Horizontal mergers in the presence of vertical relationships

Arghya Ghosh, UNSW
Hodaka Morita, UNSW
Chengsi Wang, Mannheim

2nd ATE Symposium, 2014

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.
- Does vertical relationship/upstream market structure affect (matter for) the welfare consequence of downstream (upstream) horizontal mergers?

Introduction

- Literature typically assumes a 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.
- This paper explicitly considers vertical relationships when evaluating the welfare consequence of a horizontal merger.

Main results

- Study horizontal mergers among symmetric downstream firms.
- Identify two channels through which downstream mergers may improve total welfare.
  - Upstream cost asymmetry.
    - reallocation: downstream merger $\Rightarrow$ reduce input price $\Rightarrow$ shift production towards more efficient firms $\Rightarrow$ improve production efficiency.
  - Upstream free entry.
    - rationalization: downstream merger $\Rightarrow$ reduce input price $\Rightarrow$ firm exit but each remaining firm produces more $\Rightarrow$ improve production efficiency.

Literature: a selective overview

- Williamson (1968): fundamental tradeoff between market power and efficiency gains.
- Comprehensive welfare analysis: Farrell-Shapiro (1990)
  - Mergers reduce total welfare in a Cournot model if
    - equally efficient firm/no reshuffling;
    - constant unit cost;
    - no synergies among merging firms.
  - Same configuration, but we also consider an upstream sector (cost asymmetry/free entry).
- Recent advance: Nocke-Whinston (2010, 2013)
  - other important aspects in merger problems: dynamic interaction between isolated mergers, unobservable merger choices, optimal policies.
- Horizontal mergers in vertical related markets: bilateral trade, specific demand functions, small number of firms.

Setting

- Framework: Successive oligopoly (Salinger, 1988).
- Downstream Cournot:
  - M firms producing homogeneous final products, Q units in total.
  - Inverse demand $P(Q)$ satisfying:
    - $P'(Q) < 0$ (downward-sloping demand)
    - $(M+1)P'(Q) + QP''(Q) < 0$ for all $M \geq 1$ (existence and uniqueness)
- Upstream Cournot:
  - N firms producing homogeneous intermediate products, X.
    - Constant marginal cost: $c_1 \leq c_2 \leq ...... \leq c_N$.
    - potential free entry.
  - One unit input transforms to one unit final output.

Sequence of moves

- A horizontal merger takes place in the downstream sector, $dM < 0$.
- In mechanism I, the number of upstream firm is fixed/
  In mechanism II, entry takes place in the upstream sector.
- Upstream Cournot competition.
- Downstream Cournot competition.

Downstream competition

- Each downstream firm $i = 1, 2, ..., M$ takes input price as given and chooses q_i to maximize

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

- The equilibrium individual output is

$$q_i(r) = -\frac{(P(Q(r)) - r)}{P'(Q(r))}$$

where $Q(r)$ solves $MP(Q) + QP'(Q) = Mr$.

- Total demand for input: $X = Q(r)$.
- Inverse demand for input: $r = g(X) \equiv P(X) + XP'(X)/M$.

Upstream Cournot competition

- Each upstream firm $u = 1, 2, ..., N$ chooses x_u to maximize
$$(g(x_u + \sum_{v \neq u} x_v) - c_u)x_u.$$

- Solving the maximization problem gives
$$x_u^* = -\frac{g(X^*) - c_u}{g'(X^*)},$$
where X^* solves $Ng(X) + Xg'(X) - \sum_u c_u = 0$. (additional regularity conditions guarantees the existence and uniqueness of upstream equilibrium.)

- Summary:
    - $x_u^* \Rightarrow X^* \Rightarrow g(X^*) = r^*$.
    - $r^* \Rightarrow Q(r^*) \Rightarrow P(Q(r^*)) \Rightarrow q_d^*$.

Characterize input-price change

- A merger takes place in the downstream sector: $dM < 0$ (ignoring integer constraint).
- Denote
$$\epsilon_d = \frac{QP''(Q)}{P'(Q)}$$
the elasticity of slope of the inverse demand function for final products, and
$$\epsilon_u = \frac{Xg''(X)}{g'(X)}$$
the elasticity of slope of the inverse demand function for inputs.

Characterize input-price change

Result

A downstream merger reduces input prices iff

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

- Following a merger, the change of input price is purely driven by the variation of elasticity of $P'(Q)$.

Example

$P = (1 - Q)^b$

- $b = 1$, $\epsilon_u = \epsilon_d = 0$.
- $b > 1$, $\epsilon_u > \epsilon_d$.
- $b < 1$, $\epsilon_u < \epsilon_d$.

Mechanism I: upstream reallocation

- No free-entry, but asymmetric upstream firms.
- Consumer surplus

$$CS = \int_0^{X^*} P(y)dy - P(X^*)X^*.$$

- Downstream merger always reduces consumer surplus. Following a merger, $M \downarrow \Rightarrow X^* \downarrow$

$$\frac{dX}{dM} = \frac{X^*(N+1+\epsilon_d)}{M(M+1+\epsilon_d)(N+1+\epsilon_u)} > 0.$$

Mechanism I: reallocation effect

- What about welfare?

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

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

Upstream reallocation

- Impact of downstream merger:

$$\frac{dW}{dM} = \underbrace{(P - \sum c_u s_u)\frac{dX^*}{dM}}_{+} - \underbrace{X^* \frac{d(\sum c_u s_u)}{dM}}_{+?}.$$

- Even if $dX^*/dM > 0$, $dW/dM < 0$ can hold, i.e. efficiency improves, if $d(\sum c_u s_u)/dM > 0$.
- Reduction in average industry cost, $\sum c_u s_u$.
  - shift production towards more efficient firms.

Input price

- Q: when does downstream merger reduces upstream average cost?
- A: input price must go down.
- Intuition:
  - $\sum c_u s_u \downarrow \Leftrightarrow s_u \uparrow$ for more efficient firms.
  - Suppose $c_i < c_j$, i more efficient than j.
  - As $r \downarrow$, production is reallocated towards more efficient firms.

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

- But we know that $r \downarrow \Leftrightarrow \epsilon_u > \epsilon_d$.

A tighter condition

- Another decomposition:

$$\frac{dW}{dM} = \sum (P^* - c_k) \frac{dx_k^*}{dM}.$$

- $dW/dM < 0$ requires $dx_k/dM < 0$ at least for small $k = 1$ (most efficient firm).
- $dx_1/dM < 0$ requires

$$\epsilon_u > \epsilon_d + 1.$$

Necessary and sufficient condition

Result

A downstream merger improves total welfare iff:

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

i $\epsilon_u - \epsilon_d$ large enough (significant input price reduction).

ii Large Herfindal Index $H = \sum_u s_u^2$ helps (concentrated upstream industry): a mean-preserving spread of unit cost $\Rightarrow$ increase H without changing X^* $\Rightarrow$ more likely for mergers to be welfare-improving.

Numerical example

- $P(Q) = (1 - Q)^b$ with $b > 0$ (Malueg, 1992).
- $N = 6$, $b = 0.05$, $c_1 = 0.1$, and $c_k = 0.8$ for $k \neq 1$.

M	ϵ_d	ϵ_u	x_1^*	x_k^*	X^*	r^*	H^*	W^*
4	6.380	10.71	0.734	0.0273	0.870	0.827	0.716	0.658
3	5.481	9.394	0.742	0.022	0.852	0.821	0.762	0.662
2	4.357	7.666	0.755	0.013	0.821	0.812	0.848	0.668

Mechanism II: rationalization

- Symmetric firms but free-entry in the upstream.

$$(r^* - c)x^* = K.$$

- Again, downstream merger reduces consumer surplus:

$$\frac{dX^*}{dM} = \frac{X^*(2N^* + 1 + \epsilon_d)}{M(2N^* + \epsilon_u)(M + 1 + \epsilon_d)} > 0.$$

Welfare-improving merger

- What about total surplus?

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

- Downstream merger:

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

- Since $dX^*/dM > 0$, $dr^*/dM > 0$ is necessary for welfare improvement.
  - In presence of free entry, $(r^* - c)X^* = NK$.
  - Reduction in industry average cost: $r^* = c + K/x^*$.
    - drive out some upstream firms, and each remaining firm produces more.

Input price

- With free-entry, input price reduction is harder following a downstream merger.

Result

Following a downstream merger, r^* decreases (increases) iff

$$\epsilon_u - \epsilon_d > 1.$$

- Additional effect when free-entry is present:
  - downstream merger $\Rightarrow$ lower upstream entry $\Rightarrow$ upward pressure on input price.

Welfare improvement

Result

A downstream merger improves welfare if and only iff:

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

Another explanation

- Another decomposition:

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

- $\partial W / \partial N < 0 \;\Leftrightarrow$ excessive entry in the upstream is necessary for welfare improvement.
- When is entry excessive?
  - Mankiw-Whinston (1986): business stealing effect.

Excessive entry

- Further decomposition:

$$\frac{dW}{dM} = \underbrace{(P-c)\frac{\partial X}{\partial M}}_{\text{market power}(+)} + [\underbrace{(P-r)M\frac{\partial q}{\partial N}}_{\text{business creating}(+)} + \underbrace{(r-c)N\frac{\partial x}{\partial N}}_{\text{business stealing(-)}}]\frac{dN}{dM}$$

- Following a downstream merger:
  - market concentration: fewer downstream firms $\Rightarrow$ final output$\downarrow$.
  - business-creating effect: upstream exit $\Rightarrow$ final output$\downarrow$.
  - business-stealing effect: upstream exit $\Rightarrow$ each entrant's output$\uparrow$.

Graphic explanation

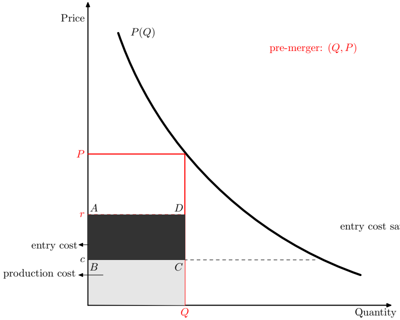

Figure : pre-merger

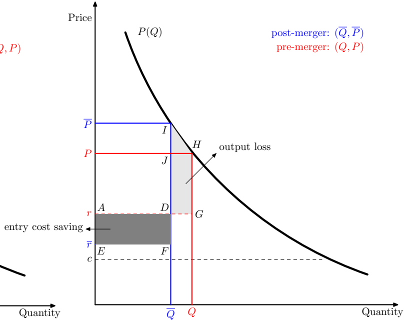

Figure : post-merger

Numerical example

- $P(Q) = (1 - Q)^b$.
- $M = 5$, $c = 0.01$, $k = 0.3$, and $b = 0.1$.

M	$\hat{Q}$	ϵ_u	ϵ_d	$\hat{r}$	$\hat{N}$	$\hat{W}$
5	0.874	13.22	6.260	0.700	2.010	0.205
4	0.861	11.76	5.569	0.6942	1.963	0.208
3	0.841	10.02	4.748	0.686	1.894	0.212
2	0.805	7.863	3.724	0.673	1.781	0.217

Upstream horizontal merger

- Everything else remains the same except
  - additional production cost for downstream firms: a_k.
  - cost asymmetry ($a_j \leq a_k$ if $j < k$) or free entry in downstream sector.

- Look for welfare-improving upstream merger.

Upstream horizontal merger

- Instead of the change of r^*, what's important now is the change of $P^* - r^*$ following a upstream merger.

Result

$$\frac{d(P^* - r^*)}{dN} > 0 \quad \Leftrightarrow \quad \epsilon_d > -1.$$

  - $N \downarrow \Rightarrow r^* \uparrow$ and $P^* \uparrow$.
  - $\epsilon_d > -1$ (inverse demand strictly log-concave) $\Rightarrow P^*$ does not increase as much as r^*.

Reallocation in downstream sector

- Suppose $a_j > a_i$. Then $P^* - r^* \downarrow \Rightarrow s_i^*/s_j^* \uparrow \Rightarrow$ improvement in production efficiency.

Result

With downstream asymmetry, upstream merger increases welfare iff

$$\epsilon_d(H_d - \frac{1}{M}) > \frac{M+N+1+\epsilon_d}{MN}.$$

- A MPS of a_s: $H_d \uparrow$ while X^* unchanged $\Rightarrow$ welfare improvement more likely.

Rationalization in downstream sector

- With downstream free-entry, $p^* - r^* \downarrow$ following an upstream merger iff $\epsilon_d > 0$.
- Free-entry makes reduction of $P^* - r^*$ harder: upstream merger $\Rightarrow$ downstream exit $\Rightarrow$ additional upward pressure on $P^* - r^*$.

Result

With downstream free-entry, upstream merger increases welfare iff

$$\epsilon_d > \frac{2(M^* + 1)}{N - 2}.$$

Conclusion

- Horizontal merger in a vertically related market:
  - characterization of the change of input price.
  - two mechanisms for welfare improvement.
  - common necessary condition: input price reduction.
- Future work:
  - bring back synergies/threshold of CS-improving synergies.
  - merger waves across vertically related industries.