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A Theory of Input Exchange Agreements

by Charles Holt and David Scheffman* Revised, July 1986

In the U.S., substantial quantities of producer goods are often
transacted via exchange agreements, rather than through spot markets, even when spot markets for the goods exist. An exchange is a simultaneous buy/sell arrangement generally involving equal amounts of each commodity. Joyce (1983) notes that markets in which exchanges are observed are characterized by the presence of vertical integration, high concentration in the input markets, and the presence of small non-integrated downstream producers. In this paper we consider the effects of input exchanges in models of markets with these characteristics.
Exchange agreements are common in markets for petroleum and many chemical
and paper products. 1 For example, a typical agreement may involve an exchange of several thousand gallons of gasoline in one location for an equal quantity in another, with a monetary adjustment that compensates for transportation cost differences. Another example arises in the case of corrugated cardboard products, an industry that stimulated our interest in exchange agreements. The two primary inputs used to fabricate cardboard are corrugating medium and linerboard, which are used in approximately fixed proportions. Corrugating medium (or IImediumU) is the paperboard product that is exclusively used to construct the fluted middle layer of

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large vertically integrated box producers are asymmetrically configured with respect to their production of linerboard and medium in regional markets, and

use common exchange agreements to align their input production and needs. 2 The bilateral exchange agreements typically stipulate that inputs will be traded on an equal tonnage basis monthly for a specified period of time. The corresponding monetary adjustment that accounts for differences in monetary values of medium

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firms, it is possible that exchanges could also have procompetitive effects on industry performance (as is the case with many other vertical

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contracts. Oliver Williamson (1983) notes that an exchange is essentially a bilateral hostage-holding situation in which each party can punish the other for failure to deliver. But firms could also establish interdependence with two standard sales contracts, specifying, for example, quantities to be purchased per month at spot market prices.
This paper provides a rationale for the use of input exchange agreements
and an analysis of the effects of such agreements on competition and economic efficiency. Section I presents the common structure of the models to be analyzed. Section II considers the situation in which all input transfers are made by exchange, and Section III contains an analysis of the equilibrium in the output and input markets in the absence of exchanges. In Section IV, the performance of markets with exchange agreements is compared with the performance of markets without exchange agreements. Finally, the analysis developed in Section V allows inputs to be acquired by negotiating bilateral exchanges and/or by engaging in unilateral market purchases of inputs. The concluding section contains a discussion of the antitrust implications of our analysis.

I. The Setting

To provide motivation for our analysis of exchanges, we present a

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products, Cournot assumed that the input producers choose prices independently. Cournot's main result can be illustrated graphically for the

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concave in Q. Thus industry marginal revenue in the market for the final product is a decreasing function of Q, which implies:

(1) f"(Q)Q + 2f'(Q) < 0 •

The two inputs in our model are indicated by the letters band m

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II. Input Specialization with Transfers Made

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Both firms must agree to any exchange, so we assume that the quantity exchanged will be the minimum of the exchange quantities preferred (i .e., that maximize a firm's profits) by the two firms. The assumed concavity of industry total revenue implies that both n I

(·) and n 2(-) are concave in e, and
so if the resulting level of exchange,

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denoted Q, that maximizes industry profit. The use of exchanges in this case is equivalent to a merger of the two firms.
When r = cm - cb' industry output is maximized in the sense that any
change in the level of r from this level will reduce the most preferred exchange quantity for at least one of the firms. To see this, note that the total sales revenues in the expressions for n

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costs and production coefficients for the unit of an input used in
exchange). A change in one of the input coefficients would alter the firms'
relative outputs and profits. since it is apparent from (4) and (5) that the
ratio of firms' profits when r = cm - cb depends on the relative magnitudes
of ~ and~. But regardless of the units of measurement. the use of exchanges
with r = cm - cb would yield the industry m.57 TcTc 13.1286 s8uts 314.28 610.33 T(r9.0.0 t.8 0 0 12.8

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own exchange level ei when r = cm - cb• let these functions be denoted

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III. Input Specialization With No Exchanges

In order to evaluate the effects of input exchange agreements, it is necessary to consider a model in which exchanges are not used. As in the previous section, we begin with the duopoly case and assume that firm 1 only produces input b and firm 2 only produces input m. Both firms also produce the final product. Without exchanges, each firm must purchase the input that it does not produce from the other firm. Input b is sold at a price Pb' which is set by firm I, and input m is sold at a price Pm' which is set by firm 2. We assume that firms set their prices noncooperatively, given correct
expectations of the effects of changes in the price of an input on the other
firm's input purchase and output production quantities.
It is useful to consider the analysis of the (subgame-perfect)
equilibrium in two stages. We will begin with the IIsecond-stagell analysis of
the equilibrium levels of input purchases for given values of the input
prices, Pb and Pm" 65c 12.8 0 31 0 0 12.8 160.69 370cza.80dc0 12m.33u3r618.04 3we consider the ll o noncooperative31 0 0 12.02 Tc

firms correctly anticipate the actions taken in the second stage.

Input Purchase Decisions ql
must purchase ql/~ units
Pmql/~' fi nn 2 purchases q/f3 units
Pbq2/ • the only supplier of
own input in the market so firm 1 incurs the of producing Q/f3 of input of producing b and firm 2 incurs the Q/~ units of input m. Thus, firms' profits, net of fixed

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anticipated in the first stage. A straightforward comparative-statics analysis of (10) and (11) yields the following "cross effects" of input price changes

Oql 1 f" (Q) q + 2f I (Q)
(12) 2 --- • fl(Q)[fll(Q)Q + 3f'(Q)] oPm I-l

(13) oq2 1 f" (Q)

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(15)
dn oq2 1 = [f' (Q)q - cb/~ + Pb/~] oPb + q2/~ = o , and dP"b 1

dn oql 2 = [f' (Q)q - c /~ + Pm/~] ~ + q/~ = o . OJ) 2 m m m

(16)

The term in square brackets in (15) is the profit margin on sales of
1/6 units of b, generalized to include the output effect, f ' (Q)ql' on the final-product sales revenue for firm 1.16 Recall that the cross derivative in (13), Oq/oPb' is negative. If q2 > 0, equation (15) implies that the generalized profit margin for sales of input b is positive:

so that P
b > c

b

. Analogously, it is easily shown that the generalized profit
margin for 1/~ units of input m is positive:

(18) f' (Q)q2 - c /~ + p I~ > 0 , m m

so that Pm > c
m •
The equilibrium levels of the four endogenous variables, Pb' Pm' ql' and
q2' are determined by the two equilibrium conditions for second stage, (10) and (11), and by the two equilibrium conditions for the first stage, (15) and (16), after using (12) and (13) to eliminate the input price derivatives in
(15) and (16).
We will first show that these equations must have a symmetric solution
with ql = q2" Subtracting the left side of (II) from the left side of (10), we obtain:

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Thus, the generalized profit margin for 1/~ units of input b must equal the generalized profit margin for 1/~ units of input m. Since the production of a unit of output requires 1/~ units of input b and 1/~ units of input m, equation (19) requires that the output-equivalent t 423.24 588.48 Tm 57he requires

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without exchanges will be such that: (i) no non-integrated firm is viable unless it has a cost advantage over integrated firms; and (ii) accounting profits for the downstream operations of the vertically integrated firms will be negative.

IV. The Effect of Exchanges

The next task is to compare the duopoly output Q* that occurs in the
~

absence of exchanges with the industry profit-maximizing output 0 that occurs in a duopoly with exchanges and a monetary adjustment rate that accounts for cost differences. To do this, recall that equation (21) is satisfied at Q = Q*, and that the right side of (21) is positive because the accounting profit margin in square brackets has been shown to be negative. The left side of (21), which

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In contrast, it is straightforward to show that equations (10) and (11) characterize a Cournot equilibrium in which the firms' marginal costs are cb/~ + Pm/~ for firm 1 and cm/~ + Pb/~ for firm 2. Recall that Pm > cm and Pb > cb' and therefore, these marginal costs exceed the marginal social costs. The output-contracting effect of this cost bias more than offsets the output-expanding effect of the Cournot equilibrium relative to collusion. Because the monopoly power in the monopolized input markets yields large potential gains from arrangements,

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Recall the result of proposition 1 that the industry output for an
oligopoly with exchanges is the output for a Cournot equilibrium
with s = min{k, n-k} firms that have constant marginal costs of
Because n > s, price competition in the input markets can, in
the absence of exchanges, result in a higher industry output than would be the case if all input transfers were made by exchange at a rate that fully compensates for production cost differences.
The intuition for the results in this section is that 1) exchanges permit output restriction because each party to a voluntary exchange has an effect on the sum of other firms' outputs at the margin, and 2) exchanges with a monetary adjustment rate tnat equals the input cost difference is equivalent to vertical integration that eliminates the distortionary effects of the monopoly power of input producers. This efficiency effect dominates the output-restriction effect when each firm is a monopolist for its own input, but the output-restriction effect of exchanges dominates when price competition in the input markets eiiminates any market power in input markets. If there is market power less than complete monopoly in input markets, the effects of exchanges is ambiguous.

v. A Model with Simultaneous Exchanges and Market Sales of Inputs

In this section, we analyze the equilibrium for a market that may contain non-integrated downstream firms. We show that the integrated firms will prefer to obtain some input through exchange. We also show that, as in the model of the previous section, the downstream subsidiaries of these integrated

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firms will show losses when the "transfer prices" used to calculate input costs are the spot market input prices.
The analysis of exchanges in section I was based on the assumption that
the monetary adjustment rate fairly compensates for cost differences:
r = cm - cb• This monetary adjustment rate "clears the exchange market" in the sense that desired input exchange quantities are balanced. In practice, some intercorporate transfers of inputs are arranged by ordinary market sales, and the monetary adjustment rate may be determined by observed transactions prices of inputs. For example, integrated box producers typically sell some medium and linerboard in spot markets, and the practice is to set the monetary adjustment rate for exchanges to be equal to the difference between the average of reported transactions prices of medium and linerboard published in Official Board Markets, i.e.,2l

(24) r = Pm - Pb •

Independent of the institution Tm 9889Tc 13.0 -0.0064 Tc 5.623 0 f Pb

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sales of inputs. The model also includes a fringe of non-integrated producers (or "box shops") who purchase all of their requirements for each input. Thus transactions can occur via exchanges or in spot markets. Firm 1 receives e units of medium by exchange and an amount, denoted x

m' by direct purchase from
firm 2. Firm 2 purchases an amount of input b, denoted xb' fr~n firm 1. Thus firm 1 obtains e + ~ units of input m, so production efficiency implies
that ql = ll(e + x

m)· Simila:-ly, q2 = ~(e + xb)·
The combined output of the non-integrated fringe firms will be denoted by
q3. Regardless of the nature of the fabrication cost function for fringe firms, it is possible to derive some general properties of their purchase decisions for inputs band m. Since the inputs are used in fixed proportions, firms that purchase inputs at prices Pb and Pm will incur a constant cost
of Pb/~ + Pm/ll for the inputs needed to produce one unit of output, so that

(25) a ,

regardless of the state of competition in the sector of the market that generates output q3.
At this point, it is useful to summarize the relationships between the input and output variables:

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(35)

The profit margin for a fringe firm that purchases both inputs is the expression in square brackets on the right side of (35). To sign the left side of

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Similarly, the necessary condition for firm 2's optimal

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were derived in the context of a simple model with two integrated firms and two inputs that are perfect complements. It will be important to determine to what extent our

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on an elaboration of these models that is tailored for the market under consideration. Nevertheless. the general implication of the analysis in this paper is that input exchanges should only be of concern to antitrust authorities to the extent that there is market power in the input markets. For merger cases, our analysis suggests that rather than being simply a "plus factor," exchanges change the effective level of concentration of the market. Our analysis indicates a

Footnotes

* University of Virginia and Federal Trade Commission respectively. We would like to acknowledge helpful comments and criticisms that we received from participants in seminars at both places and from Eric Engen, James Walker and Steve Salop. Peggy Claytor assisted in the preparation of this manuscript.
1. Walter Measday (1982) discusses the prevalence of exchanges in petroleum products markets. Joyce (1983) reports that exchanges are also common in markets for inorganic chemicals, iron ore, gypsum, and aluminum. He suggests that exchanges permit vertically integrated input producers with market power to transfer inputs among themselves at below-market prices.
2. From 1977 to 1980, about three-fourths of domestic inter-corporate transfers of medium by West Coast medium producers were made through bilateral exchange agreements. See In the Matter of Weyerhaeuser Company and Weyerhaeuser West Coast, Inc. (hereafter Weyerhaeuser), Complaint Counsel's Proposed Findings of Fact, Conclusions of law, and Order, before the Federal Trade Commission, June 1983, p. 154.
3. Weyerhauser (1983).
4. In the parlance of merger analysis, plus factors are non-structural factors that are likely to facilitate collusion, ceteris paribus. Frederick Scherer (1980) discusses a number of factors that facilitate collusion, but he does not specifically mention input exchange agreements.
5. Walter Measday (1982), however, argues that the costs of administering the elaborate network of exchanges observed in the petroleum products industry would exceed the costs of doing business in the market.

6. Cournot shows that this result holds in a more general setting with nonlinear demand and unequal input proportions. It

14. Charles Holt and David Scheffman (1985) use (1) to show that if a Cournot equilibrium with positive outputs for each firm exists, then the equilibrium is unique.
15. The 1984 Department of Justice Merger Guidelines specify the way in which pre-merger and post-merger Herfindahl indices are used to determine whether a proposed merger is likely to be challenged.
16. Note that 1/~ units of input b is needed to produce one unit of output. Each sale of 1/~ units of input b yields a profit margin of Pb/~ - cb/~ for firm 1, but the sale will increase q2 and reduce output price by approximately fl(Q) at the margin, which reduces input sales revenue by an amount fl(Q)q1'
17. Recall that fabrication costs have been assumed to be constant, and have been subsumed in f(Q) by letting f(Q) represent price minus average fabrication cost. For a fringe firm with a cost advantage, average revenue minus average fabrication cost would equal f(Q) + cf' where cf is its absolute cost advantage. Such a cost advantage might arise from geographic location.
18. For example, consider a market with linear demand: f(Q) = A - BQ, A > 0, B > O. Also, let ~ = ~ = 1. With these parameters it is straightforward to show that Pm = (5A - 5cb + 6cm)/11 and Pb = (5A - 5cm + 6Cb)/11.

If c
m * cb' the Nash equilibrium input prices will differ, but both markups
will be equal: Pb - cb = Pm - cm = (5/11)(A - cb - cm). Also,

A will

Q* c

1(5/11)(A)Tj 0 Tc172 0 102d [()5691/2BTJ 1.362 0.357 Tdm [()587(c66 cTm (f(Q))Tj 89.67 25m 0 0 1 12Tj 89.67 0 0 15 207.52 2501)

m

independently and produced to meet orders, the outcome, in the absence of fixed costs, would be a competitive output price.
21. This is an independent trade publication that reports prices by product and region on a regular basis.
22. For example, a unit of input b costs cb to produce, it sells for Pb' and the purchaser uses this input in the production of ~ units of output, which reduces price by ~f'{Q) at the margin. Thus the generalized profit margins on the right sides of (33) and (34) are calculated on a per-unit-of-input
basis. The profit margins discussed earlier in footnote 16 differ from the margins in (33) and (34) by factors of ~ and ~ respectively because the margins discussed in footnote 16 were calculated on a per-unit-of-final-product basis.
23. Analysis of (38) and (39) would not change if firms perceive the monetary adjustment rate to be exogenous: or/oPb = or/oPm = O.
24. To complete the analysis of the symmetric case, note that there are five endogenous variables to be determined: q1' q2' q3' Pb' and Pm. We have shown that, in the symmetric equilibrium, the weak inequalities in (29) and (30) hold with equality. The third and fourth equations are (38) and (39). Consideration of the fringe firms that purchase both inputs provides a fifth equation that represents the behavior of these fringe firms. For most commonly used behavioral assumptions, e.g. competitive and Cournot, the fringe can be represented by a functional relationship between the aggregate output of the fringe, q3' and the variables that fringe firms would consider to be fixed parameters: Pb' Pm' q1'

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References

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