Pricing Information Goods

Arun Sundararajan
Stern School of Business, NYU
December 2002

Research agenda

- Determine optimal pricing strategy for information goods under incomplete information
  - Fixed-fee vs. usage-based pricing
  - Nature of usage-based pricing contract
  - Customer adoption, profits, surplus
- Study the impact of changes in
  - Contract administration costs for firms/customers
  - Market characteristics (distribution of usage levels, average usage/value, skewness)
  - Presence and nature of network externalities
  - Competition, budgets, level of digital piracy
- Apply and adapt theory to specific verticals
  - Software licensing, digital marketing, online brokerage, wireless data access...
- Examine implications of theory for
  - Bundling and product versioning strategies
  - Regulatory policy for information-goods monopolists

Background: Fixed-fee & usage-based pricing

- Fixed fee pricing
  - Provides the customer with an unlimited quantity of a good, for a fixed payment
  - Not the fixed part of a two-part tariff
  - Definition depends on 'quantity unit'
  - Examples
    - Internet service (AOL), research (Jupiter), DVD's (NetFlix), digital music (emusic.com), wireless web downloading (Sprint Vision)
    - Site licenses for software
    - unlimited monthly trades, MB of content, minutes of cellular voice time,...
- Usage-based pricing
  - Specifies a menu of price-usage pairs
  - Generally based on the assumption that seller cannot first-degree price discriminate
  - Examples
    - Per-hour ISP usage (AOL)
    - Per-report research services (Aberdeen)
    - Per-share trading commission (LiquidNet)
    - Per-download/stream MP3 files (PressPlay)
    - Per-concurrent-user (software)

Background: Nonlinear pricing

![Graph showing nonlinear pricing](image-url)
**Background: Some existing work**

- Monopoly under incomplete information
  - Basic theory on price screening (Maskin and Riley, 1984, Wilson, 1993)
    - Under a set of general assumptions the optimal pricing strategy is fully-revealing
  - Recent theory
    - Type-dependent alternatives (Jullien, 2000)
- Monopoly pricing for information goods
  - Pure bundling always dominates mixed bundling or per-good pricing schemes (Bakos and Brynjolfsson, 1999)
  - Offering a single high quality product version often dominates offering multiple versions (Jones and Mendelson, 1998)
  - If there are positive transaction costs, fixed-fees always dominate usage-based pricing (Varian, 2000)
  - Mixed (horizontal+vertical) versioning of information goods is dominated by pure (either horizontal or vertical) versioning (Weber, 2001)

**Snapshot of some results**

- Purely usage-based pricing continues to be optimal even when variable costs are zero.
- With positive contract administration costs (borne by either the consumer or the firm):
  - Fixed-fee pricing is always optimal, sometimes exclusively
  - The optimal usage-based contract is
    - independent of the level of the fixed-fee
    - identical to that in the absence of a fixed-fee
- As information-goods markets evolve
  - Fixed-fee penetration pricing is optimal in early-stage markets
  - As the markets mature, high-end fixed-fee pricing in conjunction with usage-based pricing is optimal
- Under a general specification of incomplete information
  - Mixed bundling of information goods is often more profitable than pure bundling
  - A continuum of self-customizable versions is often more profitable that a single version
- Under different kinds of positive network effects, offering fixed-fee pricing is always optimal
- Total welfare can often be strictly improved by a costly 'tax' on usage-based pricing

**Model: Overview**

- Seller: Profit-maximizing monopolist
- Product: Homogeneous information good, used in continuously variable quantities
- Customers:
  - Heterogeneous, indexed by type \( \theta \)
  - Utility function \( U(q, \theta) \) with maximum \( v(\theta) \)
  - Distribution of types \( f(\theta), F(\theta) \)
- Contracts:
  - Fixed-fee (unlimited-usage) \( T \)
  - Usage-based \( r(\theta), q(\theta) \)
  - Usage-based contract administration fee \( c_q \) \( (\text{generalizes to } C(q)=K+cq, q>0) \)
- Key assumptions:
  - Finite maximum usage \( a(\theta) \) for each type
  - Higher types get higher utility
  - Higher types get higher increase in utility for the same increase in usage
  - Utility is strictly concave in usage
  - Absolute risk-aversion non-increasing in type
  - Hazard rate of type distribution is increasing

**Model: Solution**

- Seller’s problem: to choose fixed-fee \( T^* \) and usage-based menu \( r(\theta), q(\theta) \) such that
  - All customers are offered both contracts
  - Each customer chooses either \( T^* \), or chooses price-quantity pair designed for their type
  - Profits are maximized
- Structuring the optimal contract
  - 1. Simplifying formulation of sub-problems
  - 2. Specifying segmentation between any fixed-fee and any IC usage-based contract
  - 3. Establishing when a profit-improving fixed-fee exists
  - 4. Determining the optimal combination of fixed-fee and usage-based contract
- Examples
1. Simplifying formulation (standard)

- The optimal usage-based contract for the sub-interval \([0, \theta_F]\) solves the following optimization problem:

\[
\max_{q(0), \theta_U} \left( U(q(0, \theta_U), 0) - cq(0, \theta_U) \right) - \frac{(U_2(q(0, \theta_U), 0) - F(\theta_U) - F(\theta))}{f(\theta) - f(0)}
\]

subject to: \(q(0, \theta_U) \geq 0\) for all \(\theta_U\)

- The solution is:

\[
U_1(q(0, \theta_U), 0) = U_2(q(0, \theta_U), 0) - \frac{F(\theta_U) - F(\theta)}{f(\theta) - f(0)}
\]

\[
\tau(0) = U(q(0, \theta_U), 0) - \int_0^\theta U_2(q(x, \theta_U), x) dx
\]

2. Segmentation due to the fixed-fee

3. Establishing whether a profit-improving fixed-fee exists

- If \(c > 0\), there exists a fixed fee that strictly increases profits from the optimal usage-based contract \(\tau(0), q^*(0)\)

4. Determining optimal combination of fixed-fee and usage-based pricing

- Optimal usage-based contract is independent of the value of the fixed-fee
- Optimal usage-based contract is identical to the one offered when fixed-fees are not feasible
  - Simplifies problem tremendously
  - Allows one to separate finding usage-based pricing schedule and fixed-fee
Example

- Quadratic utility function, uniformly distributed types
  \[ U(q, \theta) = (\beta + \theta)q - \frac{1}{2}q^2 - \theta - U(0, 1) \]

- Optimal contract
  \[ q^*(\theta) = 20 + \beta - (c + 1) \]
  \[ \tau^*(\theta) = \frac{\beta^2 + 2\beta(c + 1) - 3(c + 1)^2}{4} + 20(c + 1) - \theta^2 \]
  \[ p(q) = \frac{1}{2}(1 + \beta + c)q - \frac{q^2}{2} \]

Adopters of the fixed-fee contract
Adopters of the usage-based contract
Non-adopters

Adoption under optimal contract
\[ \theta_L(\beta, c) = \frac{e + 1 - \beta}{2} \]
\[ \theta_F(\beta, c) = 1 + 2c - \sqrt{2c^2 + 3c} \]
\[ T^*(\beta, c) = \frac{(1-\beta+e)^2}{4} - c[1-\theta_F^*(\beta, c)] \]

Example: Levels of customer adoption

Switch from usage-based to not adopting as \( c \) increases
Switch from usage-based to fixed-fee as \( c \) increases

Example: Profits and customer surplus

Profits

Customer surplus

Example: Total surplus

\[ S(\beta, c) \]
Changes in total surplus: a closer look

Furthermore...

- As contract administration costs fall
  - increase % values of quantity discounts
  - lower magnitude of fixed fee
  - increase total adoption levels

- As average usage/product value increases
  - reduce % value of quantity discount
  - increase magnitude of fixed fee
  - increase total adoption levels

- As usage distribution becomes less positively-skewed (less 'skewed to the left')
  - expand usage-based pricing so as to shift some fixed-fee adopters
  - increase magnitude of fixed fee substantially
  - often, reduce total adoption levels

- As positive network externalities increase
  - Increase both fixed-fee and usage-based prices
  - shift more users to fixed-fee pricing
  - generally, raise equilibrium usage levels for all types (but not always)

Key contribution

- Optimality of simultaneous offers of fixed-fee and usage-based pricing for information goods
  - generalizes the purely usage-based price screening results, and the purely fixed-fee results from the information goods literature
  - generalizes some renting information goods results (e.g., Varian, 2000)
  - highlights the importance of non-production variable costs in designing pricing for information goods, and the sensitivity of the theory to 'small perturbations'
  - brings the theory closer to reality

- Guidelines for the evolution of pricing strategy as information-goods markets mature
  - Early-stage markets: fixed-fee penetration pricing
  - As the market matures: high-end fixed-fee pricing along with increased usage-based pricing

- Implications for bundling and product versioning
  - Mixed bundling generally dominates pure bundling when one offers a non-linear pricing schedule
  - With a continuum of customer types, optimal product lines often offer a menu of versions

- Modeling framework for analyzing pricing in more specific domains
  - Separability of the design of the usage-based and fixed-fee prices

Ongoing work

- Further development of theory
  - Comparative statics for general model
  - Optimal combination of pricing for markets with network externalities
  - Empirical distributions for different markets
  - Development of complete nonlinear bundling model

- Customization for specific verticals
  - Corporate software: named-user, concurrent-user and site licenses
  - Direct digital marketing: performance-based pricing and optimal risk-sharing
  - Online retail brokerage: asset-base and trading volume

- Digital piracy and fixed-fee pricing
- Product differentiation and competition