Pricing Online Banking amidst Network Effects

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Network Effects

- When the value of a product is affected by how many people buy/adopt it:
  - Example: Phone System

- Types of Network Effects:
  - Direct
  - Indirect
  - Post-purchase
Direct Network Effects

- The number of users directly impacts the value of the system
- Based on interaction between members of a network
  - E.g. Telephone service

- Metcalfe’s Law: Network of size $N$ has value $O(N^2)$
Indirect Network Effects

- Do not directly affect the value of the product
- Indirect influence
- Credit cards:
  - More adopters of the card → more merchants accept it → higher value for the card
Post-Purchase Network Effects

- Mostly support related
- Examples
  - Software user groups (LINUX Users Group)
  - Consumer networks
The Model

- Value of a product in a market with network effects is given by:

\[ V = \alpha + \gamma Z_t \]

\( Z_t \) is the size of the network at time \( t \),
\( \alpha \) represents the value without network effects
\( \gamma \) represents value from network effects.
Pricing with Network Effects

- Value ascribed to system by customer: Willingness to Pay (WTP)
  - Most optimal policy: price at WTP
  - Difficulty: How to determine WTP?

- High collective switching costs
  - Leads to default standards (e.g. QWERTY; VHS, Java...)
Monopoly pricing

- What happens to Coase conjecture?
  - Coase (1937): prices drop to marginal costs over a long period of time even in monopolistic settings

\[ V = \alpha + \gamma Z_t \]
Standard Assumptions

- Product purchase decision
- Positive network effects
- Constant parameter to represent network effect
Services and Network Effects

- Assumptions in product purchase model are not valid
  - Not a one-time purchasing decision
  - Possibility of reneging and resubscribing: Market is not depleting over time
Services and Network Effects (contd.)

- Network effects can be negative
- Service systems have fixed capacities
- Fixed capacities → deterioration in service
- User notices negative network effects:
  - Random sampling; or word-of-mouth
Are network effects constant?

- Previous discussion implies time-dependency
- Thus, not really constant, but random (how many users are already on the system, when an additional user enters?)
- Thus, stochastic network effects
E-Banking and Network Effects
Network Externalities in Retail Banking

- Checking facility and exchange of checks
  - Critical mass theory and Internet-banking users

- Credit cards and indirect network effects
  - Introduced in 1930s, “re-introduced” in the 60s, did not take off till the mid-80s

- Econometric Studies
  - Gowrisankaran and Stavins (1999) find strong evidence of network effects in electronic payments (ACH)
  - Kauffman et al have observed network effects in ATM networks
Why Electronic Banking?

- Tremendous reduction in transaction costs
- Coordination of Delivery Supply Chain
# Cost of Transactions Across Delivery Channels

<table>
<thead>
<tr>
<th>Delivery Channel</th>
<th>Cost of Transaction</th>
</tr>
</thead>
<tbody>
<tr>
<td>Teller</td>
<td>$1.09</td>
</tr>
<tr>
<td>ATM</td>
<td>$0.27</td>
</tr>
<tr>
<td>Internet</td>
<td>$0.01</td>
</tr>
</tbody>
</table>

Source: Jupiter Communications 1997 Home Banking Report
Coordination of Delivery Supply Chain

- Electronic transactions facilitate:
  - Exchange of information with other banks through Electronic Clearing Houses (ECH)
  - Flow of information within the firm
    - Workflow management; process control
### Some Online Banking Options and Prices (March 2002)

<table>
<thead>
<tr>
<th>Bank</th>
<th>Price</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nations Bank</td>
<td>$5.95/month</td>
</tr>
<tr>
<td>Bank One</td>
<td>$4.95/month</td>
</tr>
<tr>
<td>Chase</td>
<td>$5.00/month</td>
</tr>
<tr>
<td></td>
<td>(Free if average account balance &gt; $5000)</td>
</tr>
<tr>
<td>Wells Fargo</td>
<td>Free with checking account</td>
</tr>
<tr>
<td></td>
<td>(Checking account balance &gt; $1500)</td>
</tr>
<tr>
<td>Huntington</td>
<td>Free first 3 months, then $4.95/month</td>
</tr>
<tr>
<td>Wachovia</td>
<td>Free first 3 months, then $5.95/month</td>
</tr>
</tbody>
</table>
Bank Problem

- Choose a price vector \((\mathbf{P})\) over the two periods at the outset

- Choose the optimal price vector assuming that the customer will switch in such a way as to optimize value over the two periods
Reservation Prices

- Each customer indexed by \( h \in [0, 1] \)
- Customer strategies
  - \((0, 0)\): Do not choose online banking in either period
  - \((0, 1)\): Choose online banking only in period 2
  - \((1, 0)\): Choose online banking in period 1 and renege in period 2
  - \((1, 1)\): Choose online banking in both periods
- Let \( h_{00} (= 0), h_{01}, h_{10}, \) and \( h_{11} \) denote the minimal reservation prices that will allow each of these strategies
Some propositions

- \( h_{11} \geq h_{10} \geq h_{01} \geq 0 \)

- There exists threshold network effects \( \gamma_u \) and \( \gamma_l \) such that
  - when \( \gamma > \gamma_u \), consumers who choose online banking in period 1, do not renege in period 2, and
  - when \( \gamma < \gamma_l \), consumers who do not choose in period 1 will not do so in period 2 also.
Consumer Surplus Equations

- **First period**

\[ V_1(h, p_1) = \begin{cases} h - p_1, & \text{for online banking} \\ 0, & \text{for non-online banking} \end{cases} \]

- **Second Period**

\[ V_1(h, p_2, q_{i-1}) = \begin{cases} \delta(h - p_2 + \gamma q_{i-1}), & \text{for online banking} \\ -\delta C_{jk}, & \text{for non-online banking} \end{cases} \]

\( \delta \) is the one-period discount factor (0 < \( \delta \) < 1)
Demand Equations

- $D_1 = 1 - h_{10}$ and $D_2 = 1 - h_{01}$

- Using indifference equations between choices in the 2 periods, we arrive at:

$$D_1 = \frac{1 - \delta - p_1 + \delta p_2 + \delta (C_{01} - C_{10})}{(1 - \delta + \delta \gamma)}$$

$$D_2 = \frac{(1 - \delta + \delta \gamma)(1 - p_2) - \gamma p_1 + \delta p_2 (1 + \gamma) + \delta \gamma (C_{01} - C_{10}) - \delta C_{01} - \delta \gamma^2}{(1 - \delta + \delta \gamma)}$$
Optimal Pricing Problem

\[ \Pi = \max_{(p_1, p_2)} \quad p_1D_1 + \delta p_2D_2 \]

s.t. \[0 \leq h_{01} \leq h_{10} \leq h_{11} \leq 1\]
Optimal Prices

\[ p_1^* = \left\{ (1 - \delta) \left( 2 - \delta \gamma + \delta^2 + 2\delta \gamma C_{10} + 2\delta C_{01} \right) - 6\delta \right\} \over \left\{ (\delta - 2)^2 + \delta^2 \gamma (\gamma - 2) \right\} \]

\[ p_2^* = \left\{ 2p_1^* + \delta (C_{10} + C_{01}) - (1 - \delta) \right\} \over \left\{ \delta (1 - \gamma) \right\} \]
Price behavior

- Note that as $\gamma \to 1$, $p_2^* \to \infty$
  - Increased network effects cause higher second period benefit.
  - Contrast with Coase conjecture; common with other studies with positive network effects
- Note also that as $\gamma$ increases, $p_1^*$ decreases
  - Increased network effect leads to low introductory pricing
- If $\delta = 0$, $p_1^* = \frac{1}{2}$ and $p_2^* \to \infty$
Optimal Prices over 2 Periods

$\gamma \rightarrow$

$C_{01} = 0.4; \ C_{10} = 0.2; \delta = 0.6$
Demands at Optimal Prices

Figure 1.2. Demands at Optimal Prices in the Two Periods
Intermediate Conclusions

- Should banks have chosen low introductory pricing to promote online banking?
- Positive switching costs lead to initial reluctance
- How are issues of security and convenience perceived by consumers?
Negative word-of-mouth effects

"Banking is founded on trust. We want an e-commerce service we can feel safe with, because if even one customer somewhere gets hacked - well that's bad for the customer but we suffer the impact to a greater extent because of the damage to customer trust."

(Bob Lounsbury of Scotiabank, 1999)

Scotia Bank was the 1998 NetCommerce Award winner in the Canada Information Productivity Association competition.
Online Banking Adoption Decision

- Kennikel and Kwast (1997)
  - 33% of respondents reported that friends and relatives who already used online banking affected decision to adopt online banking
  - Highest reported source of information in adoption decision
    - (next is financial consultants/brokers at 26.8%)
Word-of-mouth Effects

- Stochastic
  - Can be positive or negative
  - Mean and variance
  - Affects adoption of online banking in future periods
How to model W-o-M effects?

Figure 1. Transition probabilities and outcomes

\[ m(t + 1) = \begin{cases} 
  m(t) + h & \text{with probability } \mu p \\
  m(t) & \text{with probability } 1 - \mu p - \mu q \\
  m(t) - l & \text{with probability } \mu q 
\end{cases} \]
Modeling the Stochastic Network Effect

- The trinomial tree can be shown to follow a Geometric Brownian motion process
- Apart from “customer-talk”, expert opinion also influences demand
- We model word-of-mouth effect, $g$, as a jump-diffusion process
Word-of-Mouth as jump-diffusion process

\[ dg = \mu_g g dt + \sigma_g g dZ + kg dQ(t) \]

\(dZ\) is the increment of a Wiener process, \(Z\), with mean, \(\mu_g\), and s.d. \(\sigma_g\)

\(dQ(t)\) is the increment of a Poisson process with mean arrival rate, \(\lambda\)

\(k\) is a draw from a normal distribution, or in other words, \(k \sim N(\mu_p, \sigma_p^2)\).
Demand function

\[ D(t) = f[S(t), p(t), g(t)] \]

where,

- \( D(t) \) is demand at time \( t \)
- \( S(t) \) is size of network at time \( t \)
- \( p(t) \) is the price at time \( t \), and
- \( g(t) \) is the stochastic network effect
Maximizing profit

\[
\max_p E_0 \int_0^\infty e^{-\rho t} \left[ p(t) - c(S(t)) \right] D(t) dt
\]

- Stochastic Optimal control
- Bellman’s equation
Effects of Word-of-Mouth on prices

Figure 2. Effect of Word-of-Mouth on Price

myopic price

mean = 0
### Pricing Strategy

<table>
<thead>
<tr>
<th>$\mu_g$</th>
<th>Positive</th>
<th>Price to Build Network</th>
<th>Price to Penetrate Market</th>
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<tr>
<td>Negative</td>
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<td>Price to Recover Sunk Costs</td>
<td></td>
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| Low | $\sigma^2$ | High |

**Table 1. Pricing Strategy with Word-of-mouth Effects**
Stochastic Cross-Product Network Effects
Consumer Surplus Equations

- **First period**
  
  \[ V_1(h, p_1) = h - p_1, \quad \text{for online banking} \]
  
  \[ = 0, \quad \text{for non-online banking} \]

- **Period i, i \geq 2**
  
  \[ V_1(h, p_1, q_{i-1}) = (h - p_2 + \gamma D_{i-1} + \eta_i D_{i-1}), \quad \text{for online banking} \]
  
  \[ = - C_{jk}, \quad \text{for non-online banking} \]
Customer’s Problem

- At the beginning of each period, the customer chooses a mode (online or not). The problem is to choose an optimal sequence of modes that will maximize value.

- To switch from mode j to mode k costs $C_{jk}$. 
Dynamic Program Formulation

- Customer chooses to maximize value over the T periods
- Consider the last period, period T:
  - Choose that mode that will give maximum value after discounting switching cost
  - Suppose customer arrives in this period in mode M

\[ V_T = \max(V^m_T - C_{Mm}), \quad m \in \{\text{Online, Non-online}\} \]
Dynamic Program Formulation (contd.)

- For any period, $j$ ($0 < j$)

\[ V_{j-1} = \max (V_{m_j} - C_{(j-1)m} + \delta E[V_j]) \]

$E[]$ being the expectation, and $\delta$ being the one-period discount factor
The Model

Value of a product exhibiting both types of network effects is given by:

\[ V = \alpha + \gamma Z_t + \eta_{\tau} Z_{t-\tau} \]

where \( Z_t \) is the size of the network at time \( t \), the parameter \( \alpha \) represents the value without network effects, \( \gamma \) represents network externality effects, and \( \eta \) represents word-of-mouth effects. \( \tau \) is the time delay for the word-of-mouth effects. For simplicity, we assume \( \tau = 1 \).
Variation of Optimal prices with Mean of Word-of-mouth Effect
Optimal Prices with Variance of Word-of-mouth Effect

$p_1$ and $p_2$ are without word-of-mouth
$k=0.15, \delta = 0.6, C_{01}=0.4; C_{10}=0.3$
mean for word_of_mouth = 0.1
Multiple Periods: Prices with Increasing Lag in Word-of-mouth Effects
Multiple Periods: Demands versus Prices with Increasing Lag in Word-of-mouth Effects

- Not much variation in optimal demand

- Optimal prices increase about 5% for every additional period of lag

- Banks seem to be more sensitive to word-of-mouth than customers
  - Back to Lounsbury’s comment
Anecdotal Evidence: Bank Strategies

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Bank Strategies (contd.)

- Wells Fargo
  - Charged for online banking in 1998
  - Now, it is free