input x than they would have earned before being acquired. In Figure 2.1, this amounts to paying the acquired suppliers the equivalent of area *enk* at each time period. Hence, per period total cost of internal production is given by area *enijk*. This is the same payment that would be required for input purchases made through establishing exclusive supply contracts when the dominant firm has perfect information about upstream firms' production costs and when the dominant firm does not in any way act as a "predator" in forming long-term contracts. Before acquisition, the dominant firm incurred external input costs of area *enok* for input production that becomes internalized in the vertically integrated firm. Hence, the net increase in input costs after integration is area *nijo*. On balance, the total benefit from backward integration is area *abcd* plus area *efgh* minus area *nijo*. The net benefit is also given by the sum of area *efgh* and area *abu*.

While we assume that the number of fringe firms is fixed, it is possible to draw some conclusions about the effects of price changes resulting from vertical integration on the profitability and behavior of fringe processors. In the case where backward integration results in an equilibrium external input price that is lower than the pre-integration input price, fringe processing firms' profitability rises, creating an incentive for the fringe to expand operations. Fringe firm expansion will place competitive pressure on the dominant firm, and may ultimately result in lost market share for the dominant firm. Alternatively, when backward integration results in a higher equilibrium external input price, this creates an unfavorable economic environment for fringe processors. In this case, backward integration could be used as a means of rasing rivals' costs to allow the dominant firm to capture a larger market share (Perry 1978b).

Mathematical Model

The rest of this paper provides a brief formal analysis of backward integration. As discussed above, we assume that the dominant firm produces a single output, y, employing a quasi-fixed production technology that does not allow substitution between input x and other inputs z and capacity k, but does allow substitution among inputs other than x. Further, we assume that the dominant firm's plant size k is fixed in the short run, so that cost is conditional on plant size.

This technology is given by:

(1) $$y = \min(x/\beta, f(z,k)),$$

where $1/\beta$ represents the x to y conversion ratio, k is quantity of capital, z is a vector of input quantities other than x and k, and f(z, k) is concave with positive and declining marginal products for capital k and all remaining inputs z (Sexton 1990). Cost minimization requires $y = x/\beta = f(z,k)$. The cost function for this technology is:

(2) $$C(y,w,v;k) = y\beta w + c(y,v;k) + FC,$$

where w is the price of raw input x, v is a vector of variable input prices associated with z, and FC is fixed costs. The first term represents raw input costs and c(y,v;k) represents costs of all remaining inputs other than capital (FC). Given these assumptions, costs can be reformulated in terms of raw input quantity so that:

(3) $$C(y,w,v;k) = xw + c(x/\beta,v;k) + FC.$$

For now, we set aside the long-run problem of determining the optimal degree of backward integration. Instead, we concentrate on the short-run problem of determining the optimal quantity of raw input to produce internally and the optimal price to set in the unintegrated upstream spot market given that the dominant firm integrates with a portion α of the upstream industry. To maximize short-run vertically integrated profit, the dominant firm must maximize the joint profit of its processing and raw input producing operations. This is achieved by acting as a monopsonist with respect to its upstream spot market residual supply and operating its internal input supply unit according to the competitive rule of choosing internal input production so that marginal benefit equals marginal cost (Perry 1978b). Total variable cost of internal input production is given by:

$$\text{(4)} \qquad TVC_x = \int_0^{x_c} x_s^{-1}(x/\alpha)\, dx ,$$

where $x_s^{-1}(x/\alpha)$ is the inverse supply function for the fraction of input supply produced internally and x_c is the amount produced internally. Fixed costs for these inputs are FC_c. The dominant firm's output expressed in terms of input x is $y = \left[(1-\alpha)\, x_s(w_m) - x_d(w_m) + x_c\right]/\beta$.

Given these definitions, the dominant firm's profit is:

$$\text{(5)} \qquad \max_{w_m, x_c} \quad \pi = p\left[(1-\alpha)\, x_s(w_m) - x_d(w_m) + x_c\right]/\beta$$
$$- w_m\left[(1-\alpha)\, x_s(w_m) - x_d(w_m)\right] - \left[\int_0^{x_c} x_s^{-1}(x/\alpha)\, dx + FC_c\right]$$
$$- c\left(\left[(1-\alpha)\, x_s(w_m) - x_d(w_m) + x_c\right]/\beta, v; k\right) - FC .$$

The first term is revenue from output sales, the second term is externally supplied input cost, the third term is internally supplied input cost, the fourth term is other input costs conditional on k, and the fifth term is fixed costs. The dominant firm's short-run profit maximizing solution solves:

$$\text{(6)} \qquad \frac{\partial \pi}{\partial w_m} = \frac{p - c'(.)}{\beta} - w_m\left[1 + \frac{(1-\alpha)\, x_s(w_m) - x_d(w_m)}{(1-\alpha)\, \epsilon_s x_s(w_m) - \epsilon_d x_d(w_m)}\right] = 0$$

and

$$\text{(7)} \qquad \frac{\partial \pi}{\partial x_c} = \frac{p - c'(.)}{\beta} - x_s^{-1}(x_c/\alpha) = 0 ,$$

where $c'(.)$ is the derivative of c(.) with respect to total input quantity x.

Interpreting equation (6), the dominant firm sets raw input price to equate VMP_x (= $p/\beta - c'(.)/\beta$) with its marginal outlay for externally purchased input MO_{rs} (= $w_m(1 + (1/\epsilon_{rs}))$, where ϵ_{rs} is the price elasticity of residual supply). Interpreting equation (7), the dominant firm sets internal raw input production to equate VMP_x with its internal marginal cost of input production. If vertical integration is achieved only through long-term contracting, then equation (7) gives the optimal contract quantity, given that the proportion of firms to contract with α has already been established. The minimum contract price is determined from:

(8) $$w_c^* = \left[w_m^* \alpha\, x_s\left(w_m^*\right) + \int_{\alpha x_s\left(w_m^*\right)}^{x_c^*} x_s^{-1}(x/\alpha)\, dx \right] / x_c^* + \delta ,$$

where x_c^* is the optimal contract quantity, w_m^* is the equilibrium price in the external input market, and δ is a small constant. From equation (8), it is apparent that when vertical control is established through long-term contracts, the equilibrium contract price will be higher than the external spot market price.

It is instructive to contrast the dominant firm/competitive fringe solutions with and without backward integration. Solving equation (6) for w_m^c gives:

(9) $$w_m^c = \frac{VMP_x^c}{1 + 1/\epsilon_{rs}^c} ,$$

where VMP_x^c is value marginal product evaluated at x_t^{c*} and ϵ_{rs}^c is the residual supply curve elasticity with contracting. With no contracting, this relationship is:

(10) $$w_m^m = \frac{VMP_x^m}{1 + 1/\epsilon_{rs}^m} .$$

The external spot market price under partial contracting can be compared with the spot market price in the case of no contracting:

(11) $$\frac{w_m^c}{w_m^m} = \frac{VMP_x^c}{VMP_x^m} \left(\frac{1 + 1/\epsilon_{rs}^m}{1 + 1/\epsilon_{rs}^c} \right) .$$

Since a processor executing long-term contracts does not act as a monopsonist with respect to its contractors, the presence of contracts for inputs will expand the dominant processor's use of input x (Perry 1978b). Then $VMP_x^c < VMP_x^m$ because the value marginal product curve is downward sloping. Therefore, the ratio of marginal value products in equation (11) is less than one, and if $\epsilon_{rs}^m = \epsilon_{rs}^c$, then w_m^c/w_m^m will be less than one. However, there is no reason to believe that ϵ_{rs}^m will equal ϵ_{rs}^c because ϵ_{rs}^c depends on the degree of backward integration and both ϵ_{rs}^c and ϵ_{rs}^m depend on equilibrium spot market supply and demand quantities. While contracting expands the dominant firm's use of input x, it is not clear exactly how the elasticities of residual demand are affected. However, if x_s, x_d, ϵ_s, and ϵ_d are assumed constant, then increased contracting results in lower values of $1 + \left(1/\epsilon_{rs}^c\right)$. Under these rigid assumptions, the price ratio w_m^c/w_m^m rises with increased backward integration. However, as the proportion of contracting rises, the quantities supplied and demanded in the market will almost certainly change. Even so, it is possible to draw some conclusions concerning the external spot market price differential with and without integration. The spot market price, with partial backward integration, will be less than, equal to, or greater than the unintegrated spot market price when the ratio VMP_x^m/VMP_x^c is less than, equal to, or greater than the ratio $\left(1 + 1/\epsilon_{rs}^m\right)/\left(1 + 1/\epsilon_{rs}^c\right)$.

Comparative Statics Results

To better understand the effects of exogenous factors on the dominant firm's decision to backward integrate, we perform a comparative statics analysis for several exogenous variables. Four were selected for analysis: elasticity of total market supply ϵ_s, elasticity of demand from fringe processors ϵ_d, amount of the dominant firm's capital k, and proportion of suppliers with which the dominant firm contracts, α. In this short-run analysis, both capital k and the degree of backward integration α are taken as given.

First, consider the effect of exogenous factors on the external market price w_m. Three unambiguous results can be obtained. Equation (12) gives the effect of a change in the elasticity of total supply on external input market price:

$$(12) \qquad \frac{dw_m}{d\epsilon_s} = \frac{\left[c''(.) \frac{w_m}{\beta^2} + \frac{\partial x_s^{-1}(.)}{\partial (x_c/\alpha)} \frac{w_m}{\alpha} \right] \left[\frac{\left[(1-\alpha) x_s(w_m) - x_d(w_m)\right] (1-\alpha) x_s(w_m)}{\left[(1-\alpha)\epsilon_s x_s(w_m) - \epsilon_d x_d(w_m)\right]^2} \right]}{|H|} > 0 ,$$

where $c''(.)$ indicates the second derivative of c(.) with respect to input x and $|H|$ indicates the determinant of the Hessian matrix. As supply becomes more elastic, it becomes more costly for the dominant firm to use its market power to depress the price of the raw input in the external market. Hence, as the elasticity of supply rises, so does the equilibrium external input market price.

Equation (13) shows that as the elasticity of demand from the fringe processors increases, the spot market price falls:

$$(13) \qquad \frac{dw_m}{d\epsilon_d} = \frac{- \left[c''(.) \frac{w_m}{\beta^2} + \frac{\partial x_s^{-1}(.)}{\partial (x_c/\alpha)} \frac{w_m}{\alpha} \right] \left[\frac{\left[(1-\alpha) x_s(w_m) - x_d(w_m)\right] x_d(w_m)}{\left[(1-\alpha)\epsilon_s x_s(w_m) - \epsilon_d x_d(w_m)\right]^2} \right]}{|H|} > 0 .$$

As ϵ_d rises, the absolute value, $|\epsilon_d|$, falls. Hence, $dw_m/d|\epsilon_d|$ is positive and a more elastic fringe demand makes it more costly for the dominant firm to exert market power.

Equation (14) shows that as the dominant firm's production capacity increases, the external spot market input price rises:

$$(14) \qquad \frac{dw_m}{dk} = - \frac{\partial c'(.)}{\partial k} \frac{1}{\beta} \frac{\partial x_s^{-1}(.)}{\partial (x_c/\alpha)} \frac{1}{\alpha} > 0 .$$

Clearly, as its output capacity expands, the dominant firm demands more of the raw input and the price it must pay for this input rises.

Equation (15) shows the effect of an increase in the proportion of firms receiving contracts α on the external spot market. This comparative static result depends on the relative magnitudes of a number of variables:

$$\frac{dw_m}{d\alpha} = \left[c''(.) \frac{1}{\beta^2} + \frac{\partial x_s^{-1}(.)}{\partial (x_c/\alpha)} \frac{1}{\alpha} \right] \frac{\left[c''(.) \frac{x_s(w_m)}{\beta^2} - w_m \left[\frac{(\epsilon_d - \epsilon_s) x_d(w_m) x_s(w_m)}{\left[(1-\alpha)\epsilon_s x_s(w_m) - \epsilon_d x_d(w_m)\right]^2} \right] \right]}{|H|}$$

$$(15) \qquad - \frac{c''(.) \frac{1}{\beta^2} \left[c''(.) \frac{1}{\beta^2} + \frac{\partial x_s^{-1}(.)}{\partial (x_c/\alpha)} \frac{x_c}{\alpha^2} \right]}{|H|} \gtreqless 0 .$$

In particular, the relative magnitudes of the elasticities of total supply and demand can change the sign of the derivative.

Comparative static results for x_c, the quantity of internally supplied raw input, are similar to those for w_m. Equation (16) shows that an increase in the elasticity of total supply results in a downward adjustment in internal input production:

$$(16) \qquad \frac{dx_c}{d\epsilon_s} = \frac{-\,c''(.)\left[(1-\alpha)\dfrac{\partial x_s}{\partial_w} - \dfrac{\partial x_d}{\partial_w}\right]\dfrac{w}{\beta^2}\left[\dfrac{\left[(1-\alpha)\,x_s(w_m) - x_d(w_m)\right]x_s(w_m)}{\left[(1-\alpha)\,\epsilon_s\,x_s(w_m) - \epsilon_d\,x_d(w_m)\right]^2}\right]}{|H|} < 0\,.$$

As supply becomes more elastic, it becomes less costly to expand input use in the external spot market since increasing use will result in a smaller price rise. In addition, with more elastic supply, it is more costly for the dominant firm to exploit market power and the external market price-reducing effect of backward integration becomes smaller. Hence, there is less incentive for the dominant firm to engage in backward integration.

Equation (17) indicates the dominant firm's optimal internal input production increases as the elasticity of fringe demand rises. As ϵ_d rises, $|\epsilon_d|$ falls, and the residual supply curve becomes more inelastic. Hence, $dx_c/d|\epsilon_d|$ is negative and the dominant firm finds it profitable to decrease internal supply x_c:

$$(17) \qquad \frac{dx_c}{d\epsilon_d} = \frac{-\,c''(.)\left[(1-\alpha)\dfrac{\partial x_s}{\partial w_m} - \dfrac{\partial x_d}{\partial w_m}\right]\dfrac{w}{\beta^2}\left[\dfrac{\left[(1-\alpha)\,x_s(w_m) - x_d(w_m)\right]x_d(w_m)}{\left[(1-\alpha)\,\epsilon_s\,x_s(w_m) - \epsilon_d\,x_d(w_m)\right]^2}\right]}{|H|} > 0\,.$$

Equation (18) shows that as the dominant firm's output capacity expands, it will produce a larger quantity of raw input internally:

$$(18) \qquad \frac{dx_c}{dk} = -\frac{\partial c'(.)}{\partial k}\,\frac{1}{\beta}\,\frac{1}{|H|}\left[1 + \frac{(1-\alpha)\,x_s(w_m) - x_d(w_m)}{(1-\alpha)\,\epsilon_s\,x_s(w_m) - \epsilon_d\,x_d(w_m)}\right]$$

$$-\frac{\partial c'(.)}{\partial k}\,\frac{w}{\beta}\,\frac{1}{|H|}\left[\frac{(1-\alpha)\,x_d(w_m)\left[\epsilon_s - \epsilon_d\right]\dfrac{\partial x_s}{\partial w_m} + (1-\alpha)\,x_s(w_m)\left[\epsilon_d - \epsilon_s\right]\dfrac{\partial x_d}{\partial w_m}}{\left[(1-\alpha)\,\epsilon_s\,x_s(w_m) - \epsilon_d\,x_d\right]^2}\right] > 0\,.$$

Increasing capacity raises total raw input demand, part of which is satisfied through increased internal input production.

The comparative statics result for a change in α is ambiguous. Equation (19) indicates that the magnitude of a number of terms will change the sign. The relative magnitudes of the elasticities of total supply and demand are important:

$$(19)\quad \frac{dx_c}{d\alpha} = -\,c''(.)\,\frac{1}{\beta^2}\,\frac{1}{|H|}\left[(1-\alpha)\,\frac{\partial x_s}{\partial w_m} - \frac{\partial x_d}{\partial w_m}\right]$$

$$\left[c''(.)\,\frac{x_s}{\beta} - w_m\left[\frac{\left[\epsilon_d - \epsilon_s\right]x_d\left(w_m\right)x_s\left(w_s\right)}{\left[\left(1-\alpha\right)\epsilon_s\,x_s\left(w_m\right) - \epsilon_d\,x_d\left(w_m\right)\right]^2}\right]\right]$$

$$-\left\{c''(.)\,\frac{1}{\beta^2}\,\frac{1}{|H|}\left[(1-\alpha)\,\frac{\partial x_s}{\partial w_m} - \frac{\partial x_d}{\partial w_m}\right] - \left[1 + \frac{\left(1-\alpha\right)x_s\left(w_m\right) - x_d\left(w_m\right)}{\left(1-\alpha\right)\epsilon_s\,x_s\left(w_m\right) - \epsilon_d\,x_d\left(w_m\right)}\right]\right.$$

$$\left. - w_m\left[\frac{\left(1-\alpha\right)\left[x_s\left(w_m\right)\left[\epsilon_d - \epsilon_s\right]\frac{\partial x_d}{\partial w_m} + x_d\left(w_m\right)\left[\epsilon_s - \epsilon_d\right]\frac{\partial x_s}{\partial w_m}\right]}{\left[\left(1-\alpha\right)\epsilon_s\,x_s\left(w_m\right) - \epsilon_d\,x_d\left(w_m\right)\right]^2}\right]\right\}$$

$$\left[c''(.)\,\frac{x_s}{\beta^2} + \frac{\partial x_x^{-1}}{\partial x_c/\alpha}\,\frac{x_c}{\alpha^2}\right] \begin{matrix} > \\ = \\ < \end{matrix}\ 0\,.$$

The comparative static results are summarized in Table 2.1. A rise in the supply elasticity will reduce the amount of the factor internally produced and raise spot market factor price. As supply becomes more elastic, it becomes less costly to expand input use in the external spot market since increasing use will result in a smaller price rise. In addition, with more elastic supply, it is more costly for the dominant firm to exploit market power and the external market price-reducing effect of backward integration becomes smaller. Hence, there is less incentive for the dominant firm to engage in backward integration.

A rise in the absolute value of fringe demand elasticity will similarly raise spot market price and lower the quantity of internally produced input. A more elastic fringe demand makes it more costly for the dominant firm to exert market power through vertical integration because increased internal input production results in lost market input market share for the dominant firm. As fringe demand becomes

TABLE 2.1 Summary of Comparative Statics Results

Exogenous Variable	Spot Market Price w_m	Internally Produced Input Quantity x_c
Supply Elasticity ϵ_s	+	-
Finge Demand Elasticity $\lvert\epsilon_d\rvert$	+	-
Dominant Firm's Output Capacity k	+	+
Degree of Backward Integration α	?	?

more elastic, it is profitable for the dominant firm to lower internal supply and purchase more on the spot market.

Increasing production capacity will cause both the spot price and internally produced supply to grow. Increasing capacity raises total raw input demand, part of which is satisfied through increased internal input production with the remainder coming from the spot market. Increased demand in the spot market raises price.

Determining the Optimal Backward Integration

In the above short-run model, the proportion of vertically integrated suppliers is exogenous. In the long-run, α is a choice variable, set to maximize profits. Applying the envelope theorem, the optimal choice for α solves:

$$(20) \qquad \frac{\partial \pi^*}{\partial \alpha} = -\left[\frac{p - c'(.)}{\beta} - w_m^*\right] x_s(w_m^*) - \frac{\partial}{\partial \alpha}\int_0^{x_c^*} x_s^{-1}(x/\alpha)dx - fc'(.) = 0 ,$$

which can be rewritten as

$$(21) \qquad \frac{\partial \pi^*}{\partial \alpha} = -\left[\frac{p - c'(.)}{\beta} - w_m^*\right] x_s(w_m^*)$$

$$+ (x_c^*/\alpha)\ x_s^{-1}(x_c^*/\alpha) - \int_0^{x_c^*} x_s^{-1}(x/\alpha)\ (1/\alpha)\ dx - fc'(.) = 0 .$$

Multiplying the RHS of equation (21) by α and rearranging results in

$$(22) \qquad \left[\frac{p - c'(.)}{\beta} - w_m^*\right] \alpha\ x_s(w_m^*)$$

$$= x_c^*\ x_s^{-1}(x_c^*/\alpha) - \int_0^{x_c^*} x_s^{-1}(x/\alpha)\ dx - \alpha\ fc'(.) .$$

The left-hand side of equation (22) is VMP_x less external spot market price, or profit from the dominant firm's use of a unit of raw input purchased in the external spot market times the contract input supply function evaluated at the equilibrium spot market price. This term represents the economic rent achieved by purchasing input in the spot market that the dominant firm could have produced internally. The first term on the RHS of equation (22) is the value to the firm of internally produced input, the second term is the negative of total variable cost of producing internal input, and the third term is the negative of incremental fixed costs incurred by contracting. Hence, the right-hand side gives the dominant firm's producer surplus from producing input internally net of incremental fixed costs associated with producing additional input internally. The firm chooses optimal α to equate the profit from external supply, gained through exertion of monopsony market power, with the profit, or increase in producer surplus net of contracting or acquisition costs from internally producing raw input.

Under the model assumption that integrated input suppliers, those under contract or purchased by the dominant firm, are paid the present value of the stream of per period initial rents, the dominant processing firm will not fully backward integrate so long as its residual spot market input supply is upward sloping and its VMP_x curve is downward sloping. A fully integrated dominant firm utilizes input to equate internal VMP_x with internal marginal factor cost. However, if residual supply is upward sloping, by reducing α the firm can make a positive profit by acting as a monopsonist with respect to its residual supply. Hence, the dominant firm will not fully backward integrate into its input market as long as the monopsony profits to be made from external input purchases are larger than the lost efficiency gains from internal production less the cost of purchasing the capacity required to achieve those gains. On the other extreme, the dominant firm will backward integrate until increased output production efficiency gains plus increased profits from monopsony power exertion equal the cost of obtaining increased internal input production capacity. The firm will backward integrate until the economic rents from purchasing input in the spot market which could have been produced internally equate with the producer surplus from internal input production net of incremental capacity costs.

Conclusions

In this paper, we demonstrate both graphically and analytically some important implications of a dominant processing firm's backward integration into its input supply industry. Contrary to the competitive view that vertical integration does not have effects external to the integrated firm, we find that backward integration has a number of important market effects. First, with backward integration, a dominant firm can potentially benefit from efficiency gains of expanded output and from a price reduction for its externally purchased inputs. Second, when the dominant firm partially integrates through long-term contracting, its contract price will be higher than the equilibrium external spot market price for inputs. Third, when the dominant firm backward integrates, the price that it pays for externally purchased inputs can be higher, lower or equal to the price it would have paid had it not integrated, depending on the effect that integration has on its elasticity of input demand and on its residual supply elasticity.

Comparative statics analysis reveals several important implications of backward integration. First, we find that an increase in the residual supply elasticity results in an increase in the external spot market price and a decrease in the quantity that an integrated dominant firm will produce internally. Second, an increase in the dominant firm's output capacity results in increases in both the input spot market price and the integrated firm's internally produced input quantity. Third, we find that as the dominant firm increases its backward integration, the effects on spot market price and internally produced input quantity are ambiguous.

Lastly, we investigate the dominant firm's backward integration choice. We find that the optimal degree of integration results when benefits from adjusting residual spot market supply just offset increased internal input production costs.

Many of the results of this model are consistent with empirical relationships uncovered in the recent PSA studies of the red meat packing industry. For example, Williams et al. (1996) and Ward et al. (1996) find that beef processors paid higher prices for cattle procured through marketing agreements than for cattle purchased in the spot market; that higher rates of capacity utilization are associated with increased use of captive supplies; and that larger plants paid more for fed cattle than smaller plants. Each of these results is predicted by our analysis. Furthermore, Williams et al. find that cattle procured from distant locations are less likely to be packer fed or to originate through marketing agreements. A characteristic of spatial models is that, as distance from the processing plant increases, the plant's input supply elasticity grows. Processors' reduced use of captive supplies as an input source as distance rises is consistent with the prediction from our analysis that the quantity of internally supplied raw input falls as the input supply elasticity rises. Williams et al. (1996) also find that packer fed arrangements are more likely where regional concentration is high. From an individual firm's perspective, higher regional concentration means a lower residual supply elasticity. Hence, this finding is also consistent with the prediction from our analysis that as the input supply elasticity rises, quantity of internally supplied raw input falls.

While this analysis does not incorporate the dynamics inherent in natural resources such as timber, many of our results are applicable to these markets. Whether depressing spot market timber prices within a mill's buying area, or timbershed, is part of the motivation for forest products companies to own timber is, of course, not known. Our results simply illustrate that dominant firms' backward integration into their input markets can have important effects on market participants external to the integrated firm.

Note

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