Price Screening with Network Effects and Entry Deterrence

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Motivation
Some examples of network goods and their drivers of network effects

- Microsoft Windows
  - File compatibility
  - Applications software
- Ability to trade on eBay
  - Liquidity
  - Supporting marketplace services
- Oracle Database
  - Software tools
  - Qualified database administrators

Motivation
In standard models of network goods
- Each customer buys one unit
- Network value depends on adoption = # of customers
- Network value is constant across customers

In reality, the usage of many network goods varies across different customers
- Number of OS licenses (Windows)
- Trading frequency (eBay)

Moreover, the network value of these goods
- Depends on total usage across customers, and not merely the number of customers
- May also depend on individual usage
- May vary across customers, even at the same levels of individual and total usage

Summary
- Model monopoly nonlinear pricing of network goods
  - Network value depends on total usage
  - Network value for each customer may depend on their individual usage
  - Marginal network value may vary across customers
- Characterize optimal pricing schedules
  - Existence of fulfilled-expectations contract
  - Uniqueness of optimal contract
  - Variation in properties with network value
- Analyze welfare properties of contracts
  - Surplus division between firm/customers
  - Surplus distribution across customers
- Study effects of entry deterrence
  - Changes in pricing
  - Changes in welfare properties

Some related work
- Monopoly models of network goods
- Single-dimensional monopoly price screening
- Empirical estimates of network effects
  - Databases (Gandal 1994, 1995)
  - Spreadsheets (Gandal 1995, Brynjolfsson and Kemerer 1996)
  - Word processing software (Grohn 1999)
  - Networking equipment (Forman 2001)
**Model**
- Monopoly seller of a network good
- Continuum of heterogeneous customers, indexed by type \( \theta \) distributed as \( F(\theta) \) with \( f(\theta) > 0 \), \( F(\theta) \) nondecreasing
- Utility functions of customer type \( \theta \): \( W(q, \theta, Q) \)
  - \( q \): individual usage of customer
  - \( Q \): gross usage across all customers
- Key properties of \( W(q, \theta, Q) \)
  - Individual usage: \( W_1(q, \theta, Q) < 0 \), \( W_2(q, \theta, Q) > 0 \)
  - Gross usage: \( W_1(q, \theta, Q) > 0 \), \( W_3(q, \theta, Q) > 0 \)
- Intrinsic value function: \( U(q, \theta) = W(q, \theta, Q) \)
- Network value: \( W(q, \theta, Q) - U(q, \theta) \)

**Base case:** \[ W(q, \theta, Q) = U(q, \theta) \]

- Optimal FE contract exists if \( W(\theta) \) is bounded, is unique if \( w_1(Q) < - U_1(q, \theta) \)
- Consumption \( q(\theta) \) increases for a positive fraction of types, may decrease for lower types
- Surplus distribution is skewed towards higher customer types
- Trade-off between price discrimination and value creation

**Solution:** \[ W(q, \theta, Q) = U(q, \theta) + qw(\theta, Q) \]

- Further accentuates the tradeoff between price discrimination and value creation

**Contract:** quantity-price pairs \( q(\theta), t(\theta) \)
- Feasible: IC and IR
- Optimal: Given expectation of gross consumption \( Q \), maximizes profits among all feasible contracts
- Optimal fulfilled-expectation: Optimal contract for \( Q \) under which actual consumption \( \int q(\theta)dF(\theta) = Q \)

Sequence of events
- Seller posts contract
- Customers form expectation \( Q \) of gross consumption
- Based on type \( q \) and expectation \( Q \), each customer chooses individual consumption \( q \) to maximize surplus
- Seller, customers get payoffs

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Base case contract \( q^0(\theta), \tau^0(\theta) \) is unique

All results illustrated for two types, for better intuition
Entry deterrence

- Incumbent monopolist
  - Customers get both intrinsic value and network value from incumbent product
- One or more potential entrants
  - Entry cost = 0
  - If entry occurs, customers who purchase get just intrinsic value from product
  - Collapses some 'dynamic' aspects of an incumbent's advantage into a static model
- Monopolist prices to deter entry, by assumption
- Problem reduces to monopoly pricing with type-dependent participation constraints

Example

\[ W(q, \theta, Q) = U(q, \theta) + qw(\theta) - \theta + U[q] \]

Example with entry deterrence

- With an entry threat, usage \( q^*(\theta) \) is either
  - exactly the same as it was without, or
  - adjusted upwards for a subset of lower types
- Monopolist profits fall, customer surplus increases
- Outcome is not efficient
  - inefficiently low usage by all types
  - ...but potentially higher total surplus than if entry actually occurs

Summary

- Existence, uniqueness conditions for nonlinear pricing with network effects
- Changes in usage induced by different network effects
  - Just \( Q \): No changes in usage
  - Both \( Q \) and \( q \): Increase in usage across all types
  - \( Q \), \( q \) and customer type: Potential further downward distortion of usage of lower types, below levels in absence of network effects
- Further changes in usage induced a costless entry threat
  - May increases usage for lower types, does not affect usage for a subset of higher types, mitigates downward distortion
- Network effects (and/or an entry threat) generally improve equity in surplus distribution across different customer types
- Threat of entry can result in socially superior outcomes than actual entry, socially efficient outcome in special cases