Lecture 7: Networks

Agenda

Last week

- Designing markets, the case of ad auctions
- Online markets

This week

- Networks
- Platforms

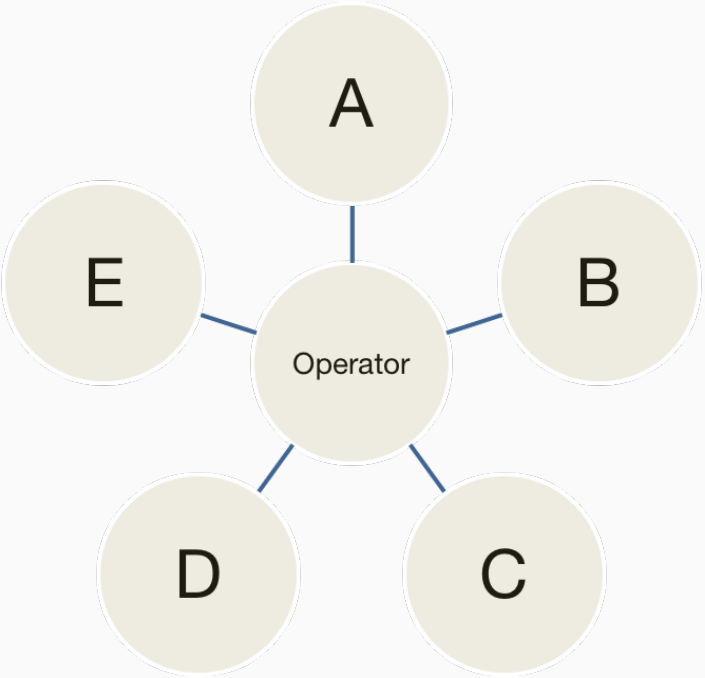
Network business – it's the 1990s

- The basic idea was simple and powerful:
  - In some cases a service is more valuable if more customers are using it because customers want to interact with each other.
  - If a firm moves fast and gets some customers, those customers will attract more customers, which will attract even more.
  - As a result, growth will be explosive and result in a single firm owning the market forever.
  - The winner would take all.
- These interrelated customers are called a network, and the feedbacks between customers are called network effects.

Source: Evans and Schmalensee, 2017.

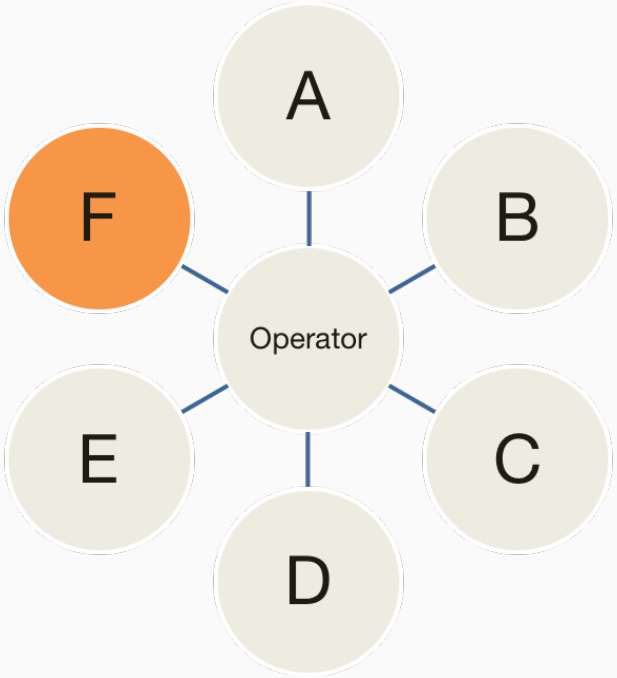
Traditional networks

In a traditional network, network externalities arise because a typical subscriber can reach more subscribers in a larger network.



Traditional networks

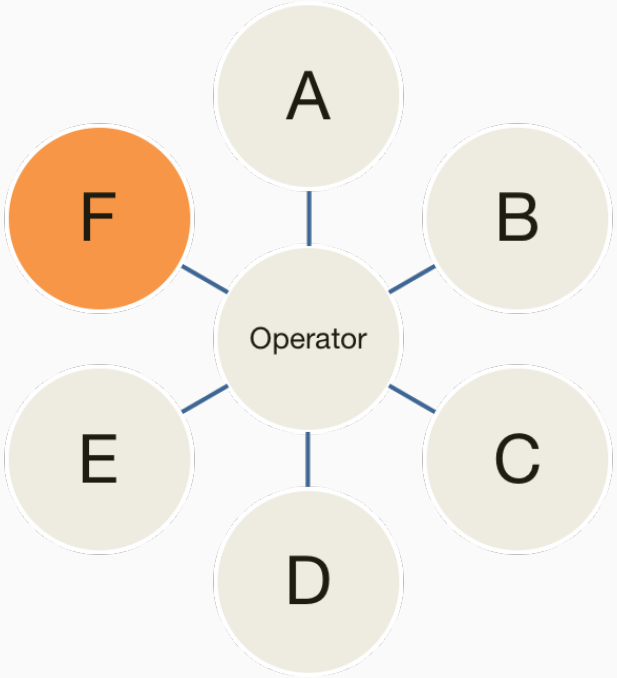
- The number of potential transactions increases with network size.
- If every new transaction has positive value, a larger network gives higher value to a subscriber.



Complementarities

Links from subscribers to the operator are used as complements:

- Enabling connection F–A through the operator enables also connections F–B, . . . , F–E.



Reminder: The law of demand with traditional goods

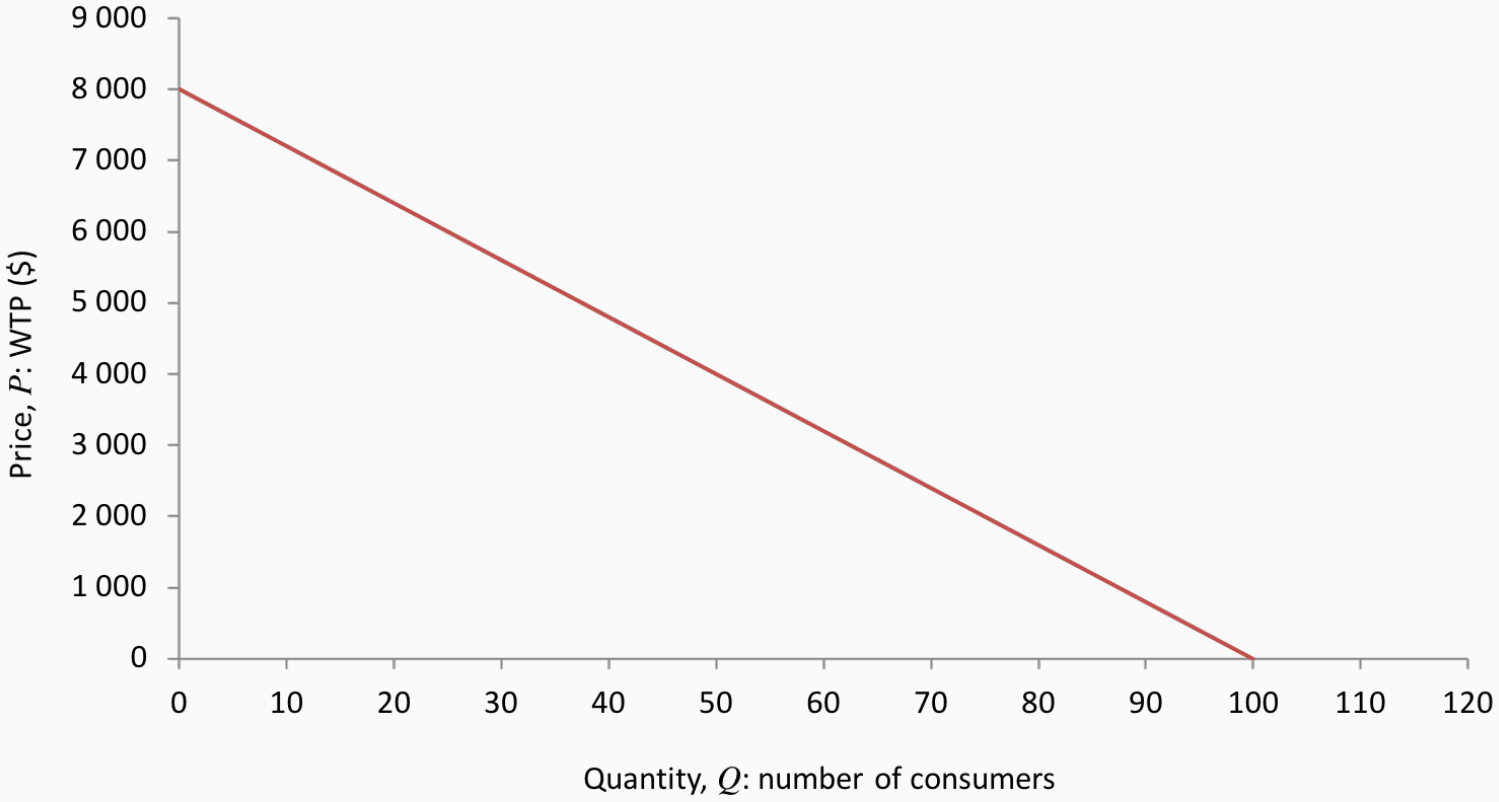


Figure. In traditional non-network industries, the willingness to pay for the last unit of a good decreases with the number of units sold.

Source: CORE.

Network effects

- The existence of positive network effects implies that, as sales expand, people are willing to pay more for the last unit.
- The key reason for the appearance of network effects is the complementarity between network components.
- The network effects may be direct or indirect, e.g.
  - Direct effects: You value Instagram because others use it.
  - Indirect effects: You don't directly gain if someone else has the same OS on their phone. But the larger user base makes the system attractive for developers, and you value the apps.
- *Different* from pure economics of scale:
  - E.g. a larger phone manufacturer has more resources to develop their phone.

Network effects

- Take 100 people who are in a market for a network good.
- Index the people from $v = 1, \ldots, 100$.
- Now assume that the value of the good the person v is vn, where n is the number of subscribers to the network.
- If price is set at p, then some individual, $\hat{v}$, is indifferent between buying the good or not buying it: $p = \hat{v}n$.
- Number of people with $v \geq \hat{v}$ is $n = 100 - \hat{v}$. Combining these we get the following equilibrium prices:

$$p = (100 - n)n$$

Network effects

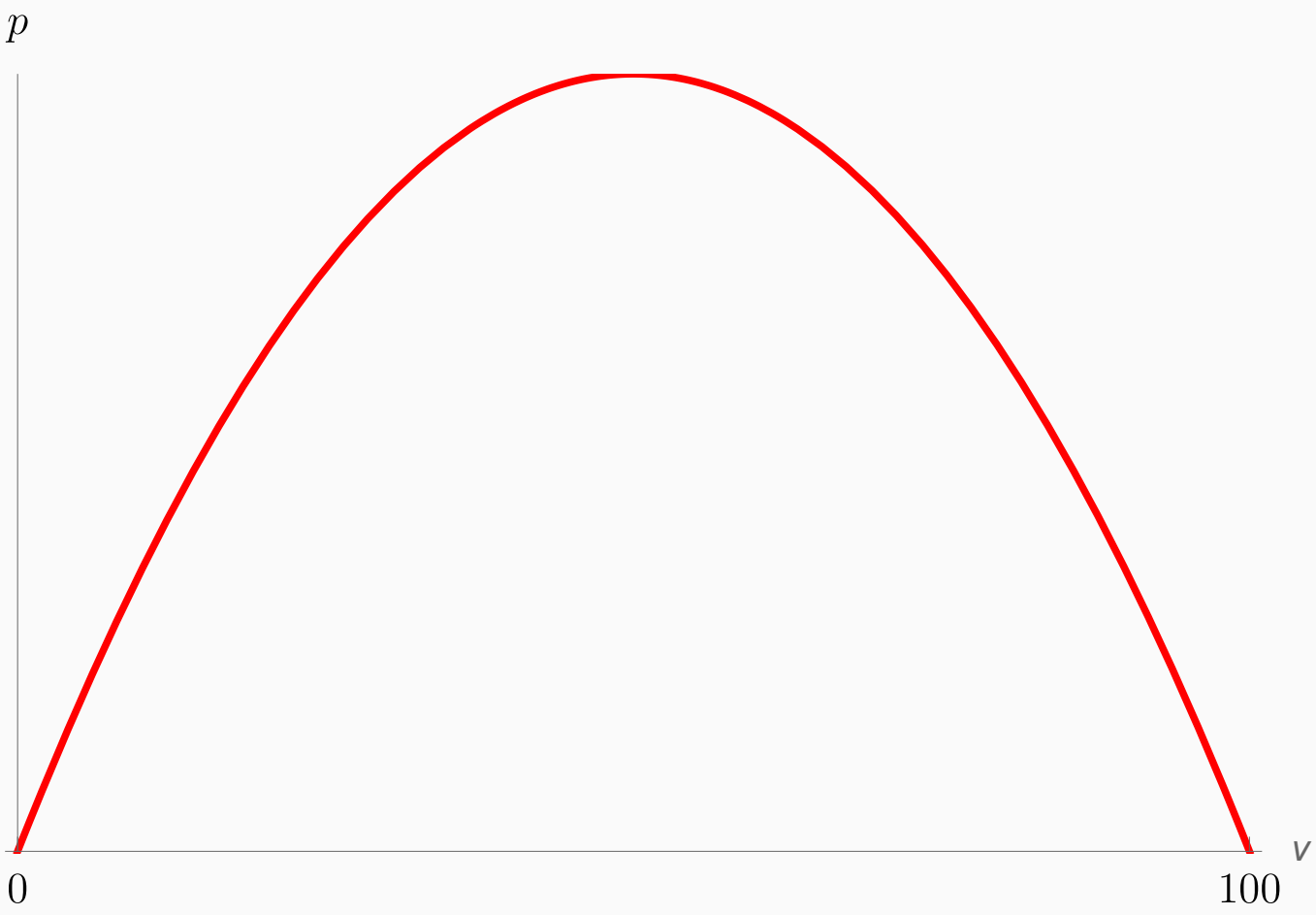


Figure. Equilibrium price as a function of people choosing to subscribe to the network.

In-class exercise: Network effects

- We will play several rounds.
- In each round, you will have to decide whether or not to join an exclusive club.

In-class exercise: Network effects

- The price of membership for everyone is $p_0 = 1,000$ € throughout the exercise.
- The value of the membership to you in a given round is determined by two things: your type and the number of people who join.
- Your private value for the item is as before:
  - Take the last two digits of your student number
  - As an example, I'd have 96 (IIRC)

In-class exercise: Network effects

- Your valuation (or willingness-to-pay or reservation price) is equal to your type times the number of other people that buy it.
- The valuation is zero if no one else buys the commodity.
- As an example
  - If 10 other people buy the commodity, then the valuation for livo is $96 * 10 = 960$ €, less than the price of 1,000 €.
  - If 20 other people buy the commodity, then the valuation for livo is $96 * 20 = 1,920$ €, more than the price of 1,000 €.

In-class exercise: Network effects

- At the start of each round, you either *Join* or *Do Not Join*.
  - Use the poll in Presemo presemo.aalto.fi/digimar.
- After everyone has decided, you will be told the number of people who joined.
- You can then calculate your valuation.
- And your payoff is as follows:
  - If your decision is *Join*, your payoff is equal to the valuation of the club to you, minus its price.
  - If your decision is *Do Not Join*, your payoff is zero.
- Keep track of your scores.

Network effects

But to which equilibrium will the market end up?

- The fulfilled expectations formulation (Katz and Shapiro, 1985) gives one possibility.

Model of fulfilled expectations

- Let n^e to denote consumer expectations on the number subscribers to the network service.
- $v(n; n^e)$ denotes the value for the nth buyer when n^e units are expected to be sold.
- Properties of the value function $v(n; n^e)$:
  - $v(n; n^e)$ is a decreasing function of n because the demand slopes downward (as normal).
  - $v(n; n^e)$ increases in n^e if the network effect is positive: the good is more valuable when the expected sales n^e are higher.

Model of fulfilled expectations

- As an example, we'll use:

$$v(n; n^e) = (1 - n)n^e$$

- n and n^e are normalized so that they represent market coverage, ranging from 0 to 1, rather than absolute quantities.
- Consumers that are indexed by low values of n value the subscription highly, whereas consumers that are indexed by n close to 1 place a low valuation on this service.
- This formulation was used in the very first paper to formalize network economics in the context of telecommunications subscriptions (Rohlfs, 1974).

Model of fulfilled expectations

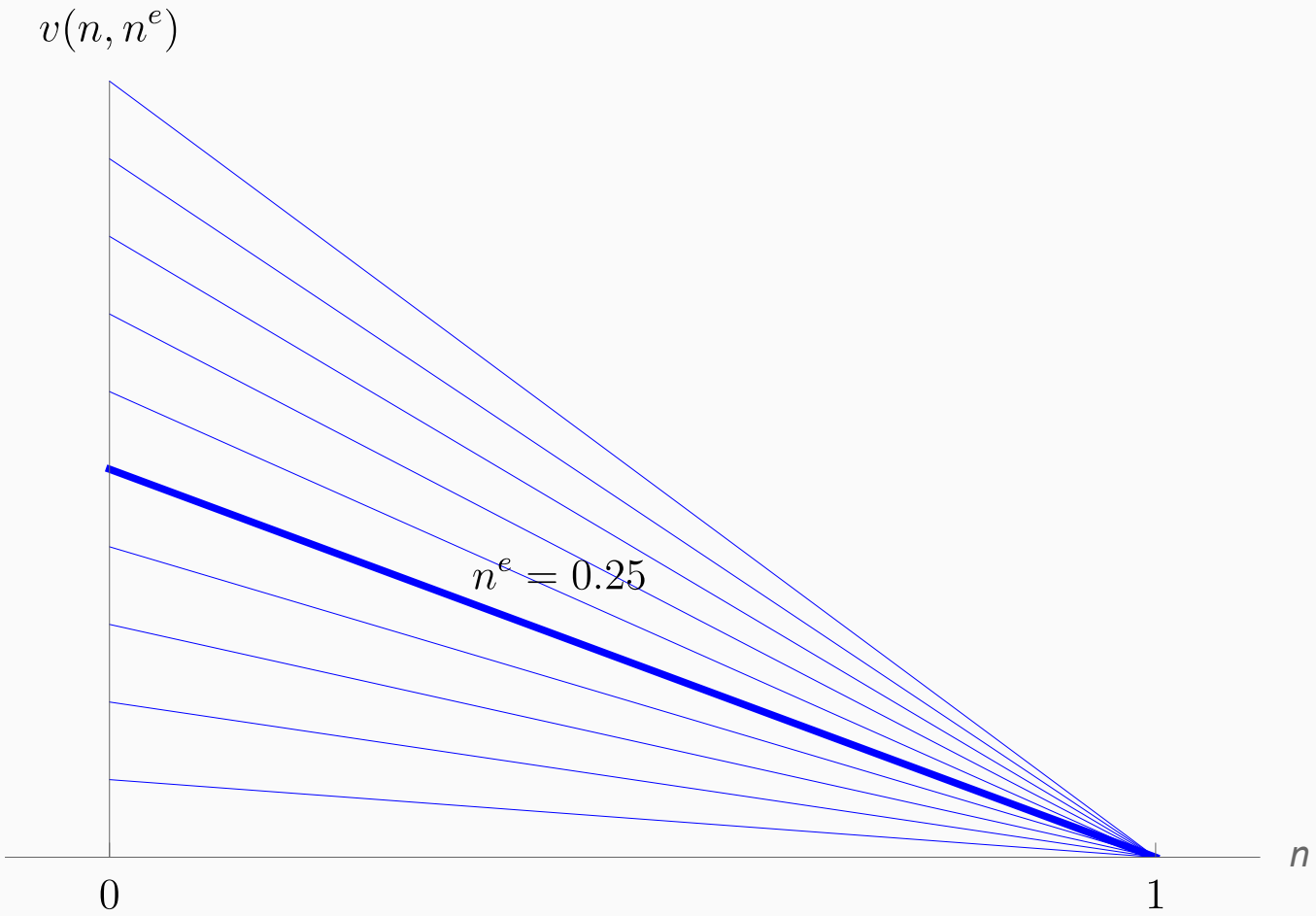


Figure. Value as a function of n when n^e is fixed to different levels, e.g. if $n^e = 0.25$ then $v(n; 0.25) = 0.25(1 - n)$.

Model of fulfilled expectations

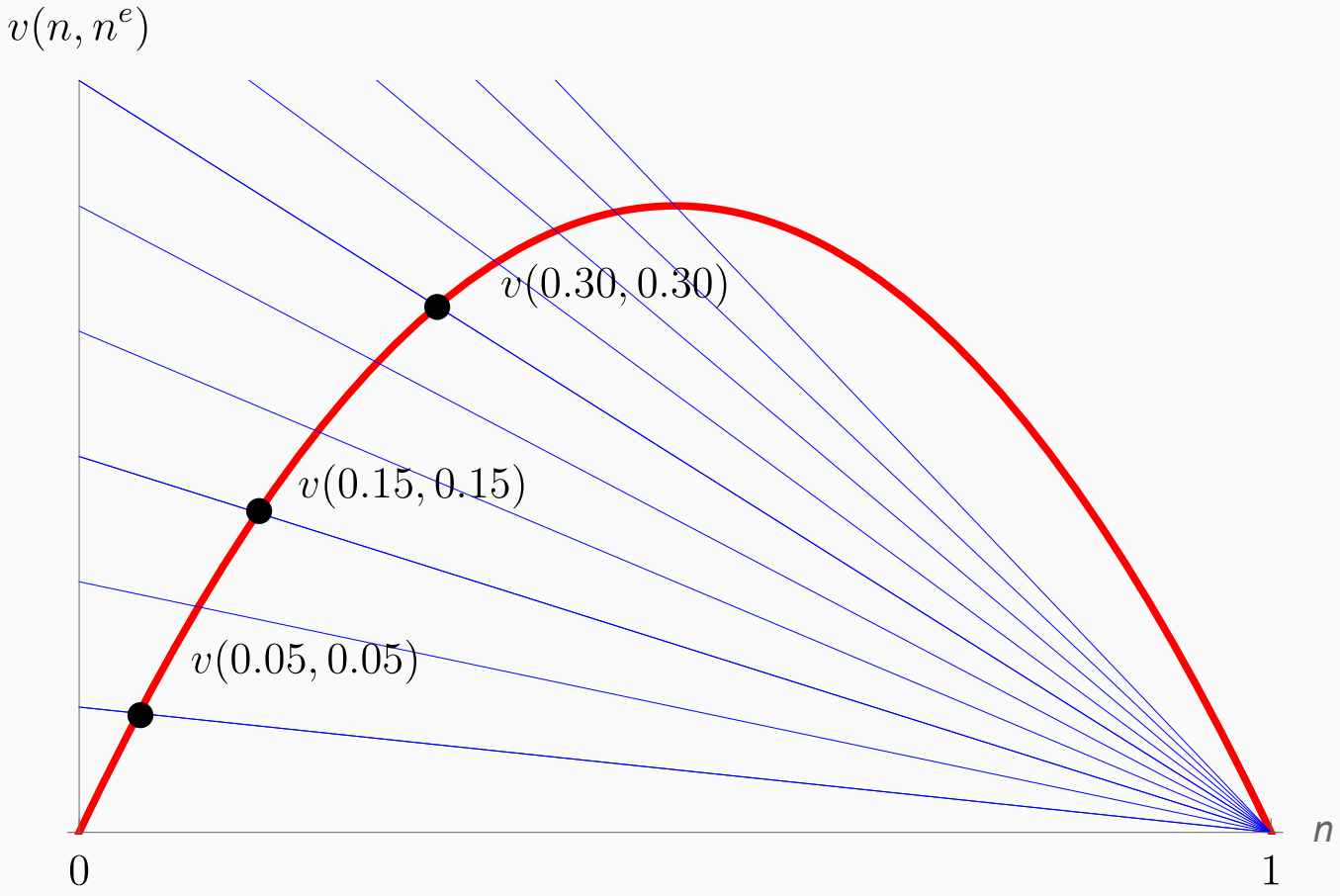


Figure. Three examples where n^e is fixed to 0.05, 0.15, 0.30 and the value is plotted as a function of n. The equilibrium points are at $n = n^e$.

Model of fulfilled expectations and prices

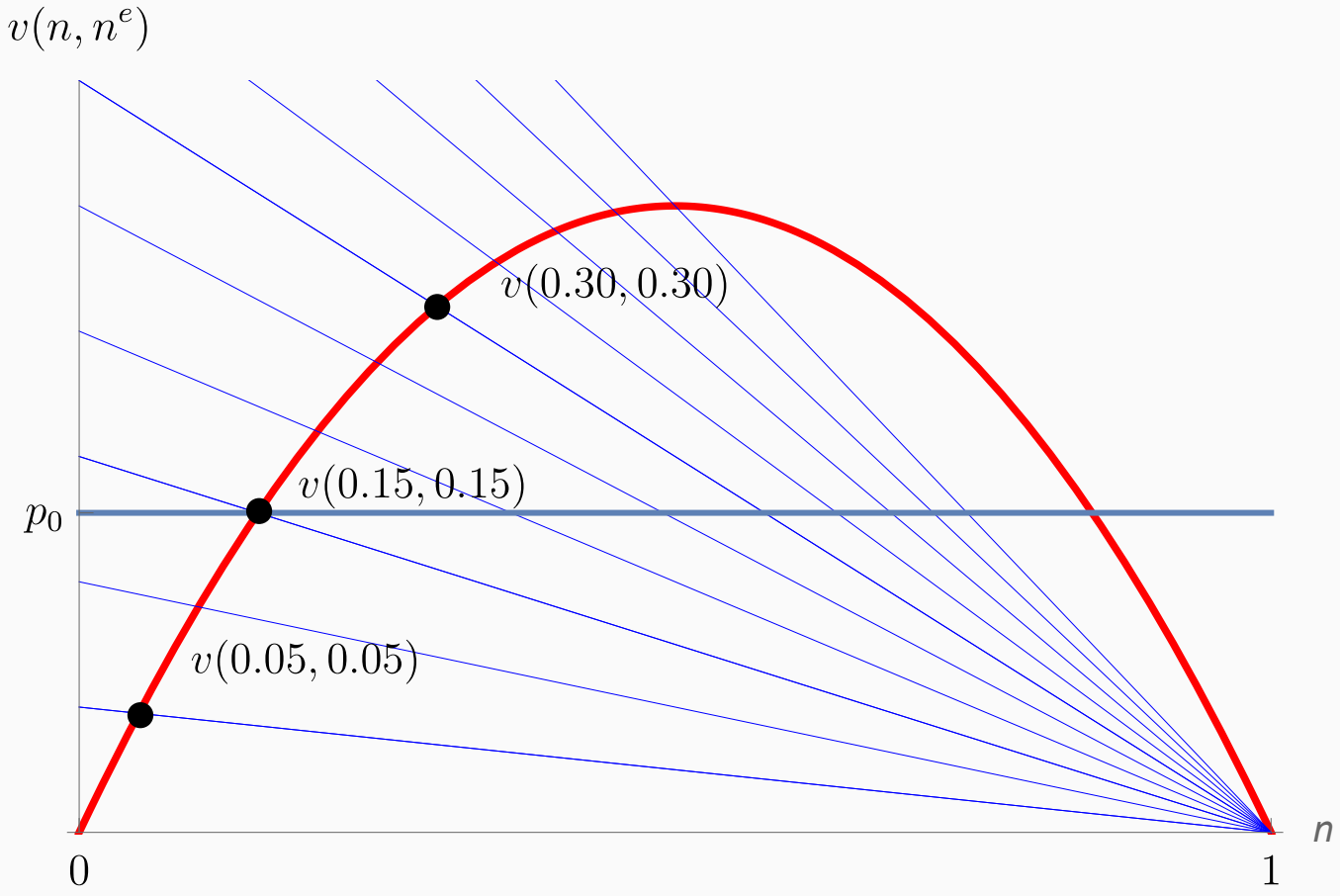


Figure. If price is set at $p_0 = (1 - 0.15) * 0.15$, then the marginal subscriber in equilibrium has a value of p_0.

Market clearing quantities and prices

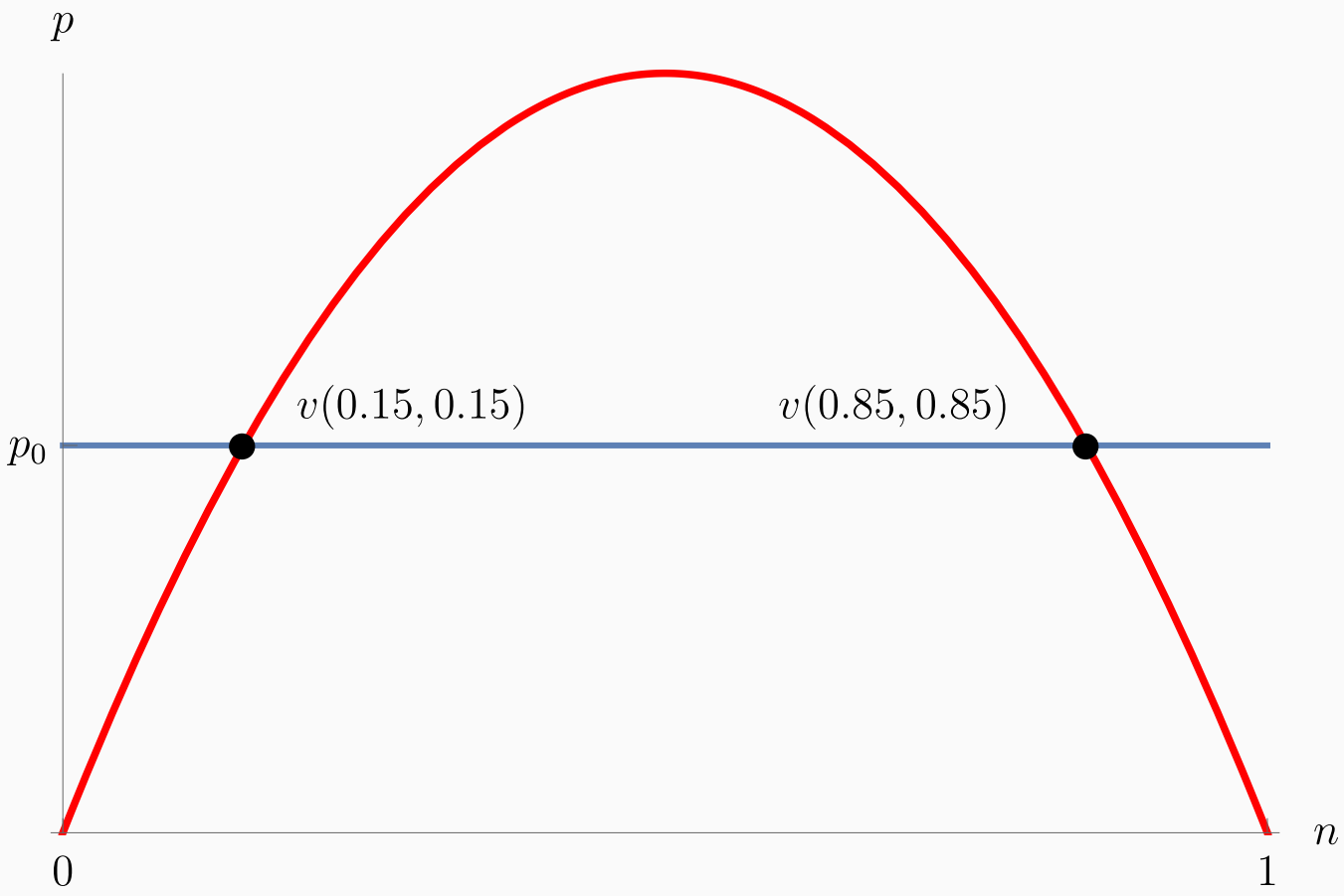


Figure. But also $(1 - 0.85) * 0.85$ is an equilibrium at the same price p_0.

Multiplicity of equilibria

- Above, the first equilibrium $(0.15, 0.15)$ is unstable:
  - A small reduction in n leads to the collapse of the network.
  - A small increase in n leads to the rapid growth of the network.
- The second equilibrium $(0.85, 0.85)$ is stable:
  - Back to the "normal" downward sloping part of the demand curve.
- Multiple equilibria are a result of the coordination problem.
  - Everyone would be better off at $(0.85, 0.85)$.
  - But need to coordinate the expectations to reach that point.
  - Network operators may facilitate coordination by e.g creating expectations and pricing differently as the network increases.

Demand in network markets

The fulfilled expectations demand is increasing for small n if one of three conditions hold:

(i) the utility of every consumer in a network of zero size is zero
  - e.g. telecommunications, Facebook.

(ii) there are immediate and large external benefits to network expansion for very small networks
  - e.g. basically any Telegram group.

(iii) many of the high-willingness-to-pay consumers are just indifferent on joining a network of approximately zero size
  - e.g. software, such as R, Python or Julia.

As a result, some portions of the demand curve can slope upwards (compare with the law of demand for traditional goods).

Source: Economides and Himmelberg, 1995.

Efficiency

- In perfect competition, prices will equal marginal cost.
- But if there are network effects, then marginal cost pricing is no longer efficient.
- When making a decision to join the network, individuals count only their own benefits.
- With a positive network *externality*, the marginal benefit to the society is greater than the marginal benefit to any one individual.
- (Note that the network externality may also be negative, and then the reverse is true. Road congestion is an example.)

Efficiency

- Socially optimal size of the network is different from the size resulting from competition.
- This is an argument for government subsidies:
  - E.g. railroad networks receive subsidies in many countries.
  - But the best form of the subsidy can be problematic.
- Monopoly does not necessarily choose optimal size:
  - Incentive of the monopolist to restrict output can outweigh its incentive to increase consumer demand by influencing expectations about network size.
  - If the network firm is allowed internalize the external benefits (i.e. take the money), then the service level can be closer to socially optimal than with strict enforcement of competition, similar to price discrimination in the typical goods case.

Learnings today

- Network effects are generated by increasing the adoption rate (popularity) of a good or a service.
- Network effects affect demand and the market equilibria: demand curve can be upward sloping and there can be multiple equilibria.
- Social efficiency is harder to achieve, because competition does not reward for the externalities.

Materials for this week

Online resources (for Lecture 7):

- **Externalities**. Remind yourself of the economics of positive externalities mru.org: Positive Externality.
- **Network externalities**. www.core-econ.org 21.3 and 21.4.

Reading assignment 4:

- Katz, M. and C. Shapiro (1994) "Systems Competition and Network Effects", The Journal of Economic Perspectives. Read at least until top of p. 103 and Conclusions.
- Evans, D. and R. Schmalensee (2007) "The Industrial Organization of Markets with Two-Sided Platforms", Competition Policy International. Feel free to skip V and VI. Also, Section III A. Pricing, will be discussed more in depth in Lecture 10.

Next time

- Platforms
- Equilibria in platforms
- Identifying externalities

Appendix

Figure: Smithsonian.

Network business – it's the 1990s

- American Online (AOL) is an example of a network business:
  - The roots of the company are in the 1980s when it was providing online services via a modem link.
  - In 1995, the company had roughly 5 million subscribers.
  - The following year AOL opened dial-up internet connection, and went on to reach 20+ million customers by 2000.
  - America Online agrees to purchase Time Warner for $165 billion in what would be the biggest merger in history.
- A quote from an analyst:

  "The dot-com guys have sort of won" (NYT, 11 Jan 2000).

Network business – it's the 1990s

- The first dotcom boom crashed in 2000, wiping out much of the expected valuations of internet companies.
- AOL's growth stopped around the same time, its dial-up subscription service lost to broadband internet.
- Clearly, the network model was not working in all cases.
- We still need to understand it to be able to discuss what went wrong; and the basic logic is still valid in many examples.

Impact of costs

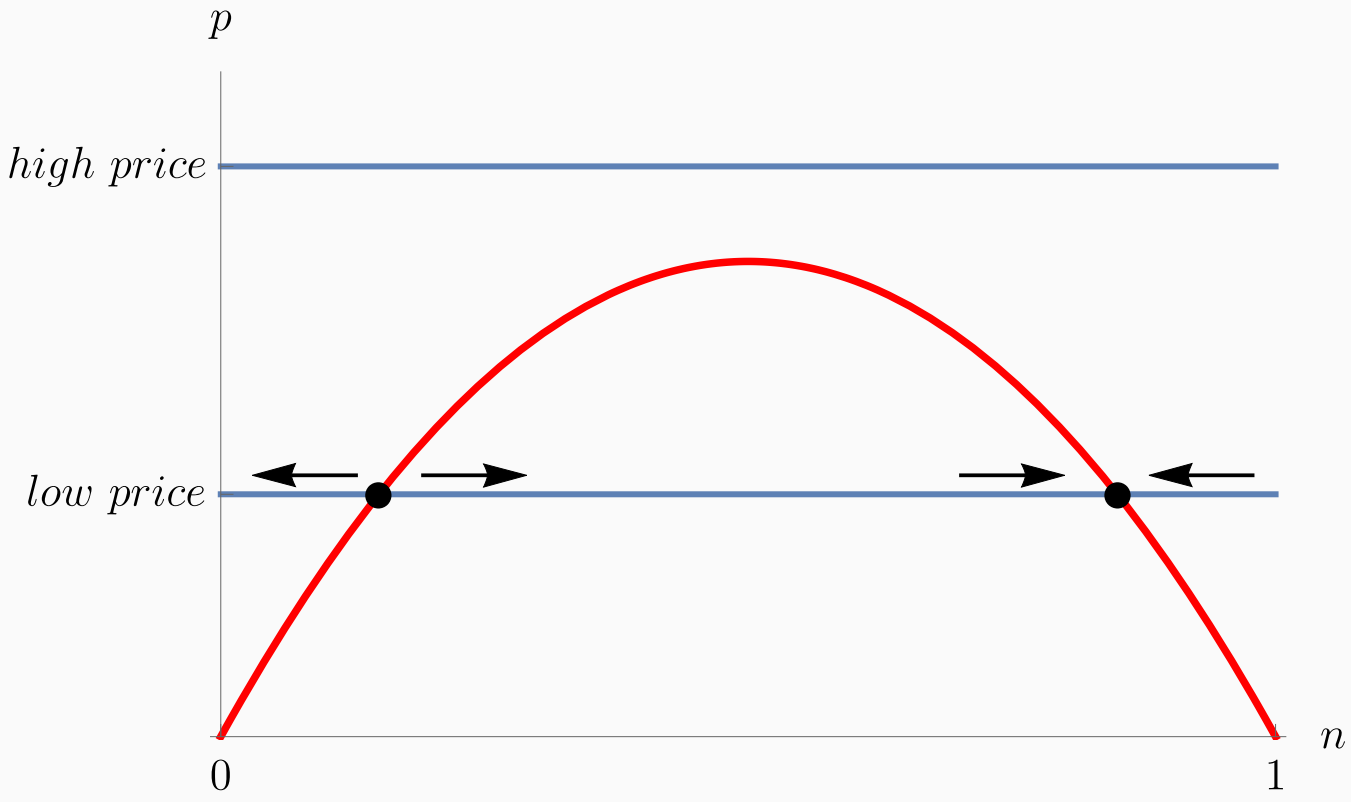
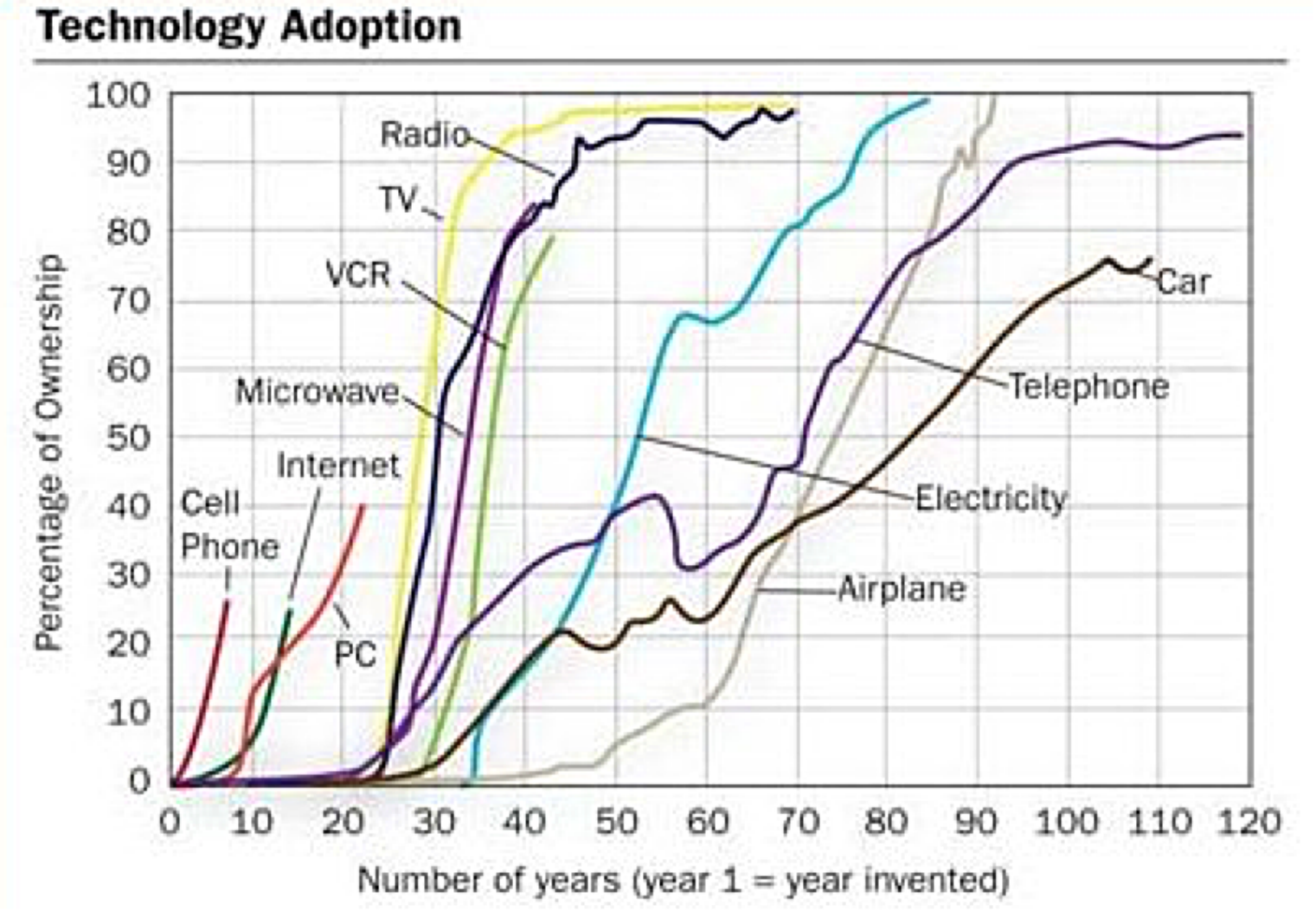


Figure. In competitive markets, the price will be set on the basis of cost. When costs are high, equilibrium is at zero. If costs come down, other equilibria become possible.

Network adoption

- The existence of an upward slopping part of the demand curve and the multiplicity of equilibria even under perfect competition also allows for a network to start with a (relatively) small size and then expand significantly.
- It is possible that the industry starts with low expectations initially as e.g. costs are high, and later on advances quickly to the right equilibrium.

Adoption – Examples



Source: Forbes Magazine.