Mergers and the Dynamics of Innovation

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Usual disclaimer applies: view expressed are those of the author only.
Why bother?

- Both antitrust authorities and academics devote much attention on
the impact of mergers on prices

- In the same time, many mergers take place in fast-growing innovative
industries where “quality” and hence innovation are key drivers of
consumer welfare

- There is a “consultant fallacy” that says that in these markets dynamic
competition for the market matters more than static price
competition

- This is a completely absurd overstatement:
  - the concern of unilateral effects remains if prices go up in any
technological state

- Nevertheless, mergers should change the incentives to innovate and
this could also have a first order effect on consumer welfare.
This paper

- We setup a simple but flexible demand model and allow for investment in quality
- Then we characterize the dynamic equilibrium under Markov strategies
- This can be used to numerically compute the equilibrium and the distribution of states
- Then, we discuss the welfare effect of mergers
- This model can be calibrated on a case by case basis
- However, it can also allow to draw general conclusions
We model $N$ firms competing in a product market.

These firms might be asymmetric in technological level.

They may market several products of, potentially, different technological levels.

The total number of products is $N_{prod}$.

The maximum gaps of technological levels is limited to $K$. 

Model of demand

- The utility of customer $i$ buying product $j$ is:

$$U_{ij} = \tilde{k}_i L - \sigma p_i + \xi_i + \epsilon_{ij}, \quad (1.1)$$

- $L$ is the taste for quality
- $\tilde{k}_i$ and $p_i$ are the technological levels and prices of product $i$
- $\sigma$ a scaling parameter of the disutility to pay
- $\xi_i$ a fixed parameter that captures the mean utility value of the fixed characteristics of product $i$ apart from the technological level and prices.
- $\epsilon_{ij}$ is the idiosyncratic component of the utility of customer $j$ when he buys product $i$. ($\epsilon_{ij}$) are independently and uniformly distributed following a Gompertz distribution.
Model of demand

- There exist a competitive fringe, \( o \).
- It markets at null price a good at most \( K \) levels behind the most advanced of all the products \( i \in [1, N_{prod}] \) and at least one level behind the least advanced.
- This competitive fringe plays the role of the outside good.
- Demands addressed to the various firms do not depend on the absolute technological level, but only on the relative one.
- We note its technological level \( k_o \) and define \( k_i = \tilde{k}_i - k_o \).
- We normalize market to 1, and this generates nice logit demands (the market share of good \( i \) is the probability that customers choose product \( i \)):

\[
  s_i = \frac{e^{k_i L - \sigma p_i + \xi_i}}{1 + \sum_{m \in [1, N_{prod}]} e^{k_m L - \sigma p_m + \xi_m}}
\]  

(1.2)
Dynamic game

- Firms can make risky investment in innovation in discrete time.
- Firm $f$ can invest in period $t$ to increase the technological level of all of its products.
  - In case of success, the technological level of all of its products increases of 1.
- The cost of R&D is assumed quadratic of the quality of success:
  - $f$ has to invest $\frac{\gamma n_f^2}{2}$ to succeed with probability $n_f$.
- For $N$ firms and $K$, we note $\Sigma$ the set of states and $\Omega$ the set of all the possible output of innovation from one period to another.
- For two firms and a maximum gap of one technological levels, we have:

\[
\Sigma = \begin{bmatrix} 1 & 1 \\ 2 & 1 \\ 1 & 2 \end{bmatrix}, \quad \Omega = \begin{bmatrix} 0 & 0 \\ 1 & 0 \\ 0 & 1 \\ 1 & 1 \end{bmatrix}
\]
We limit ourselves to pure Markov equilibria, where all the players play pure Markov strategies.

Thus, we can write the value function of firm $f$ in state $s$ in period $t$ as:

$$V_{f,s}^t = \max_{n_{f,s}^t} \left\{ \pi_{f,s} - \frac{\gamma n_{f,s}^2}{2} \right\}$$

$$+ \delta \left( \sum_{\omega \in \Omega} P(\omega|s, N_s^t) V_{f,t+1}^t(s,\omega) \right)$$

where:

$$P(\omega|s, N_s^t) = \prod_{f' \in F} \left\{ n_{f,s}^t \omega_{f'} (1 - n_{f,s}^t)(1 - \omega_{f'}) \right\}$$

is the probability of outcome $\omega$ in state $s$, with the profile of actions $N_s^t = \left( n_{f,s}^t \right)_f$ and $T(s,\omega)$ is the state resulting from the outcome $\omega$ in state $s$. 
One can easily characterize the equilibria of this dynamic game. However, even in the simpler case where there exist two firms and two technological levels, it is not possible to find a closed form to this equilibrium.

However, one can see this as the search of a fixed point and it is possible to find the numerical solutions by an iterative process.

Even though this process is generally not a contraction mapping, it converges fairly quickly and the simulations never showed that the solution depended on the initial point.

This finding is in line with the literature (see for instance Doraszelski and Pakes, 2007).
It is then relevant to focus on the ergodicity of the process of states. If the process is ergodic, one can indeed focus on this (unique) stationary distribution on states and on the aggregate average innovation.

- That is what Aghion et al. (2001) and Aghion et al. (2006) do, but they somehow assume ergodicity.
- With maximim $K$ technological gaps, there is always a positive probability to be in the unlevelled state after $K$ periods.
- This means that starting from any point, two chains will meet with positive probability after at least $K$ periods.
- This ensures that the system is ergodic and that the distribution converges to the stationary one (for instance Stachurski, 2009 pp. 90).

Then, this distribution can be found by solving:

$$(I - M + B)'p^* = b$$

where $I$ is the identity, $B$ a matrix of ones and $b$ a vector of ones.
### Results

The influence of market structure

**Composition matters**

<table>
<thead>
<tr>
<th></th>
<th>2 firms</th>
<th></th>
<th>3 firms</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>leveled</td>
<td>1,1</td>
<td>0.07</td>
<td>0.74</td>
<td>0.60</td>
</tr>
<tr>
<td></td>
<td>1,1,1</td>
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<td>0.71</td>
<td>0.55</td>
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<tr>
<td></td>
<td>1,0</td>
<td>0.93</td>
<td>0.05</td>
<td>0.02</td>
</tr>
<tr>
<td></td>
<td>1,1,0</td>
<td>0.49</td>
<td>0.30</td>
<td>0.24</td>
</tr>
<tr>
<td></td>
<td>1,0,0</td>
<td>0.46</td>
<td>0.36</td>
<td>0.04</td>
</tr>
</tbody>
</table>

Note: All firms are symmetric, with $\xi = 0$ and one product each. The other parameters are: $\delta = 0.9$, $\gamma = 5$, $L = 1$, $\sigma = 1$. 
## Results

The influence of market structure

### Comparison of the innovation with 2 and 3 firms (3 technological levels)

<table>
<thead>
<tr>
<th></th>
<th>2 firms</th>
<th>3 firms</th>
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</thead>
<tbody>
<tr>
<td>1,1</td>
<td>0.00</td>
<td>0.77</td>
</tr>
<tr>
<td>2,1</td>
<td>0.00</td>
<td>0.91</td>
</tr>
<tr>
<td>2,2</td>
<td>0.01</td>
<td>0.87</td>
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<tr>
<td>3,1</td>
<td>0.90</td>
<td>0.09</td>
</tr>
<tr>
<td>3,2</td>
<td>0.09</td>
<td>0.68</td>
</tr>
</tbody>
</table>

Note: All firms are symmetric, with $\xi = 0$ and one product each. The other parameters are: $\delta = 0.9$, $\gamma = 5$, $L = 1$, $\sigma = 1$. 
Because logit demand emerges from a random utility model, we can compute the expected utility:

\[ \mathbb{E}_t \{ U_t \} = \ln \left( \sum_{m \in \{1, \ldots, N_{\text{prod}}\}} e^{\tilde{k}_t^m L - \sigma p_t^m + \xi_m} \right) \] (2.1)

\[ = \ln \left( \sum_{m \in \{1, \ldots, N_{\text{prod}}\}} e^{k_t^m L - \sigma p_t^m + \xi_m} \right) + \tilde{k}_0^t \] (2.2)

Because \( \tilde{k}_0^t \) tends to increase over time, utility is not stationary and we cannot compute such a thing as \( \mathbb{E}\{ U \} \).
Nevertheless, there are two things we can compute

1. The expected utility, abstracting from the fringe:

\[
EU = \mathbb{E} \left\{ \ln \left( \sum_{m \in [1,N_{prod}]} e^{k_m t} L - \sigma p_m^t + \xi_m \right) \right\} \tag{2.3}
\]

2. The expected increase of utility from one period from another:

\[
\partial EU = \mathbb{E} \{ U_{t+1} - U_t \} = \mathbb{E} \{ \mathbb{E}_t \{ U_{t+1} \} - U_t \} \tag{2.4}
\]
Mergers are better modelled as a change of ownership of products.

When two firms merge, they take joint decisions of the pricing of their products:
- The other characteristics of products remain constant.
- In particular no product disappears.
- This is important because:
  1. this is the basis for keeping more or less the pre-merger market shares.
  2. comparing pre and post-merger utilities only makes sense if we keep the same number of products.

They can put the R&D together, which benefits all products of the joined entity.
- Then we talk here of a full merger.

Alternatively, each party can keep its own R&D and simply take joint decisions.
- Then we talk here of a conglomerate merger.
Moreover, as what matters is persistence in rivalry, we expect symmetry to matter.

More precisely, we expect mergers that increase or decrease symmetry to have different effects.

Then, we will look at two types of mergers:

1. Starting from a symmetric situation ($\xi = 0$) and creating a larger player:
   - The size of this player increases, but he faces less rivalry.

2. A leader ($\xi > 0$) with double market shares to the other players faces a merger of two of its followers:
   - The size of this player increases, but he creates more rivalry to the leader.

Here, we focus on one maximum technological gap and simulate mergers with a large range of parameters.
Price effect of mergers

![Graph showing the price effect of mergers with different types of mergers and their impact on relative average price increase and initial number of firms.]

- Full-mergers to asymetry
- Conglomerate mergers to asymetry
- Full-mergers to symetry
- Conglomerate mergers to symetry

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Mergers and Innovation

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Static utility effect of mergers

![Graph showing the static utility effect of mergers](image)

- **Full-mergers to asymmetry**
- **Conglomerate mergers to asymmetry**
- **Full-mergers to symmetry**
- **Conglomerate mergers to symmetry**

<table>
<thead>
<tr>
<th>Initial number of firms</th>
<th>Relative average price increase</th>
</tr>
</thead>
<tbody>
<tr>
<td>3</td>
<td>-0.3</td>
</tr>
<tr>
<td>4</td>
<td>-0.25</td>
</tr>
<tr>
<td>5</td>
<td>-0.2</td>
</tr>
<tr>
<td>6</td>
<td>-0.15</td>
</tr>
</tbody>
</table>
Dynamic utility effect of mergers

Graph showing the relative dynamic utility effect for different types of mergers as the initial number of firms changes. The graph compares full mergers to asymmetry, conglomerate mergers to asymmetry, full mergers to symmetry, and conglomerate mergers to symmetry.

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Dynamic vs. Static utility effect of mergers

- Full-mergers to asymmetry
- Conglomerate mergers to asymmetry
- Full-mergers to symmetry
- Conglomerate mergers to symmetry