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Economics of Innovation

Lecture 6 –
Strategic management of innovation
in network markets

http://www.economics-of-innovation.com

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Why QWERTY?

- The most ergonomically efficient keyboard layout? – No.
- The only technically feasible layout? – No.
- The cheapest layout to produce? – No.

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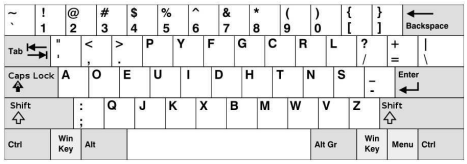
Dvorak Simplified Keyboard (DSK)



- Patented in 1932
- World record in speed typing
- 1940's experiment by U.S. Navy showed that increased efficiency obtained with DSK compared to QWERTY would amortize costs of retraining typists within 10 days of subsequent full-time employment
- Offered as alternative layout on Apple and Microsoft for decades
- But have you ever heard of it???

Original QWERTY "Type Writer"

- Patented 1867 by Christopher Latham Sholes, the 52nd man to invent the typewriter
- Since 1873 produced by Remington and Sons, a famous arms makers in the US
- Typebar clashs and jams led to the development of QWERTY layout

David (1985): Historical 'lock in' – 1

1. Technical interrelatedness (indirect network externalities)
   - Complementarity between keyboard layout (hardware) and training of typists (software)
     - Type of special human capital
2. Demand-side economies of scale (direct network externalities)
   - Every purchase of a QWERTY system was a positive externality to other users of the system
     - Having one standard is more efficient than having many competing systems
     - More typists trained on QWERTY meant decreasing user cost for every system based on QWERTY

David (1985): Historical 'lock in' – 2

3. Quasi-irreversibility of investment
   - Costs of retraining all typists was going up with every additional unit of QWERTY keyboards sold
   - Costs for hardware conversion to QWERTY was going down
     - None-typebar technologies available since 1880's that allowed any possible keyboard design
     - Computers can also easily support any possible keyboard layout
   - Result:
     - More and more manufacturers adopted the QWERTY design from the mid-1890's onwards
     - Users of type writers bought QWERTY systems because this lowered their costs of training typists and increased their chance of hiring typists who were already trained on QWERTY

David (1985): Historical 'lock in' – 3

4. Historical accidents and chance
   - Same logic would have been true for all competing systems, so why QWERTY?
   - Maybe because Sholes and his partners succeeded in placing the manufacturing rights for their 'machine' with Remington
     - Remington was known for manufacturing weapons and ammunition
     - Remington already had a brand name in the US
     - Remington had manufacturing plants that would allow to exploit economies of scale in production
     - Remington had a distribution network and access to consumer markets
   - Expectations of consumers could have been favorable towards 'Type Writer' from Remington's commitment onwards…

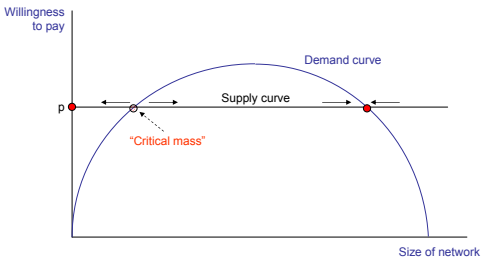
Network externalities – a quick repetition

- Utility of each consumer depends positively on the number of other consumers of the same product
- Examples:
  - Telephone
  - Fax
  - Email
  - Internet…
- This leads to many interesting features:
  - Critical mass
  - Lock-in
  - Winner-takes-all markets
  - Market failures

A simple model of network externalities

- Varian (2006, ch. 35):
  - Suppose there are 1000 people we index $v = 1,\ldots,1000$
  - v is the reservation price of each person for the good
  - Let's say the value of the good depends on the number of other users - the value for *v* is *vn*
  - For every price *p* we have some 'marginal' consumer $\hat{v}$ who is indifferent between purchasing and not purchasing: $p = \hat{v}n$
  - Everyone with a *higher* value will want to buy: $n = 1000 - \hat{v}$
  - Together: $p = n(1000 - n)$

Two stabile equilibria



Reaching critical mass

- Once critical mass has been reached, the system grows on its own towards the high-adoption equilibrium
- Strategies that can kick-start the network (increasingly aggressive):
  - Penetration pricing (start cheap, than increase prices)
  - Give away product / access to network for free to first users
  - Give away for free AND add additional perks (gifts etc.)

Inefficiencies

- Lock-in may create monopoly situation
- High adoption equilibrium might be socially preferable to low adoption, but technology providers may not have enough start-up capital to create critical mass
- In case of competing incompatible systems:
  - There might be a "winner take all" situation, but the winner might not be the best technology
- Other potential problems…
- Let's focus for the moment on technological lock-in and the role of history…

Arthur (1989): Competing technologies... – 1

- Two different technologies (*A* and *B*) competing for the same consumers
- Each consumer decides to purchase only one technology (perfect substitutes), no switching later on
- Two types of consumers, *R* and *S*
  - *R* has a preference for technology *A*
  - *S* has a preference for technology *B*
- Consumer types arrive at the market in random sequence (Bernoulli trials), one consumer each at time *t*
- Upon arrival, consumer observe previous sales of technologies and decide which one to purchase

Arthur (1989): Competing technologies... – 2

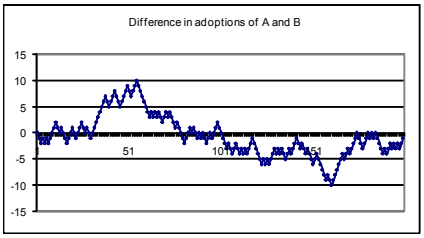
- Number of previous adopters of technology *A* and *B* is denoted with n_A and n_B, respectively
- Utility depends on number of previous adopters:

	Technology A	Technology B
R-agent	$a_R + rn_A$	$b_R + rn_B$
S-agent	$a_S + sn_A$	$b_S + sn_B$

with $a_R > b_R$ and $a_S < b_S$

- Constant (demand side) returns: $r = 0; s = 0$
- Decreasing (demand side) returns: $r < 0; s < 0$
- Increasing (demand side) returns: $r > 0; s > 0$

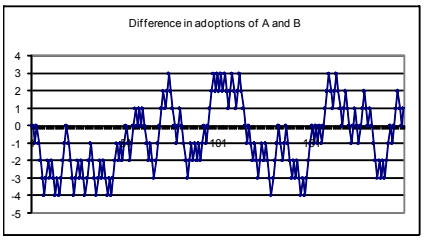
Example: Constant returns



Parameters: $r = s = 0; a_R = b_S = 2; a_S = b_R = 0.5$

Difference in adoption is $n_A(n) - n_B(n)$, when n choices in total have already been made

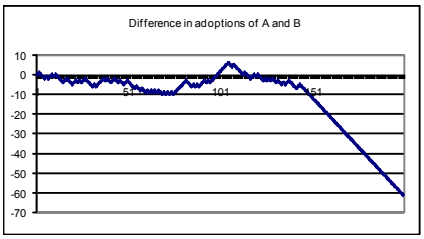
Example: Decreasing returns



Parameters: $r = s = -0.5$; $a_R = b_S = 2$; $a_S = b_R = 0.5$

Difference in adoption is $n_A(n) - n_B(n)$, when n choices in total have already been made

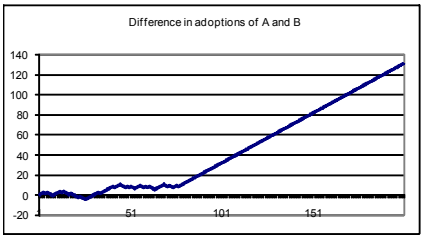
Example: Increasing returns – 1



Parameters: $r = s = 0.2$; $a_R = b_S = 3$; $a_S = b_R = 0.7$

Difference in adoption is $n_A(n) - n_B(n)$, when n choices in total have already been made

Example: Increasing returns – 2



Parameters: $r = s = 0.2$; $a_R = b_S = 3$; $a_S = b_R = 0.7$

Note: Same parameters as before, only different random sequence of agents!

Winner takes all…

- Increasing returns in Arthur's model equivalent to network externalities
  - Utility of consumers depends positively on the size of other users of the product / system
  - Examples for products with direct network externalities:
    - Marketplaces on the Internet (Ebay…)
    - Computer software (Word, Excel…)
  - Examples for products with indirect network externalities (through complementary products / services):
    - Blue-Ray vs. HD DVD (players, recorders & software)
    - VHS vs. Sony Beta (players, recorders & software)

Strategic management in network markets – 1

- The central decision of firms:
  - Either compete *against* system of rival(s) – Standards war:
    - No compatibility, no links between systems
    - Users of one system do not have access to services / products / users of competing systems
  - Or compete *within* system of rival(s)
    - Compatibility of systems, links or adapters – which standard?
    - Customers of one firm have access to services / products / users of competing firm(s)
    - Relevant size of the *network* is number of customer of all firms producing within a particular technological system or standard
- Does the firm want to be a monopolist in a (maybe very) small market, or a competitor in a larger market?

Strategic management in network markets – 2

- Customer decision:
  - Consider benefits of competing technologies
    - Technological utility
    - Installed base of users
    - Availability of complementary goods and services
  - What is going to be the future network size for the competing technologies?
    - Form expectations
    - If all or at least most customers form the same expectations, expectations will become a "self-fulfilling prophecy"
    - If consumers expect a seller to be dominant, they will be willing to pay more for the firm's product

Katz and Shapiro (1985) – 1

- Some assumptions:
  - Consumers buy at most one brand
    - First, consumers form expectations about future network sizes
    - Second, firms play a Cournot output game, taking expectations as given
    - Third, based on the resulting quantities and prices, consumers make their purchase decision, given their reservation prices
  - Consumers are heterogeneous regarding willingness to pay for a product, but homogeneous regarding their valuation of network externality
    - Network externality valuation is continuous and "well behaved"
    - Basic demand for product (excluding network effect) is linear and positive

Katz and Shapiro (1985) – 2

- Some assumptions (continued):
  - Numerous firms competing in the network market
    - Products in the market can be:
      - Completely incompatible
      - Partially compatible (> 2 firms)
      - Completely compatible
  - Fixed and variable costs of production are zero, but achieving compatibility with other products (e.g. building an adapter) is costly
  - Fulfilled expectations equilibrium
    - Only consider equilibria for which costumer expectations turn out to be correct
    - It is not modeled *how* expectations are formed

Katz and Shapiro (1985) – 3

- Some results:
  - When all products are mutually **compatible**, there is a unique equilibrium. It is symmetric, and if the number of firms is large, the solution approaches the perfectly competitive equilibrium.
  - Complete **incompatibility** - there can be three types of equilibrium outcomes:
    - Symmetric oligopoly with n active firms (always exists)
    - Symmetric oligopoly with $k < n$ active firms (possible for some parameter values)
    - Asymmetric oligopoly with $k \geq 2$ firms produce unequal levels of output (possible for some parameter values)
  - Multiple equilibrium outcomes for identical parameters possible
    - Which one is realized depends on ***consumer expectations***!

Katz and Shapiro (1985) – 4

- Some results:
  - Market failure:
    - Complete compatibility maximizes industry output and social welfare, but firms joint incentives to achieve compatibility is too low
  - Mergers harm outside competitors and benefit consumers:
    - If two or more firms decide to make their products compatible, this will rise total output, the average output of each postmerger firm, and harm the output of all firms that are not in the merger
  - Pesky little brother:
    - Incentives to achieve compatibility (constructing an adapter) are bigger for small players and lower for large players.
    - In fact, large players may have a strong interest to **avoid compatibility** of smaller rivals.