Quality, Upgrades and (the Loss of) Market Power in a Dynamic Monopoly Market

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Outline

1. Questions and Framing
2. Overview of Results
3. Model Structure
4. Formal Results
5. Policy Thoughts and Questions
What do we know about dynamic multi-product monopoly?

• Most work – single-good (Coase Conjecture)

• ‘Upgrade’ Monopoly
  – Higher quality over time
  – Complementarity ‘upward’
  – Buyers never exit market

• Questions
  – Commercialization
  – Efficiency
  – Delay
  – Market Power
Basic Monopoly Market
(Zero Marginal Cost)

Monopoly Price

Demand

Seller Profit

Price

Quantity
Seller Profit

Deadweight Loss

Consumer Surplus

Monopoly Price

Perfect Competition

Basic Monopoly Market

Price

Quantity
Rising Quality and Upgrades

Demand Shifts Up
Upgrade Goods

• Examples
  – Software: operating systems (Microsoft), applications (Scientific Word, Adobe)
  – Commercial Airplanes: (Boeing, Airbus)
  – Defense Systems: planes, ships

• “Independent goods”
  – Computer, television, cars

• Complements (up) versus substitutes
Important Upgrade Market Properties

- Infinite horizon – expectations of future

- Seller
  - New upgrades (quality increments) in future
  - Bundling of upgrades

- Buyers
  - Private information re value
  - Return to market for quality upgrade

- “Upward” Complementarity
  - Buyers need previous upgrades for next increment to be valuable
Goals of Research Program

1. Pure Upgrade Monopoly (this paper)
   - Focus on quality $\uparrow$ and market power

2. Intertemporal price discrimination (next)
   - Upgrades and market segments

3. Innovation (future)
   - Rate of innovation
   - Incentives and dynamic efficiency
2. Overview of results

- Critical Assumptions
- Main results – limits to market power
- Core argument – credible threat for buyers
Critical Assumptions - Overview

1. Quality Growth
   • Seller offers higher quality over time

2. Upgrade structure
   • Upward Complementarity: a buyer must hold all lower quality levels to derive benefit from next quality level

3. Lifetime Buyers
   • Buyers return to market for upgrades
   • Identical preferences
   • Individually have no market significance
Quality Growth

Limit to Seller
Market Power

Upgrade Structure

Lifetime Buyers
“Speed-Up” and Market Power

Do Buyers have a “credible threat”
• Seller makes offer today – accept or reject?
• Expectation of trade in the future and associated payoff
• Rejection rational if expected future supports

But…
• Seller offers price today that targets future payoff
  – “We are going to trade tomorrow. We know delay has a cost. Here is my offer and you can see that the price shares the social gain from avoiding delay…You get the good now and my profits are higher – a win-win.”
• Speed-up implies no delay in trade
• Speed-up pushes buyers to indifference and extracts all surplus
Speed-Up and Upgrades

- Seller has one good to sell (Coasian logic)
- Buyers have identical preferences
- Does speed-up logic apply to upgrade monopoly?
- Our result: No.

→ Limits on seller market power in an upgrade monopoly market
Main Results

- There are many equilibria
- One has seller extracting all surplus – high prices
- One has seller with almost no market power – low prices → Buyers have a credible threat
- Equilibrium can be efficient (above cases)
- There are inefficient equilibria
  - Trade is delayed
  - Upgrades are sold periodically in a bundle
The core argument – Credible Threats

• Why does the speed-up logic break down in an upgrade market?
• Individual buyers care about their position relative to others
  – Expect to return to market for future upgrades
  – Expect other buyers to do so as well
• What happens if there is no trade today?
  – Seller has unsold upgrade and a new one
  – Social surplus is larger
  – Expectations over how surplus from current upgrade is shared and how surplus over future upgrades will be shared
• When can seller realize profit on later upgrades?
  – Must sell earlier upgrades first (or together)
  – Upward complementarity in quality
Individual Buyer Decision

• Accept the current upgrade offer or reject?

• Choice based on ‘willingness to pay’

• Suppose other buyers are expected to reject

• Delay $\rightarrow$ seller has multiple upgrades to offer tomorrow

• Accept today $\rightarrow$ individual buyer will be ‘ahead’ of the market
  – Next period seller offers bundled upgrade
  – Reject next period $\rightarrow$ fall ‘behind’
  – Accept and forced to ‘re-buy’ last period upgrade
• Expectation for how surplus is shared
  – If expect zero/small increment in future → accept high price today
• Suppose buyers expect significant share of surplus in future
• Decision of individual buyer today
  – Others expected to reject today
  – Ahead of market tomorrow but share of surplus large
  – Buy tomorrow is optimal (keep up with market)
  – Cost versus benefit of buying today?
    • Cost is price seller is asking for upgrade
    • Benefit is one period of flow value

Willingness to pay = flow value
3. Model Specification – basic elements

- Infinite horizon – periods 1, 2, …

- Seller
  - Monopoly, no competition
  - A new quality increment (upgrade) in each period
  - Zero costs
  - Can offer all feasible bundles (set of qualities)
  - Maximize discounted profits
Model basics - continued

• Buyers
  – Set of buyers, individually insignificant (no market power)
  – Constant value (marginal utility) per unit quality per period
    • Flow value of v for unit of quality
    • Lifetime value of unit of quality
    • Lifetime value of all quality units acquired over time
  – Maximize discounted lifetime value of
    value from quality less payments to seller

• Information – complete
  – All costs and valuations known
  – Any bundle/price available to any consumer (no conditioning)
  – All players observe aggregate market position
Model basics- continued

• Timing of Market transactions – each period
  – Inherit market position from past
    • Buyer holdings from past purchases
    • Feasible seller offer up to current maximal quality level
  – Seller offers bundles of quality and associated prices
  – Buyers decide which, if any, bundles to purchase
    • individual buyer choices
    • Simultaneous move

• Discount factor
  – Rate of time preference
  – Rate of innovation
Efficiency

- Maximize sum of seller profit and buyer utility

- Efficient Path - buyers acquire new unit of quality immediately
  - Upgrade as soon as feasible
  - Payments are transfers
  - No implementation costs
    - Switching costs, adoption, etc.
  - No externalities
    - Network effects
    - Compatibility - forward and back

- Efficiency measure – surplus on the efficient adoption path
Equilibrium

• Solve game for player strategies
  – Seller offers of upgrades and prices
  – Buyer acceptance decisions

• Markov perfect equilibrium
  – ‘Perfect’ → No commitment and must make an optimal decision at each turn
  – ‘Markov’ → summarize ‘history’ in simple way: quality gap for decision making
    • Quality level seller can offer
    • Current quality held by buyers
Benchmark Outcomes

• Finite Horizon → Market Power
  – Last period, no further innovation
  – Buyers have no credible threat
  – Seller extracts full surplus at last stage
  – Work back

• Single Buyer → Market Power
  – Individual action changes quality gap
  – No credible threat and ‘speed-up’ logic
  – No buyer expectations issue

• No Quality Growth → Market Power
  – Standard in literature for identical buyers
4. Basic Results

• Flow Dominance
  – Seller offers to close ‘quality gap’
  – Move to ‘state of the art’
  – Price at flow value (very low)
  – Buyers necessarily accept
    • Offer pays for itself in one period
    • Advantageous future position
Basic Results - continued

• **Cycles**
  – Every equilibrium has cyclical structure
  – Delay periods with no sales
  – Sell full bundle upgrade to ‘state of the art’
  – Repeat cycle

• **Efficiency and Delay**
  – Cycle length at 1 $\rightarrow$ efficient outcome
  – Cycle length longer $\rightarrow$ delay and inefficiency
Equilibrium and Efficiency

• Main result – Seller market power may be trivial in equilibrium

• In an efficient equilibrium, the seller’s payoff ranges from
  
  – Full extraction: sell an upgrade each period at price = full surplus value
  
  – Flow Dominance: sell at price = one period flow value

• In equilibrium, almost all of social surplus can be captured by buyers

• Result holds for any discount factor between 0 and 1
Example: numerical magnitudes

- Suppose per period value of unit of quality is $1
- Suppose interest rate is 10% → discount factor is .9
- Then
  - Flow value of one upgrade = $1
  - Present discounted value of an upgrade = $10
  - Total social surplus on efficient path = $100
- There is an equilibrium where seller offers
  - New upgrade each period
  - Price = $1
  - Seller profit in game = $10
  - Buyer payoff in game = $90
Delay (inefficiency) and Equilibrium

- There exist cyclical equilibria in which delay occurs
- No sales for one or more periods
- Then a sale to state of the art quality via upgrade bundle
- High discount factors support delay
- Buyers are never extracted in a delay equilibrium
5. Policy Thoughts and Questions

- Loss of market power in upgrade monopoly $\rightarrow$ Antitrust
  - Prices for upgrades: high or low versus flow value?
  - Efficiency – market rate of adoption
  - Network effects and market power $\leftrightarrow$ upgrade surplus expectations

- Bundling
  - Suppose observe upgrade market with delay and bundling
  - Model $\rightarrow$ evidence of a lack of market power

- Versioning and buyer segments
  - Intertemporal price discrimination
  - Contractual provisions

- R&D incentives and market power