Network effects, switching costs and competition policy

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with credit to
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“In traditional industries with network effects, high switching costs are often an important compounding factor. Consider the case of operating systems, where switching costs can be relatively high for individual users and for firms with large computer installations. Switching between internet platforms or using multiple platforms can be considerably easier. That is, one can shop on Amazon and eBay, be a Facebook user and try Twitter. At least in some cases, the combination of low switching costs and low costs to creating new platforms might mitigate traditional concerns about lock-in and dynamic inefficiency.”

But what do we know about the relationship between switching costs and network effects?
To grasp what HP has in mind, one has to understand the two main currents in the IT industry. First, nearly any new technology quickly becomes a commodity that is easily copied and hence not very profitable.
“To grasp what HP has in mind, one has to understand the two main currents in the IT industry. First, nearly any new technology quickly becomes a commodity that is easily copied and hence not very profitable. . . . Second, the biggest IT firms typically control what is known as a “platform”: a digital foundation on which others build their products, such as Microsoft’s Windows.”
The simplest possible models

- Main assumptions:
  - One incumbent;
  - Free entry;
  - No discrimination.
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Switching cost

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\text{price} = \sigma,
\]
\[
\text{profit} = \alpha \sigma.
\]

Efficient.
The simplest possible models

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  - No discrimination.

- **Switching cost**
  
  \[
  \text{price} = \sigma, \\
  \text{profit} = \alpha\sigma.
  \]

  Efficient.

- **Network effects**
  
  \[
  \text{price} = \alpha\nu, \\
  \text{profit} = \alpha^2\nu.
  \]

  Efficient.
Efficiency issues revisited

Assume that the entrants offer (stand-alone) utility $W + \varepsilon$. 

With switching costs: consumers pay $\sigma - \varepsilon$. ⇒ Efficiency is preserved.

With network effects: consumers pay $\alpha n - \varepsilon$. ⇒ Inefficient equilibrium.

Note that we can have inefficiency without discrimination.
Efficiency issues revisited

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- With network effects: consumers pay \( \alpha \nu - \varepsilon \).
  \[ \implies \text{Inefficient equilibrium.} \]

⇒ Note that we can have inefficiency without discrimination.
“network effects lead to substantial collective switching costs and lock-in”, which are “even worse than individual switching costs due to coordination costs”.
Four themes

How do switching cost models and network models differ?
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How do we model inertia and incumbency advantage in networks?
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2. How do we model inertia and incumbency advantage in networks?
3. What are the consequences of heterogeneity of consumers in dynamic models of both types?
4. How do switching cost and network effects mix?
Four themes

How do switching cost models and network models differ?

How do we model inertia and incumbency advantage in networks?

What are the consequences of heterogeneity of consumers in dynamic models of both types?

How do switching cost and network effects mix?

No two sidedness!
Elementary repeated games with homogeneous consumers

- no commitment
- no discrimination
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$$\Pi = (-\delta \sigma + \sigma) + \delta \sigma = \sigma.$$  

$$\Pi = (-\delta \alpha \nu + \alpha \nu) + \delta \alpha \nu = \alpha \nu.$$  

You do not become rich on switching costs (or network effects) alone.
Some consumers with switching costs/network effects equal to zero (or with no value for network effect).

\[
\text{price} = \sigma; \\
\text{profit} = \alpha_H \sigma.
\]
Heterogeneity of consumers: static model

Some consumers with switching costs/network effects equal to zero (or with no value for network effect).

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\text{price} = \sigma;
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\text{price} = \alpha_H \nu
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Remark: With heterogeneous consumers a no discrimination rule can be costly in terms of social welfare.
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Remark: With heterogeneous consumers a no discrimination rule can be costly in terms of social welfare.
Dynamics with heterogeneous consumers
With an $\infty$ horizon, the profit is not equal to the one period profit.

\[ \Pi = \alpha_H (-\delta \Pi + \sigma) + \delta \Pi \]

\[ \implies \Pi = \frac{\alpha_H \sigma}{1 + \alpha \delta - \delta}. \]
With an $\infty$ horizon, the profit is not equal to the one period profit.

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\Pi = \alpha_H(-\delta \Pi + \sigma) + \delta \Pi
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\[
\Pi = \alpha_H(-\delta \Pi + \alpha_H \nu) + \delta \Pi
\]

\[
\Rightarrow \Pi = \frac{\alpha^2_H \nu}{1 + \alpha_H \delta - \delta}.
\]
With an $\infty$ horizon, the profit is not equal to the one period profit.

\[ \Pi = \alpha_H (-\delta \Pi + \sigma) + \delta \Pi \]
\[ \implies \Pi = \frac{\alpha_H \sigma}{1 + \alpha \delta - \delta}. \]

\[ \Pi = \alpha_H (-\delta \Pi + \alpha_H \nu) + \delta \Pi \]
\[ \implies \Pi = \frac{\alpha_H^2 \nu}{1 + \alpha_H \delta - \delta}. \]

Profit is greater than one period profit . . .
With an $\infty$ horizon, the profit is not equal to the one period profit.

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$$\implies \Pi = \frac{\alpha_H\sigma}{1 + \alpha_H\delta - \delta}.$$

$$\Pi = \alpha_H(-\delta\Pi + \alpha_H\nu) + \delta\Pi$$

$$\implies \Pi = \frac{\alpha_H^2\nu}{1 + \alpha_H\nu}.$$
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Adding zero switching cost/network effects customers increase the profit of the incumbent.
With an $\infty$ horizon, the profit is not equal to the one period profit.

$$\Pi = \alpha_H (-\delta \Pi + \sigma) + \delta \Pi$$

$$\implies \Pi = \frac{\alpha_H \sigma}{1 + \alpha \delta - \delta}.$$  

$$\Pi = \alpha_H (-\delta \Pi + \alpha_H \nu) + \delta \Pi$$

$$\implies \Pi = \frac{\alpha_H^2 \nu}{1 + \alpha_H \delta - \delta}.$$ 

When $\delta \to 1$, $\Pi \to$ 1 period profit.
$\sigma_L > 0$

is different from

$\nu_L > 0$. 
Two periods: $\sigma_L > 0$ and $\alpha \sigma_H > \sigma_L$

In 1st period,
1. incumbent charges $(1 - \alpha \delta)\sigma_H$ (this requires some work);
2. entrants charge $-\delta \sigma_L$
   and attract all the “low switching costs” consumers.
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$< (\delta \sigma_L + \sigma_H) + \delta \sigma_H = (1 + \delta)\sigma_H - \delta \sigma_L,$
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\]
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< (1 - \alpha \delta)\sigma_H + \delta \sigma_H = (1 + \delta - \alpha \delta)\sigma_H
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< (-\delta \sigma_L + \sigma_H) + \delta \sigma_H = (1 + \delta)\sigma_H - \delta \sigma_L,
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Requires lots of rationality from consumers, who need to be able to predict path of prices.
Two periods: $\sigma_L > 0$ and $\alpha \sigma_H > \sigma_L$

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Because

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a proportion strictly between 0 and 1 of $\sigma_H$ consumers will purchase from an entrant.
Two periods: $\sigma_L > 0$ and $\alpha \sigma_H > \sigma_L$

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   and attract all the “low switching costs” consumers.

Because

\[ (-\delta \sigma_L) + \sigma_H < (1 - \alpha \delta) \sigma_H + \delta \sigma_H = (1 + \delta - \alpha \delta) \sigma_H \]
\[ < (1 - \delta \sigma_L + \sigma_H) + \delta \sigma_H = (1 + \delta) \sigma_H - \delta \sigma_L, \]

a proportion strictly between 0 and 1 of $\sigma_H$ consumers will purchase from an entrant.
Network effects
Two networks; a mass $\alpha$ of consumers. Utility of consumers is equal to

$$\nu \times \text{mass of consumers in same network.}$$

Cost of providing service is zero.
Puzzles

Two networks; a mass $\alpha$ of consumers. Utility of consumers is equal to

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Forget about incumbency: the market has just opened. Network 1 charges 0; network 2 charges $\alpha \nu / 2$. Which network do the consumers choose?
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What prices will the network charge at equilibrium?
Modeling coordination failures in network effects
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- Crémer, Rey, Tirole: a mass of “trapped” consumers.
- Caillaud, Jullien: coordination on worse equilibrium for the entrant.
- Weyl: Insulated Tariffs
- Cabral: differentiated consumers compete for new consumer
- Ambrus and Argenziano: Coalitional Rationalizability
- Trying to say things about the whole set of equilibria.

- Our solution: strong non-coordination.
The model

- $\alpha_H$ consumers of type $H$ and $\alpha_L$ consumers of type $L$.
- Within group network effects are either $V_H$ or $V_L$, with $\alpha_H V_H > \alpha_L V_L$.

Utility of consumer of type $H$ who belongs to network $n$ is

$$V_H \times (\gamma_{nH} + \lambda_H \gamma_{nL})$$

where $\gamma_{nH}$ is mass of consumers of type $H$ belonging to network $n$ and $0 \leq \lambda_H < 1$.

Utility of consumer who belongs to no network: $-\infty$. 
Nomadic consumers equilibria

\[ V_H(\gamma_{nH} + \lambda_H \gamma_{nL}) - p_n \overset{\text{def}}{=} u_H \]  
\[ V_H(\lambda_H \gamma_{nL}) - p_i \leq u_H \]

if \( \gamma_{nH} > 0 \),

if \( \gamma_{nH} = 0 \),

Same thing for \( L \) consumers.

This is the standard definition of equilibrium for networks.
Sedentary consumers equilibria

An allocation of consumers among networks is a “sedentary consumers” (sc) equilibrium if it is a nomadic consumers equilibrium.
Sedentary consumers equilibria

An allocation of consumers among networks is a “sedentary consumers” (SC) equilibrium if it is a nomadic consumers equilibrium and we can find a sequence of moves of “small” masses of consumers which converge to a nomadic consumers equilibrium, where at each stage it is the consumers gaining the most who move.
Two networks; a mass $\alpha$ of consumers. Utility of consumers is equal to

$$\nu \times \text{mass of consumers in same network}.$$ 

Cost of providing service is zero.
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- Period 1 starts with one incumbent
- Each period $t > 1$ starts with one or several incumbents
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- Incumbent(s) set prices
  - Consumers play the "within period" dynamic game of choosing their networks
  - Nash timing works also.
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Dynamic model

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Incumbent(s) set prices

Entrants set prices

The consumers play the “within period” dynamic game of choosing their networks
Lemma (Myopia principle)

In the continuation game played by the consumers in each period, the set of equilibria is the same as if the game was a one period game.
The myopia principle

Lemma (Myopia principle)

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Really different from network effects model! Consumers can be short sighted.
Under which conditions can we have two networks?

\[ \alpha_H \lambda_L V_L + \alpha_L \lambda_H V_H < \alpha_H - \alpha_L \lambda_H V_L. \]
Under which conditions can we have two networks?

Necessary condition:

\[ \alpha_H \lambda_L V_L + \alpha_L \lambda_H V_H < \alpha_H V_H - \alpha_L V_L. \]

Small cross-effects.
Under which conditions can we have two networks?

(2)

Necessary and sufficient condition:

\[
\frac{[(1 - \delta)\alpha_L + \alpha_H \lambda_L] [(1 - \delta)\alpha_L + \alpha_H]}{\alpha_H (1 - \delta)(\alpha_H - \alpha_L \lambda_H)} \leq \frac{V_H}{V_L},
\]

Incumbent only keeps \( H \) consumers.
Under which conditions can we have two networks?

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Necessary and sufficient condition:

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- Incumbent only keeps $H$ consumers.
- If $\lambda_L = 0$, then can hold for $\delta$ close to 1.
- If $\lambda_L > 0$, then as $\delta \to 1$, it cannot hold.
Under which conditions can we have two networks? (2)

Necessary and sufficient condition:

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- Incumbent only keeps \( H \) consumers.
- If \( \lambda_L = 0 \), then can hold for \( \delta \) close to 1.
- If \( \lambda_L > 0 \), then as \( \delta \to 1 \), it cannot hold.
- Given any \( \delta \), there exists \( V_H / V_L \) such that a two network equilibrium exists.
Profits of the incumbent

\[ \Pi_H = \frac{\alpha_H (\alpha_L + \alpha_H)(\alpha_H - \alpha_L \lambda_H) V_H}{\alpha_L (1 - \delta) + \alpha_H}. \]

The profits of the incumbent . . .

. . . are greater than the one period profit;
. . . are smaller than the value of a flow of one period profit;
. . . are increasing in \( V_H \);
. . . are independent of \( V_L \);
. . . are increasing in \( \alpha_H \);
. . . can be increasing or decreasing in \( \alpha_L \) (decreasing when \( \delta \to 0 \).)
Network effects + switching costs
In static model with only network effects, incumbent charges $\alpha \nu$;
In static model with only switching costs, incumbent charges $\sigma$. 
In static model with only network effects, incumbent charges $\alpha \nu$;

In static model with only switching costs, incumbent charges $\sigma$.

Focal equilibrium with both effects: incumbent charges $\sigma + \alpha \nu$.

Profits are the sum of the profits in the pure network model and in the pure switching cost model.
More interesting

- $1/2$ consumers have switching cost 0 and $1/2$ switching cost $\sigma$. Assume also

$$\sigma < \alpha \nu.$$
1/2 consumers have switching cost 0 and 1/2 switching cost \( \sigma \). Assume also

\[ \sigma < \alpha \nu. \]

With both effects present, if the incumbent charges \( \alpha \nu + \varepsilon \), the 0 switching cost customers switch.

Then, the \( \sigma \) switching cost customers will also switch.
1/2 consumers have switching cost 0 and 1/2 switching cost $\sigma$. Assume also

$$\sigma < \alpha \nu.$$ 

With both effects present, if the incumbent charges $\alpha \nu + \varepsilon$, the 0 switching cost customers switch.

Then, the $\sigma$ switching cost customers will also switch.

The focal equilibrium has the incumbent charge $\alpha \nu$. 

*Additivity disappears.*
An illustrative story
"Some have argued that once a consumer purchases a body of music from one of the proprietary music stores, they are forever locked into only using music players from that one company."
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"Some have argued that once a consumer purchases a body of music from one of the proprietary music stores, they are forever locked into only using music players from that one company. Some have argued that once a consumer purchases a body of music from one of the proprietary music stores, they are forever locked into only using music players from that one company. Or, if they buy a specific player, they are locked into buying music only from that company’s music store..."
...On average, that’s 22 songs purchased from the iTunes store for each iPod ever sold.
On average, that’s 22 songs purchased from the iTunes store for each iPod ever sold. Today’s most popular iPod holds 1000 songs, and research tells us that the average iPod is nearly full. This means that only 22 out of 1000 songs, or under 3% of the music on the average iPod, is purchased from the iTunes store and protected with a DRM.
On average, that’s 22 songs purchased from the iTunes store for each iPod ever sold. Today’s most popular iPod holds 1000 songs, and research tells us that the average iPod is nearly full. This means that only 22 out of 1000 songs, or under 3% of the music on the average iPod, is purchased from the iTunes store and protected with a DRM.

It’s hard to believe that just 3% of the music on the average iPod is enough to lock users into buying only iPods in the future."
“Many iPod owners have never bought anything from the iTunes Store. Some have bought hundreds of songs. Some have bought thousands. At the 2004 Macworld Expo, Steve revealed that one customer had bought $29,500 worth of music."
“Many iPod owners have never bought anything from the iTunes Store. Some have bought hundreds of songs. Some have bought thousands. At the 2004 Macworld Expo, Steve revealed that one customer had bought $29,500 worth of music.

If you’ve only bought 10 songs, the lock-in is obviously not very strong. However, if you’ve bought 100 songs ($99), 10 TV-shows ($19.90) and 5 movies ($49.95), you’ll think twice about upgrading to a non-Apple portable player or set-top box.
“Many iPod owners have never bought anything from the iTunes Store. Some have bought hundreds of songs. Some have bought thousands. At the 2004 Macworld Expo, Steve revealed that one customer had bought $29,500 worth of music.

If you’ve only bought 10 songs, the lock-in is obviously not very strong. However, if you’ve bought 100 songs ($99), 10 TV-shows ($19.90) and 5 movies ($49.95), you’ll think twice about upgrading to a non-Apple portable player or set-top box. In effect, it’s the customers who would be the most valuable to an Apple competitor that get locked in. The kind of customers who would spend $300 on a set-top box.”
Conclusions

Distribution of switching costs/network effects is important.

Even consumers to which the incumbent/dominant firm does not sell can influence the outcome.

There are still many things we do not understand at the fundamental theoretical level about the dynamics of markets with switching costs and/or network effects.

Identifying anti-competitive behavior requires close attention to the specificities of the cases.