Horizontal mergers in the presence of vertical relationships

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1st ATE Symposium
Competition Policy Issues: Theory Meets Practice

Introduction

Firms in an industry procure intermediate products from firms in vertically related upstream industries and / or sell intermediate products to firms in downstream industries.

- Automobile manufacturers purchase steel, tires, and a number of parts produced in other industries;
- General constructors purchase cement, steel, and other construction materials produced by other firms.
- ....

Question: Does **vertical relationships matter** for **horizontal mergers**?

Splitting up the question

- 1. How does the set of profitable mergers change once we introduce vertical relationships?
- 2. How does the set of welfare improving mergers change?

Today's talk is about 2: welfare improvements

Splitting up the question further

- 2a. Consider environments where mergers do not improve welfare under the standard set up. Can welfare improve once vertical relationships are taken into account?
- 2b. Opposite scenario

Today's talk is mostly about 2a: welfare improvements

Vertical relationships: different flavors

- Markets
- Bargaining
- Auctions
- Contracts

Today's talk focuses on the market interface.

Horizontal mergers: what's out there?

- Merger between symmetric firms
  - Focus on profitability of mergers
  - Salant, Switzer, Reynolds, QJE 1983 (Cournot, constant marginal costs);
  - Perry and Porter, AER 1984 (Dominant firms and fringe, convex costs);
  - Davidson and Deneckre, RAND 1985 (Price competition).
- Merger between firms with asymmetric costs
  - Focus on welfare
  - Williamson, AER, 1968
  - Lahiri and Ono, EJ, 1988
- Synergies + focus on external effects of mergers
  - Farell and Shapiro, AER 1990

What's out there (contd.)?

- Typical assumption: perfectly competitive upstream sector
- Input price is not affected by downstream mergers
- No welfare gain or loss in the upstream sector induced by downstream mergers.

So, what do we do?

- Study the effect of horizontal mergers without cost asymmetry or synergies among merging firms
- Identify two mechanisms through which downstream mergers between symmetric firms may improve total welfare.

Mechanism 1

Reallocation towards efficient upstream firms

- Fixed number of upstream firms with differing efficiencies
- Downstream merger *can* reduce input price
- $\rightarrow$ reallocates upstream output towards more efficient upstream firms
- $\rightarrow$ welfare gains from increased production efficiency can outweigh welfare loss from lower output

Mechanism 2

Rationalization of upstream sector

- Free entry of upstream firms
- Downstream merger *can* reduce input price
- $\rightarrow$ fewer upstream firms (rationalization)
- $\rightarrow$ each firm produces more, average cost goes down
- $\rightarrow$ welfare gains from rationalization of the upstream sector could outweigh the welfare loss from lower output.

Input price reduction

- A necessary condition for welfare improvement in both cases: reduction in input price following the merger
- So, when does input price go down?

Need a model...

Setting

Successive oligopoly framework

Downstream Cournot

- M firms producing a homogeneous final product
- Inverse demand $P(Q)$ satisfying:
  - $P'(Q) < 0$ (downward-sloping demand)
  - $2P'(Q) + QP''(Q) < 0$ (downward-sloping marginal revenue)

Upstream Cournot:

- N upstream firms producing homogeneous intermediate product, X units in total.
  - Constant marginal cost: $c_1 \leq c_2 \leq ...... \leq c_N$.
  - Potential free entry.
- One unit of input transforms costlessly to one unit of final output.

Sequence of moves

- Horizontal merger takes place in the downstream sector
- In mechanism I, the number of upstream firm is fixed/
  In mechanism II, entry/exit occurs in the upstream sector.
- Upstream Cournot competition.
- Downstream Cournot competition.

Downstream Cournot competition

- Each downstream firm i chooses q_i to maximize

$$(P(q_i + \sum_{j \neq i} q_j) - r)q_i.$$

- First order conditions (FOC): $P(.) + P'(.)q_i = r$
- Add up the FOCs

$$MP(Q) + QP'(Q) = Mr \qquad (1)$$

- Because of one-to-one technology, input demand $X = Q$.
- Substitute Q by X in (1), rearrange and derive the inverse demand for input:

$$r = P(X) + \frac{XP'(X)}{M} \equiv g(X, M)$$

Upstream Cournot competition

- Each upstream firm u chooses x_u to maximize

$$(g(x_u + \sum_{v \neq u} x_v) - c_u)x_u.$$

- First order condition (FOC): $g(.) + g_X(.)x_i = c_u$
- Add up the FOCs

$$Ng(X, M) + Xg_X(X, M) = \sum_u c_u \tag{2}$$

- Let $X = X^*$ denote the solution to (2). Then X^* is the equilibrium aggregate output.
- $X^* \Rightarrow g(X^*, M) = r^*$.
- $X^* \Rightarrow Q^* \Rightarrow P^*$.

Prices and Elasticities

- Downstream:
$$P(1-\frac{1}{Me_d})=r$$
e_d: elasticity of downstream demand (involves P').
- Upstream:
$$r(1-\frac{1}{Ne_u})=\frac{\sum_u c_u}{N}$$
e_u: elasticity of upstream demand (involves $g_X(.)$ or P'').
- Overall:
$$P(1-\frac{1}{Me_d})(1-\frac{1}{Ne_u})=\frac{\sum_u c_u}{N}$$
- How does a reduction in M affect r and P?
$\rightarrow$ depends on how a reduction in M affects e_u and e_d
$\rightarrow$ Seems complicated as 3rd derivatives come into play

Changes in prices and changes in elasticities

- While price levels depend on demand elasticities, change in price levels depend on change in demand elasticities which leads us to..
- *Elasticity of slope* of the inverse dd for the final product:

$$\epsilon_d = \frac{QP''(Q)}{P'(Q)}$$

- *Elasticity of slope* of the inverse dd for input

$$\epsilon_u = \frac{Xg_{XX}(X,M)}{g_X(X,M)}$$

- Similar notions discussed in the literature:
  $\rightarrow$ pass through (Weyl and Fadinger, JPE 2013)
  $\rightarrow$ relative prudence $= -\frac{xU'''(x)}{U''(x)}$

Getting comfortable with elasticity of slope

Constant elasticity of slope:

Example

- $P = a - Q^b; \epsilon_u = \epsilon_d = b - 1$
- $P = aQ^{-\frac{1}{e}}; \epsilon_u = \epsilon_d = -(1 + \frac{1}{e})$

Beyond constant elasticity of slope:

Example

- $P = a - bQ - dQ^2;\ b > 0.$
  $\rightarrow d = 0,\ \epsilon_u = \epsilon_d = 0$
  $\rightarrow d > 0,\ \epsilon_u > \epsilon_d$
  $\rightarrow d < 0,\ \epsilon_u < \epsilon_d$

Characterizing change in input price

Result

A downstream merger reduces input price if and only if

$$\frac{dr}{dM} > 0 \Leftrightarrow \epsilon_u > \epsilon_d \Leftrightarrow \frac{d\epsilon_d}{dQ} > 0.$$

- Note: reduction in input is more likely if cost functions are strictly convex (e.g., $C_u(x_u) = c_u x_u + dx_u^2$). In particular,

$$\epsilon_u \geq \epsilon_d \rightarrow \frac{dr}{dM} > 0$$

Mechanism I: reallocation among upstream firms

- N upstream firms with different cost levels
- $c_1 < c_2 < ... < c_N$
- Welfare (Total surplus):

$$W = \int_0^{X^*} P(y)dy - \left(\sum_u c_u s_u \right) X^*,$$

where $s_u = x_u / X$ is upstream firm u's market share.

Mechanism I: reallocation..

- Effect of downstream merger:

$$\frac{dW}{dM} = (P - \sum c_u s_u)\frac{dX^*}{dM} - X^* \frac{d(\sum_u c_u s_u)}{dM}$$

- Consider the effect on output

$$\frac{dX^*}{dM} = \underbrace{\frac{\partial X^*}{\partial M}}_{+} + \underbrace{\frac{\partial X^*}{\partial r}}_{(-)} \underbrace{\frac{dr^*}{dM}}_{(+/-)}$$

- Even when input price declines with merger we find that total output decreases; $\frac{dX^*}{dM} > 0$
- Nevertheless, welfare can increase with merger if average upstream cost decreases; $\frac{d(\sum_u c_u s_u)}{dM} > 0$

Mechanism I: reallocation..

- Suppose $c_i < c_j$, i more efficient than j.

$$\frac{s_i}{s_j} = \frac{x_i}{x_j} = \frac{r - c_i}{r - c_j} = 1 + \frac{c_j - c_i}{r - c_i}.$$

- As $r \downarrow$, production reallocated towards more efficient firm i
- Output share (s_u)increases for more efficient firms.
- Average cost declines; i.e., $\sum_u c_u s_u \downarrow$.

Mechanism I: reallocation..

Result

A downstream merger improves total welfare if and only if

$$\left(\frac{N+1+\epsilon_d}{M+1+\epsilon_d}\right) + H(N+1+\epsilon_d) - (NH-1)(\epsilon_u - \epsilon_d) < 0.$$

i Need to have $\epsilon_u - \epsilon_d$ positive and large enough (significant input price reduction).

ii Large Herfindal Index $H = \sum_u s_u^2$ helps (concentrated upstream industry).

Mechanism II: Rationalization of upstream firms

- Symmetric production cost $c_1 = c_2 = ... = c_N$
- Free entry of upstream firms: $(r^* - c)x^* = K$.
- Welfare

$$W = \int_0^{X^*} P(y)dy - cX^* - N^*K = \int_0^{X^*} P(y)dy - r^*X^*.$$

Mechanism II: rationalization..

- Downstream merger:

$$\frac{dW}{dM} = \underbrace{(P^* - r^*)\frac{dX^*}{dM}}_{+} - \underbrace{X^*\frac{dr^*}{dM}}_{+/-}$$

- Again, $dX^*/dM > 0$
- Input price reduction (i.e.,$dr^*/dM > 0$) is necessary for welfare improvement.
- In presence of free entry, $r^*X^* = cX^* + NK$.
  $\rightarrow r^* = c + \frac{K}{x^*}$ (average cost).
  $\rightarrow$ reduction in average cost is necessary for merger to improve total welfare.

Mechanism II: rationalization..

- A simple decomposition:

$$\frac{dW}{dM} = \underbrace{\frac{\partial W}{\partial M}}_{>0} + \underbrace{\frac{\partial W}{\partial N}}_{?} \underbrace{\frac{dN}{dM}}_{>0}.$$

- Necessary condition for welfare improvement $\partial W/\partial N < 0 \;\Leftrightarrow$ (excessive entry in the upstream sector)

Mechanism II: rationalization..

- How can entry be excessive?

  $\rightarrow$ Both the social planner and the marginal entrant take entry cost K into account.
  $\rightarrow$ Marginal benefit might be less for the social planner as part of the existing firms' business is stolen by the marginal entrant.

- Entry always excessive in a single-stage oligopoly

  Mankiw and Whinston, Rand 1986
  Suzumura and Kiyono, ReSTUD 1987

- Not necessarily in vertical oligopoly

  Ghosh and Morita, Rand 2007

Mechanism II: rationalization..

Result

A downstream merger improves welfare if and only if:

$$\frac{(N+\epsilon_u)(\epsilon_u-\epsilon_d)-(N+1+\epsilon_d)}{(N+1+\epsilon_u)(2N+\epsilon_u)} > \frac{1}{M+2+\epsilon_d}$$

where N is evaluated at the free-entry equilibrium level.

- Again, input price has to fall following the merger ($\epsilon_u > \epsilon_d$).
- A more competitive downstream sector helps.

Extension I: Upstream mergers

Mergers take place in the upstream sector:

- Symmetric upstream, asymmetric downstream firms.
- One unit of final output needs one unit of the intermediate good and a_i units of labor (wage is normalized to 1).
- Rank firms so that $a_i \leq a_j$
- $$\frac{q_i}{q_j} = \frac{P - r - a_i}{P - r - a_j} = 1 + \frac{a_j - a_i}{P - r - a_j}$$
- Efficiency enhancing reallocation arise if and only if

$$\frac{d(P - r)}{dN} > 0 \;\Leftrightarrow\; 1 + \epsilon_d > 0 \;\Leftrightarrow\; \text{logconcave dd.}$$

Extension II: Matching and Bargaining

- M upstream firms and N downstream firms form bilateral matches according to matching function

$$S(M, N) = \min\{M, N\}$$

- Free-entry in the upstream sector
  $\rightarrow$ assume entry cost is low enough so that $S(M, N) = M$.
- Input prices are determined by post-matching bargaining.
- Each pair bargain over input price and competes with other pairs in quantities
- Downstream mergers improve total welfare if and only if

$$(1 - \beta)(M + 3 + 2\epsilon_d) > 1,$$

  where β denotes downstream firms' bargaining power.
- Low $\beta \Rightarrow$ High upstream bargaining power $\Rightarrow$ excessive entry $\Rightarrow$ merger improves welfare.

Extension III: Possibility of consumer surplus improvement in the original set up

- Allowing for strictly convex costs expands the range of parameterizations for which input price goes down
- However, still CS improvement not possible for logconcave demand functions $1 + \epsilon_d > 0$
- A weaker assumption like $1 + \epsilon_d > -M$ can deliver CS-improving downstream merger.

Example

- $P = a + Q^{-b}$ with $b > 1$ and $C(x) = cx^2/2$.
- $\epsilon_d = \epsilon_u = -(b + 1)$.
- $dX/dM < 0$ if $M - 2 - (McX^{*b+1})/b < 0$.

Conclusion

Horizontal merger in a vertically related market

- Two mechanisms for welfare to improve
- Common necessary condition: input price reduction.
- Characterize necessary and sufficient condition for
  $\rightarrow$ input price reduction
  $\rightarrow$ welfare improvement

The paper ends... but still early days for the project

Ongoing work

- CS-improving mergers (Nocke and Whinston JPE 2011, AER 2013)
  - → Suppose firms 1 and 2 with cost c_1 and c_2 merge.
  - → Synergies reduces unit cost to $c < \min\{c_1, c_2\}$.
  - → Find c^* such that CS increases if and only if $c < c^*$
  - → How does c^* change in presence of vertical relationships?
- Is the set of CS-improving mergers larger or smaller under vertical relationships?

Ongoing work

Merger waves across industries

- Does merger in one sector trigger mergers in the other sector?
- An exercise in complementarity