Switching Costs and Dynamic Price Competition in Network Industries

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Switching cost (SC) is an important feature in network industries: consumers can switch between networks but costly to do so

- switching from one PC operating system to another: requires substantial effort in learning the new environment
- switching from one wireless phone network to another: needs to inform contacts of new phone number; may have to pay early termination fee
- switching from one bank to another: needs to inform all relevant parties (direct deposits, automatic payments, etc.)

According to Shy (2001), SC is one of the main characteristics of network industries that distinguish them from other types of industries
This study investigates the effects of SC in network industries.

Motivated by policy makers’ recent interest in reducing SC in various network industries to increase competition:

- Mobile number portability (MNP) was implemented in more than forty countries during the past few years.
- In the EU retail banking and payments systems markets, the European Competition Authorities Financial Services Subgroup recommends the implementation of switching facilities and account number portability to lower SC.

A good understanding of how market outcome is affected by SC in network industries will allow regulators to make informed decisions.

This paper: effects of SC on market concentration and price are quite different when we go from a setting with only SC to one with both NE and SC.

→ The interaction between NE and SC does matter.
Model

- $N$ firms selling to a sequence of heterogeneous buyers with unit demands
- At the start of a period, firm $i$ is endowed with an installed base (users of its product), $b_i \in \{0, 1, \ldots, M\}$
- $M$ is the bound on the sum of the firms’ installed bases
- Price competition
- Outside good ("no purchase"): indexed 0
  - $b_0 = M - b_1 - \ldots - b_N$
  - does not offer network benefits
Demand in each period comes from a random consumer

$r \in \{0, 1, ..., N\}$ denotes the good that has the consumer’s loyalty

- distributed according to $\Pr(r = j | b) = b_j / M$
- a larger installed base implies a larger expected demand from loyal consumers
Model

- The utility that a consumer who is loyal to \( r \) gets from buying good \( i \) is

\[
v_i + 1(i \neq 0) \theta g(b_i) - p_i - 1(r \neq 0, i \neq 0, i \neq r)k + \epsilon_i.
\]

- \( v_i \) is the intrinsic product quality
  - fixed over time; common across firms: \( v_i = v, i = 1, \ldots, N \)
  - without loss of generality, set \( v = 0 \), but consider different values for \( v_0 \)
- \( \theta g(.) \) captures NE
  - \( \theta \geq 0 \) controls the strength of NE
  - linear NE: \( g(b_i) = b_i / M \)
- \( p_i \) denotes the price for good \( i \); \( p_0 \) is always zero
- Nonnegative constant \( k \) denotes SC
  - incurred if the consumer switches from one inside good to another
- \( \epsilon_i \) is the consumer’s idiosyncratic preference shock
The consumer buys the good that offers the highest current utility.

Assume $\epsilon_i$ is distributed type I extreme value, independent across products, consumers, and time.

- Logit choice probabilities

In each period, each unit of a firm’s installed base independently depreciates with probability $\delta \in [0, 1]$.

- Discrete time with an infinite horizon.

- Numerically solve for a Markov perfect equilibrium.
Types of Equilibrium

- **Sharing equilibrium:**
  - the market tends to be shared by firms that are of comparable size (fragmentation)
  - examples: video game consoles, wireless phone networks, credit card payment systems, etc.
  - two subtypes based on the shape of the policy function: Rising and Peaked

- **Tipping equilibrium**
  - the market tends to be dominated by a single firm (monopoly)
  - examples: the QWERTY keyboard, the VHS format in the home VCR market, Windows PC operating system, etc.
Rising Equilibrium

- Rising equilibrium: when both NE and SC are weak
  - Larger firm’s price rises in own base and falls in rival’s base
  - Smaller firm’s price is lower than the larger firm’s
  - Industries spends most of the time in fairly symmetric states
Peaked Equilibrium

- Peaked equilibrium: when SC is strong and the outside good is inferior
  - a peak in the price function when each firm has half of the consumers
  - SC segments the market into submarkets
  - firms focus on harvesting their locked-in consumers; resembles collusion
  - market dominance unlikely
Tipping Equilibrium

- Tipping equilibrium: when NE is strong and depreciation is modest
  - intense price competition when firms’ installed bases are of comparable size (deep trench along and around the diagonal)
  - away from the diagonal, the smaller firm gives up the fight
  - market dominance is likely
Examine how SC affects firms’ expected sales: basis for later analysis of market dominance and price

Consider a permanent increase in the SC, $k$

- both the current-period SC, $k^c$, and the SC in all future periods, $k^f$, are increased

At a given state, let $\phi = (\phi_1, \phi_2)$ denote the firms’ expected sales

- $\phi$ depends on firms’ equilibrium prices $p$, as well as $k^c$
- $p$ in turn depends on $k^c$ and firms’ next-period value function $V'$
- $k^f$ affects $V'$, and therefore affects $p$ through its impact on $V'$
We are interested in $d\phi/dk$: how a permanent increase in SC affects the firms’ expected sales.

To highlight the dependence on $k^c$ and $k^f$, $\phi$ can be written as $\phi(p(k^c, V'(k^f)), k^c)$.

Totally differentiate $\phi$ with respect to $k$:

$$
\frac{d\phi}{dk} = \frac{d\phi}{dk^c}\bigg|_{dk^f=0} \frac{dk^c}{dk} + \frac{d\phi}{dk^f}\bigg|_{dk^c=0} \frac{dk^f}{dk}
$$

$$
= \left( \frac{\partial \phi}{\partial k^c} + \frac{\partial \phi}{\partial p} \frac{\partial p}{\partial k^c} \right) + \left( \frac{\partial \phi}{\partial p} \frac{\partial p}{\partial V'} \frac{dV'}{dk^f} \right)
$$

$$
= \begin{bmatrix}
\frac{\partial \phi}{\partial k^c} \\
\frac{\partial \phi}{\partial p}
\end{bmatrix}_{2 \times 1} + \begin{bmatrix}
\frac{\partial p}{\partial k^c} \\
\frac{\partial p}{\partial V'}
\end{bmatrix}_{2 \times 1} \begin{bmatrix}
\frac{dV'}{dk^f} \\
\frac{dV'}{dk^f}
\end{bmatrix}_{2 \times (M+1)^2}
$$

\begin{align*}
\text{direct channel} & \quad \text{indirect channel}
\end{align*}
Direct Channel: Network Solidification Effect and Market Contraction Effect

- SC heightens the “exit barrier” for locked-in consumers and solidifies existing networks
  - makes consumers in the base less likely to switch to rival products
  - an installed base advantage becomes better protected
  - \( \rightarrow \text{network solidification effect} \), which reinforces NE and makes market dominance more likely

- When there exists an outside good, SC also has a \( \text{market contraction effect} \):
  - makes the inside goods less attractive relative to the outside good
  - decreases the size of the market \( (b_1 + b_2) \)

- To examine these effects, consider the discrete analogue of \( \frac{\partial \phi}{\partial k^c} \)
  - marginally increase \( k^c \) from \( k^0 \) to \( k^0 + 0.01 \) while holding prices fixed at those from \( k = k^0 \)
Direct Channel: Network Solidification Effect and Market Contraction Effect

Without an outside good \((v_0 = -\infty)\): *asymmetry movements* of the industry state

**Change in resultant forces**

**Change in limiting distribution**
Direct Channel: Network Solidification Effect and Market Contraction Effect

With an outside good \((v_0 = 0)\): *asymmetry movements* and *contraction movements* of the industry state.
The literature on SC without NE:

- SC makes the larger firm price less aggressively and lose consumers to the smaller firm
- asymmetries in market shares are dampened over time
- markets with SC tend to be stable
- → fat cat effect, with the larger firm being a nonaggressive “fat cat”
Indirect Channel: Fat Cat Effect and Top Dog Effect

In markets with NE:

- a basic property of NE: can tip the market to one firm as soon as it has an installed base advantage
- for a firm to price aggressively and give up current profit:
  - the prospect of future dominance by investing in its installed base must be sufficiently great
  - requires that the installed base does not depreciate too rapidly
- SC solidifies existing networks and makes an installed base advantage longer-lasting and more valuable (network solidification effect)
- consequently, the larger firm prices more aggressively in order to obtain and keep a dominant position
- → top dog effect, with the larger firm being an aggressive “top dog”
To examine the fat cat effect, consider the discrete analogue of $\frac{\partial p}{\partial k^c}$

- marginally increase $k^c$ from $k^0$ to $k^0 + 0.01$ while holding $k^f$ fixed at $k^0$
- examine the change in firms’ equilibrium prices
Fat Cat Effect

Change in firms’ equilibrium prices: increases in own installed base and decreases in rival’s installed base

\[ v_0 = -2 \]
Below the 45 degree line, firm 1 is the larger firm

Negative numbers are framed
Fat Cat Effect

Existence of an outside good dampens the fat cat effect

\[ \Delta p_1(b_1, b_2) \times 10^{-3} \]

- \( v_0 = -\infty \)
- \( v_0 = -2 \)
- \( v_0 = 0 \)
To examine the top dog effect, consider the discrete analogue of
\[ \frac{\partial p}{\partial V'} \frac{dV'}{dk'} \]
- marginally increase \( k' \) from \( k^0 \) to \( k^0 + 0.01 \) and compute the new
  next-period value function \( V' \)
- examine the change in firms’ equilibrium prices in response to the
cchange in the next-period value function
Top Dog Effect

- Change in firms’ equilibrium prices:
  - the fight for dominance is made fiercer
  - the larger firm acts as a top dog by pricing more aggressively than the smaller firm
Top Dog Effect

Existence of an outside good dampens the top dog effect
The Effects of Switching Costs on the Likelihood of Market Dominance

Fixed market size ($\nu_0 = -\infty$):

- Two forces compete against each other
  - the fat cat effect, which works against dominance
  - the network solidification effect and the top dog effect, which facilitate dominance

- Which of these two forces dominates is an empirical question

- Results from this model:
  - at low SC the network solidification effect and the top dog effect dominate → SC facilitates market dominance
  - at high SC the fat cat effect takes over → SC works against market dominance
Likelihood of Market Dominance

- Fixed market size ($v_0 = -\infty$):
  - If the NE is weak: the HHI is low throughout; first slightly increases in SC, then slightly decreases; Rising→Peaked
  - If the NE is strong: the HHI starts with a high value; initially increases in SC but later drops significantly; Tipping→Peaked
Likelihood of Market Dominance

Endogenous market size \( (v_0 = 0) \):

- the fat cat effect and the top dog effect are dampened by the competition from the outside good
- but the network solidification effect is not much affected
- \( \rightarrow \) SC generally increases market asymmetry
Endogenous market size \((v_0 = 0)\):  
- SC generally increases the likelihood of market dominance, contrary to findings in prior literature  
- Rising equilibrium when the NE is weak; Tipping equilibrium when the NE is strong  
- Increase in SC results in the limiting distribution putting more mass in more asymmetric states and states closer to the origin
Likelihood of Market Dominance

- As the outside good becomes more attractive, the ability of SC to reduce market asymmetry is weakened.
- Highlight the importance of the NE and the outside good in the analysis of SC and market dominance.

\[ (1) \ v_0 = -\infty \]

\[ (2) \ v_0 = -2 \]

\[ (3) \ v_0 = 0 \]
The effects of switching costs on prices

- An increase in the SC tends to increase the average price if there does not exist an outside good.
- With an outside good, a stronger NE makes it more likely that the average price will increase in the SC.
The effects of switching costs on prices

- As the quality of the outside good increases:
  - the market contraction effect is strengthened
  - makes it more likely that an increase in the SC will cause the average price to drop

- Fundamental property of NE: creates a “bandwagon” or “snowball” effect that allows a small base differential to quickly widen
  - network solidification effect of SC gives the larger firm an extra advantage
  - this extra advantage gets amplified by a stronger NE
  - an increase in SC becomes more effective in pulling the industry towards asymmetric states, in which prices are generally higher
  - makes it more likely that the average price will increase in the SC
The effects of switching costs on prices

“Price puzzle of switching costs”

- The traditional view in the theoretical literature: harvesting incentive dominates investment incentive; SC increases equilibrium prices
- several recent studies find that equilibrium prices can be decreasing in SC
- empirical studies also reach conflicting findings (next slide)

This study offers a new perspective on this puzzle

- shows that both scenarios can arise as equilibrium outcomes
- NE and competition from the outside good are important determinants
The effects of switching costs on prices

Existing empirical studies provide anecdotal evidence

- Dubé, Hitsch, and Rossi (2009) study the markets for refrigerated orange juice and tub margarine
  - simulations based on the calibrated model show that prices are lower with than without SC
- Park (2009) studies the wireless phone industry
  - finds that the introduction of number portability caused prices to decrease
  - SC leads to higher equilibrium prices
- It is likely that the wireless phone industry has a stronger NE and a weaker outside good than the markets for refrigerated orange juice and tub margarine
- Support the notion that prices tend to rise in the SC when the NE is strong and the outside good is weak
Conclusion

- SC is an important feature of network industries
- The effects of SC on market outcome critically depend on the strength of the NE and the quality of the outside good
  - the existence of NE enables SC to increase the likelihood of market dominance, sometimes dramatically so, via the network solidification effect and the top dog effect
  - the existence of an outside good can significantly dampen the fat cat effect, reducing the ability of SC to prevent market dominance
  - prices tend to rise in the SC when the NE is strong and the outside good is weak
- Policy makers need to carefully evaluate those two factors (NE and the outside good) in order to make informed decisions about public policies in network industries