Network Economics

for the MBA class

"Networks, Telecommunications Economics,

and Digital Convergence"

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- This course is about the economics of network industries.

- The crucial defining feature of a network industry is the existence of *network effects*.

- An market has network effects when, everything else being equal, the willingness to pay of a consumer increases with the number of units sold or expected to be sold.

- In the presence of *full compatibility*, each firm is able to reap the network effects from the whole industry.

- In the absence of full compatibility, a firm is able to reap the network effects from a set of firms which are compatible with it, which may even consist of only itself.

- The economics (market structure and shares, pricing, investment) of a network industry are fundamentally different depending on whether a firm is able to individually define and alter technical standards so that its products are compatible or incompatible with other firms.

- When firms are able to lawfully alter technical standards and be incompatible with other firms, there are fundamentally new and interesting features of market structure. Moreover, the decision whether to be compatible with other firms, and to what extent, is a fundamental strategic decision of firms in these markets.

- We will study this class of markets in the first part of the course.

- On the other hand, in a regulated industry, and most notably in many telecommunications markets, firms are required to be compatible with competitors.

- In telecommunications, this is guaranteed by mandatory interconnection among all service providers.
    - This maximizes network effects, and simultaneously eliminates the possibility of choosing incompatibility.
    - Thus, in a regulated network industry the issues are usually confined to the special case of full compatibility.

- Regulation also raises a number of new issues. In practice, only some telecommunications markets are regulated and many of these are progressively deregulated.

- This raises the issue of which telecommunications markets to deregulate and how to shield markets from potentially anti-competitive effects.

- We will study the telecommunications sector in the second part of the course.

Fundamentals of Network Industries

- Network industries are key industries.

- They include: telecommunications, computers, broadcasting, cable television, airlines, railroads, electricity, roads, and shipping, and the delivery services that "live" on these, such as the postal service and its competitors.

- In the financial sector, networks include traditional financial exchanges for bonds, equities, and derivatives, clearing houses, B2B and B2C exchanges, credit and debit card networks, as well as automated transactions banking networks, such as ATM networks.

- Besides network industries where the network is immediately apparent, many of the features of networks apply to virtual networks.

- A virtual network is a collection of compatible goods that share a common technical platform.
    - For example, all VHS video players make up a virtual network.
    - Similarly, all computers running Windows 95 can be thought of as a virtual network.
    - Compatible computer software and hardware make up a network, and so do computer operating systems and compatible applications.
    - More generally, networks are composed of complementary components, so they also encompass wholesale and retail networks, as well as information networks and servers such as telephone yellow pages, Yahoo, Google, etc.

- Networks are composed of complementary nodes and links.

- The crucial defining feature of networks is the complementarity between the various nodes and links.

- A service delivered over a network requires the use of two or more network components.

- Thus, network components are complementary to each other.

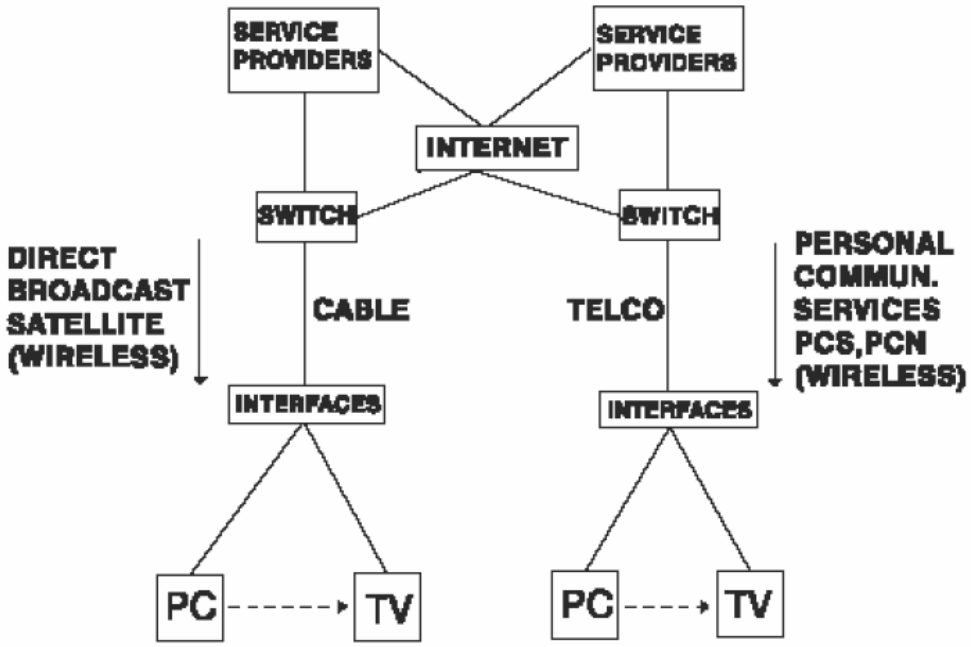


Figure 1: **The Information Superhighway**

- Network effects arise because of complementarities.
    - In a traditional network, network externalities arise because a typical subscriber can reach more subscribers in a larger network.
    - See Figure 2 which depicts a traditional telecommunications network where customers A, B, …, G are connected to a switch at S.
    - Although goods "access to the switch" AS, BS, …, GS have the same industrial classification and traditional economics would classify them as substitutes, they are used as complements.
    - In particular, when customer A makes a phone call to customer B, he uses both AS and BS.

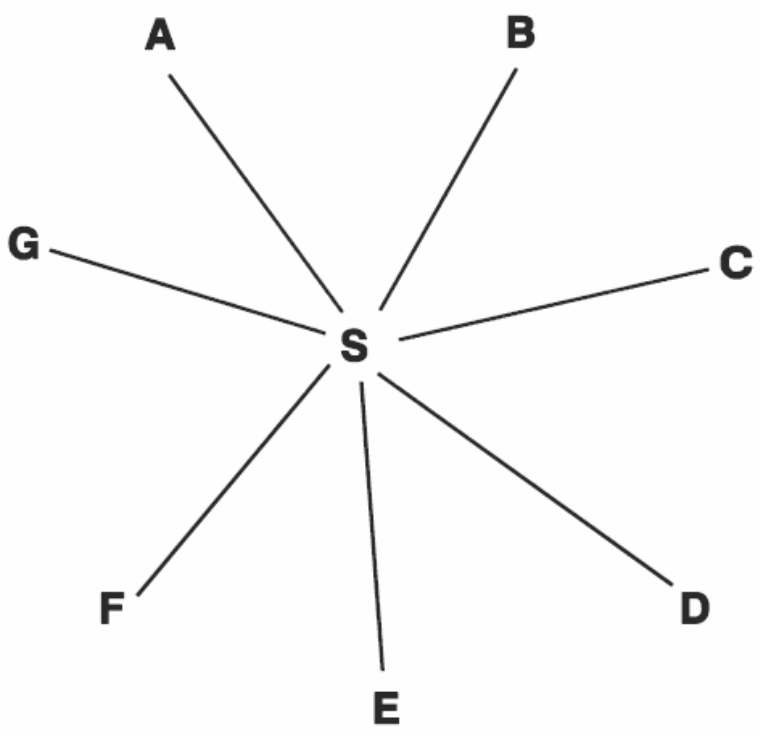


Figure 2: A star network

One-way and Two-way Networks

- Networks where services AB and BA are distinct are called “two-way” networks.
    - Two-way networks include railroad, road, and many telecommunications networks.

- When one of AB or BA is unfeasible, or does not make economic sense, or when there is no sense of direction in the network so that AB and BA are identical, then the network is called a one-way network.

- In a typical one-way network, there are two types of components, and composite goods are formed only by combining a component of each type, and customers are often not identified with components but instead demand composite goods.

- For example, radio and TV broadcasting and early paging networks are one-way networks.

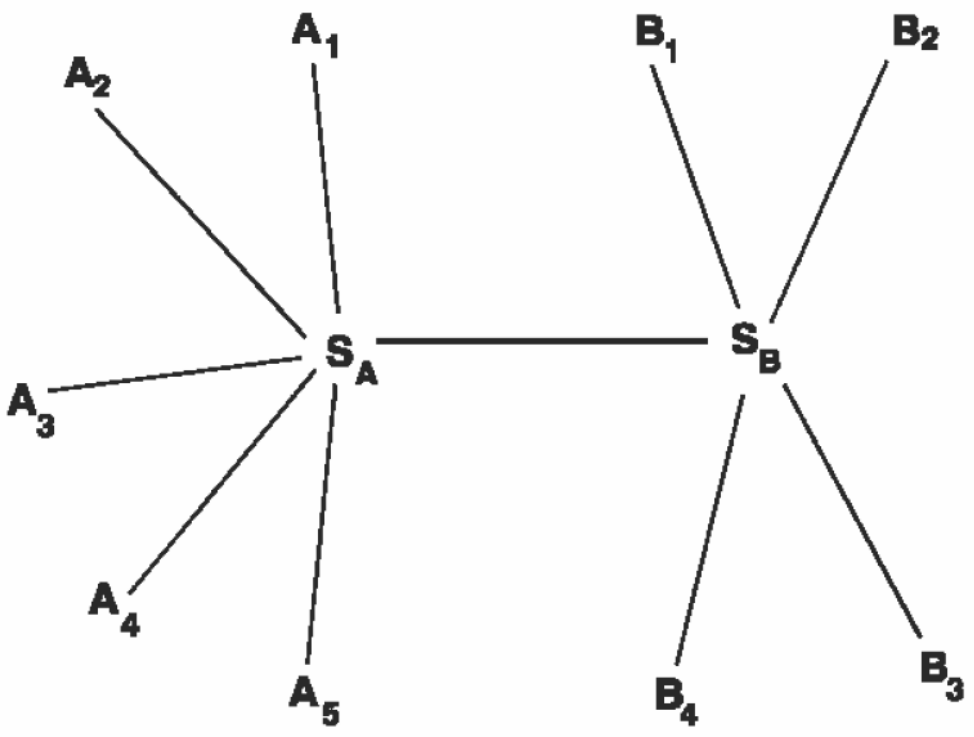


Figure 3: **A long distance network**

- The network in Figure 3 can be interpreted as a long distance (two way) network or, alternatively, as an ATM (one-way) network.

- The crucial relationship in both one-way and two-way networks is the complementarity between the pieces of the network.

- This crucial economic relationship is also often observed between different classes of goods in non-network industries.

- Figure 4 can represent two industries of complementary goods A and B, where consumers demand combinations D_iS_j.

- Notice that this formulation is formally identical to our long-distance network of Figure 3 in the ATM interpretation.

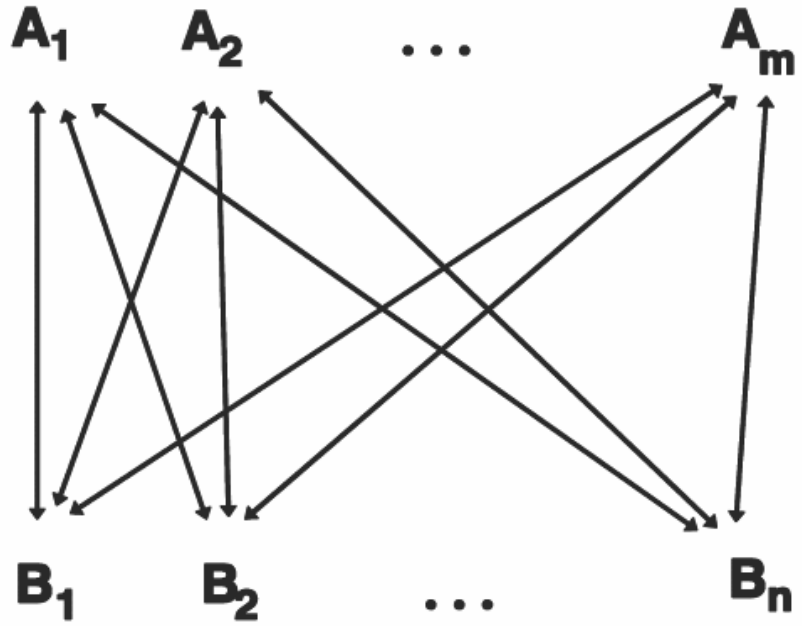


Figure 4: A virtual network of complementary goods

Compatibility

- So far we have assumed compatibility, i.e., that various links and nodes on the network are costlessly combinable to produce demanded goods.

- Two complementary components A and B are compatible when they can be combined to produce a composite good or service.
    - For example, we say that a VHS-format video player is compatible with a VHS-format tape.
    - Two substitute components A1 and A2 are compatible when each of them can be combined with a complementary good B to produce a composite good or service.
        - For example, two VHS tapes are compatible;
        - two VHS video players are compatible.
    - Similarly we say that two software products are compatible (more precisely two-way compatible) when they each can read and write files in a common format.
        - Clearly, compatibility may be one-way when one the files of format B1 of software A1 can be read by software A2 , but the files format B2 of software A2 cannot be read by software A1.
        - Moreover, compatibility may be only partial in the sense that software A1 is able to read files of format B2 but unable to write files in that format.

- Links on a network are potentially complementary, but it is compatibility that makes complementarity actual.

- Some network goods and some vertically related goods are immediately combinable because of their inherent properties.

- However, for many complex products, actual complementarity can be achieved only through the adherence to specific technical compatibility standards.

- Thus, many providers of network or vertically-related goods have the option of making their products partially or fully incompatible with components produced by other firms.

- This can be done through the creation of proprietary designs or the outright exclusion or refusal to interconnect with some firms.

- As we will see, it is not always in the best interests of a firm to allow full compatibility of its products with those of its competitors.

- The extent to which a firm is compatible with the products of other firms is an important strategic decision for a firm, and will be discussed in detail further on.

Virtual Networks

- A virtual network can be thought of as a collection of compatible goods that share a common technical platform.
  - For example, all VHS video players make up a virtual network.
  - Similarly, all computers running Windows XP can be thought of as a virtual network.

- More generally, a virtual network can be thought of a combination of two collections of two types of goods $\{A_1, \ldots, A_m\}$ and $\{B_1, \ldots, B_n\}$ such that
  - (i) each of the A-type good is a substitute to any other A-type good;
  - (ii) each of the B-type good is a substitute to any other B-type good; and
  - (iii) each of the A-type good is a complement to any A-type good.

- Virtual networks are one-way networks.
  - Examples of virtual networks: computer hardware and software; computer operating systems and software applications, cameras and compatible film, razors and compatible blades etc.

- Clearly there are many more virtual networks than traditional networks.

- In a *virtual network,* externalities arise because larger sales of components of type A induce larger availability of complementary components B_1, ..., B_n, thereby increasing the value of components of type A. See Figure 4.

- The increased value of component A results in further positive feedback.

- Despite the cycle of positive feedbacks, it is typically expected that the value of component A does not explode to infinity because the additional positive feedback is expected to decrease with increases in the size of the network.

Network Effects
Sources of Network Effects

- In traditional non-network industries, the willingness to pay for the last unit of a good decreases with the number of units sold.
    - This is called the law of demand, and is traditionally considered to hold for almost all goods.

- However, the existence of network effects implies that, as more units are sold, the willingness to pay for the last unit may be higher.

- This means that for network goods, the fundamental law of demand is violated: for network goods, some portions of the curve demand can slope upwards.

- For some portions of the demand curve, as sales expand, people are willing to pay more for the last unit.

- The law of demand is still correct if one disregards the effects of the expansion of sales on complementary goods.

- But, as increased sales of a network good imply an expansion in the sales of complementary goods, the value of the last unit increases.

- Combining the traditional downward slopping effect with the positive effect due to network expansion can result in a demand curve that has an upward-slopping part.

- The key reason for the appearance of network externalities is the complementarity between network components.

- Depending on the network, the network effect may be direct or indirect.

- When customers are identified with components, the externality is direct.

- Consider for example a typical two-way network, such as the local telephone network of Figure 1. In this n-nodes 2-way network, there are 2n(n - 1) potential goods. An additional (n + 1th) customer provides direct externalities to all other customers in the network by adding 2n potential new goods through the provision of a complementary link (say ES) to the existing links.

- In typical one-way networks, the network effect is only indirect.

- When there are m varieties of component A and n varieties of component B as in Figure 2 (and all A-type goods are compatible with all of B-type), there are mn potential composite goods.

- An extra customer yields indirect externalities to other customers, by increasing the demand for components of types A and B.

- In the presence of economies of scale in production, the increase in demand may potentially increase the number of varieties of each component that are available in the market.

- Exchange networks (financial networks such as the NYSE and NASDAQ, commodities, futures, and options exchanges as well as business to business "B2B" exchanges) also exhibit indirect network externalities.

- There are two ways in which these externalities arise.
    - First, externalities arise in the act of exchanging assets or goods.
    - Second, externalities may arise in the array of vertically related services that compose a financial transaction.
        - These include the services of a broker, bringing the offer to the floor, matching the offer, etc.
        - The second type of externalities are similar to other vertically-related markets.

- The first way in which externalities arise in financial markets is more important.

- The act of exchanging goods or assets brings together a trader who is willing to sell with a trader who is willing to buy.

- The exchange brings together the two complementary goods, "willingness to sell at price p" (the "offer") and "willingness to buy at price p" (the "counteroffer") and creates a composite good, the "exchange transaction."

- The two original goods were complementary and each had no value without the other one.

- Clearly, the availability of the counteroffer is critical for the exchange to occur.

- Put in terms commonly used in Finance, minimal liquidity is necessary for the transaction to occur.

- Financial and business-to-business exchanges also exhibit positive size externalities in the sense that the increasing size (or thickness) of an exchange market increases the expected utility of all participants.

- Higher participation of traders on both sides of the market (drawn from the same distribution) decreases the variance of the expected market price and increases the expected utility of risk-averse traders.

- Higher liquidity increases traders' utility.

Network Effects Under Compatibility and Perfect Competition

- Let the willingness to pay for the nth unit of the good when n^e units are expected to be sold be p(n; n). n and n^e are normalized so that they represent market coverage, ranging from 0 to 1, rather than absolute quantities.

- Willingness to pay $p(n; n^e)$ is a decreasing function of n because the demand slopes downward.

- $p(n; n^e)$ increases in n^e; this captures the network externalities effect, i.e., that the good is more valuable when the expected sales n^e are higher.

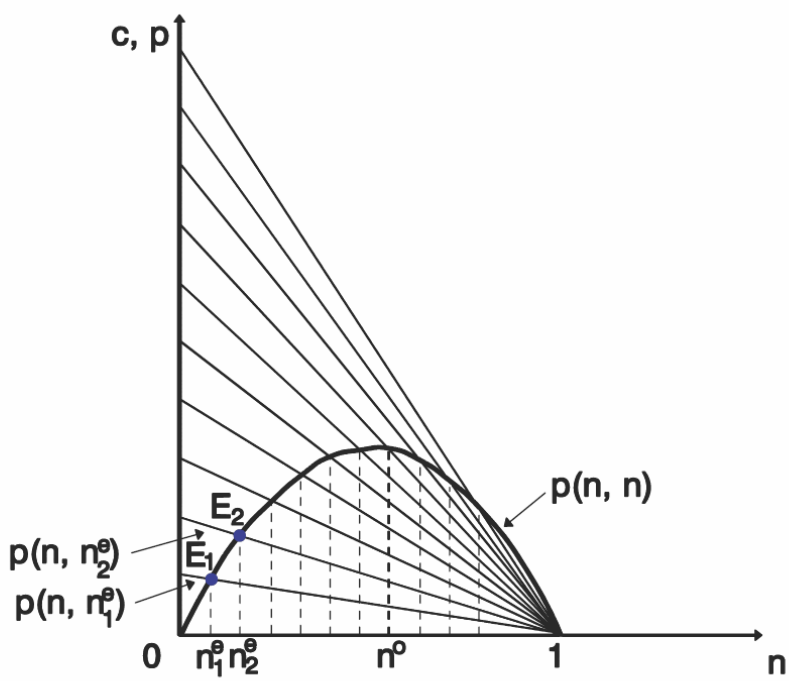


Figure 6: The fulfilled expectations demand and critical mass

- At a market equilibrium of the simple single-period world, expectations are fulfilled, $n = n^e$, thus defining the fulfilled expectations demand $p(n, n)$.

- Each willingness-to-pay curve $p(n, n_i^e)$, $i = 1, 2, ...$, shows the willingness to pay for a varying quantity n, given an expectation of sales $n^e = n_i^e$. At $n = n_i^e$, expectations are fulfilled and the point belongs to $p(n, n)$ as $p(n_i^e, n_i^e)$.

- Thus $p(n, n)$ is constructed as a collection of points $p(n_i^e, n_i^e)$.

- Economides and Himmelberg (1995) show that the fulfilled expectations demand is increasing for small n if either one of three conditions hold:
    - (i) the utility of every consumer in a network of zero size is zero; or
    - (ii) there are immediate and large external benefits to network expansion for very small networks; or
    - (iii) there is a significant number of high-willingness-to-pay consumers who are just indifferent on joining a network of approximately zero size.

- The first condition is straightforward and applies directly to all two-way networks, such as the telecommunications and fax networks where the good has no value unless there is another user to connect to

- The other two conditions are a bit more subtle, but commonly observed in networks and vertically-related industries.

- The second condition holds for networks where the addition of even few users increases significantly the value of the network.
    - A good example of this is a newsgroup on an obscure subject, where the addition of very few users starts a discussion and increases significantly its value.

- The third condition is most common in software markets.
    - A software application has value to a user even if no one else uses it.
    - The addition of an extra user has a network benefit to other users (because they can share files or find trained workers in the specifics of the application), but this benefit is small.
    - However, when large numbers of users are added, the network benefit can be very significant.

Critical Mass

- When the fulfilled expectations demand increases for small n, we say that the network exhibits a positive critical mass under perfect competition.

- If we imagine a constant marginal cost c decreasing as technology improves, the network will start at a positive and significant size no (corresponding to marginal cost c^o).

- For each smaller marginal cost, $c < c^o$, there are three network sizes consistent with marginal cost pricing:
    - a zero size network;
    - an unstable network size at the first intersection of the horizontal through c with p(n, n); and
    - the Pareto optimal stable network size at the largest intersection of the horizontal with p(n, n).

- The multiplicity of equilibria is a direct result of the coordination problem that arises naturally in the typical network externalities model.

- In such a setting, it is natural to assume that the Pareto optimal network size will result.

Multiplicity of Equilibria

- 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 small size and then expand significantly.

- Suppose, for example, that marginal cost is at $c < c^o$ and a new invention creates a new product with significant network effects.

- Then, it is possible that the industry starts at the left intersection of the horizontal at c with p(n, n) as expectations are originally low, and later on advances suddenly and quickly to the right intersection of the horizontal at c with p(n, n).

- Thus, the multiplicity of equilibria in network industries can lead to sudden significant expansions of network size.

Efficiency

- In the presence of network externalities, it is evident that perfect competition is inefficient.

- The marginal social benefit of network expansion is larger than the benefit that accrues to a particular firm under perfect competition.

- Perfect competition will provide a smaller network than is socially optimal, and, for some relatively high marginal costs, perfect competition will not provide the good while it is socially optimal to provide it.

- Since perfect competition is inefficient, state subsidization of network industries is beneficial to society.
    - The Internet is a very successful network that was subsidized by the US government for many years.
    - The subsidized Internet was aimed at promoting interaction among military research projects.
    - During the period of its subsidization, almost no one imagined that the Internet would become a ubiquitous commercial network.
    - The foundation of the Internet on publicly and freely available standards has facilitated its expansion and provided a guarantee that no firm can dominate it.

General Features of Markets with Network Effects

Ability to Charge Prices on Both Sides of a Network

- Fundamental properties of network industries that arise out of the existence of network effects.

- A firm can make money from either side of the network.
  - For example, a telecommunications services provider can charge subscribers when they originate calls or when they receive calls or for both.
  - When a network consists of software clients and servers, both provided by the same firm, the firm can use the prices of the client and server software to maximize the network effect and its profits.
  - For example it can distribute the client software at marginal cost (free) and make all its profits from the server software.
    - Adobe distributes the "Acrobat Reader" free while it makes its profits from the "Acrobat Distiller" product that allows the creation of files that can be read by the Acrobat Reader.

- The availability of prices on both sides of the network allows for complex pricing strategies, and, depending on the dynamics and market shares on the two sides of the market, can be used strategically to enhance and leverage a firm's strong strategic position on one side of the network.

Externalities Internalized or Not

- In network industries, often the additional subscriber/user is not rewarded for the benefit that he/she brings to others by subscribing.

- Hence typically there are "externalities," i.e., benefits not fully intermediated by the market.

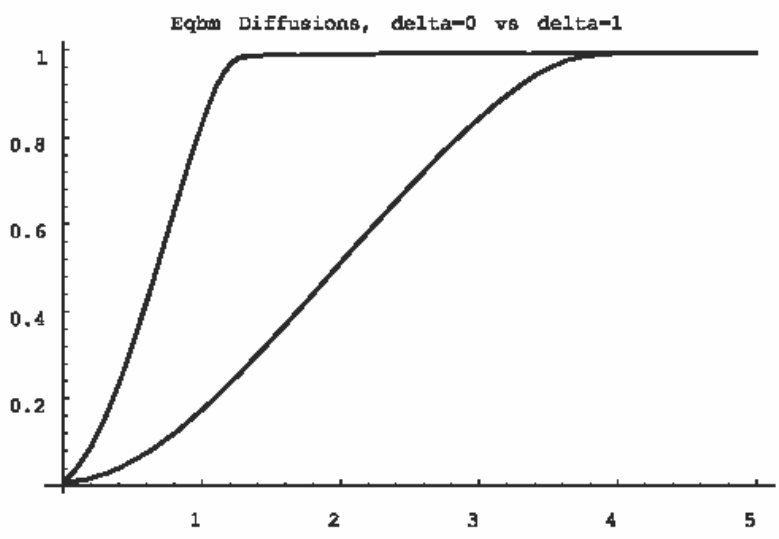
- However, firms can use price discrimination to provide favorable terms to large users to maximize their network effect contribution to the market.
    - For example, a large customer in a financial market can be given a very low price to be compensated for the positive network effect it brings to the market.
    - It is anecdotally known that Cantor Fitzgerald, which has a 70% market share in the secondary market for US government 30-year bonds, offered to Salomon (the largest "primary dealer" and trader of US bonds) prices equal to 1/10 to 1/5 of those charged to small traders.
    - This is consistent with profit maximization by Cantor Fitzgerald because of the liquidity (network effect) brought to the market by Salomon, which is by far the largest buyer ("primary dealer") in the auctions of US government bonds.

Fast Network Expansion

- Generally, the pace of market penetration (network expansion) is much faster in network industries than in non-network industries.

- In the earlier discussion on critical mass, we saw that, in a one-period model, as unit cost decreases, the network starts with significant market coverage.

- In the presence of frictions and not perfectly elastic supply, the network expansion is not instantaneous from 0 to no but rather is a rapid expansion following an S-shaped curve.



Features of Markets with Network Effects Under Incompatibility and Imperfect Competition

Strategic Choices of Technical Standards and Compatibility In Network Industries

- **Standards Wars**.

- A key strategic decision for a firm is the extent to which it will be compatible with other firms.

- A network good has higher value because of the existence of network effects.
    - Different firms conforming to the same technical standard can create a larger network effect while still competing with each other in other dimensions (such as quality and price).

- The decision to conform to the same technical standard is a strategic one.
    - A firm can choose to be compatible with a rival and thereby create a larger network effect and share it with the rival.
    - A firm could alternatively choose to be incompatible with the rival, but keep all the network effects it creates to itself.

- Which way the decision will go depends on a number of factors.

- First, in some network industries, such as telecommunications, interconnection and compatibility at the level of voice and low capacity data transmission is mandated by law.

- Second, the decision will depend on the expertise that a firm has on a particular standard (and therefore on the costs that it would incur to conform to it).

- Third, the choice on compatibility will depend on the relative benefit of keeping all the network effects to itself by choosing incompatibility versus receiving half of the larger network benefits by choosing compatibility.

- Fourth, the choice on compatibility depends on the ability of a firm to sustain a dominant position in an ensuing standards war if incompatibility is chosen.

- Finally, the compatibility choice depends on the ability of firms to leverage any monopoly power that they manage to attain in a regime of incompatibility to new markets.

- Standards may be defined by the government (as in the case of the beginning of the Internet), a world engineering body (as in the case of the FAX), an industry-wide committee, or just sponsored by one or more firms.

- Even when industry-wide committees are available, firms have been known to introduce and sponsor their own standards.

- Incentives of firms to choose to be compatible with others; coordination game

Standards war leading to compatibility

		Player 2	
		Standard 1	Standard 2
		←←←←←←←←←←	
Player 1	Standard 1	↑ (a, b)	(c, d) ↓
	Standard 2	↑ (e, f)	(g, h) ↓
		→→→→→→→→→→	

- Full compatibility at both non-cooperative equilibria.
- Standard 1 is a non-cooperative equilibrium if $a > e$, $b > d$. Similarly, standard 2 is an equilibrium if $g > c$, $h > f$.
- In this game, we will assume that firm i has higher profits when "its" standard i get adopted, $a > g$, $b < h$.
- Profits, in case of disagreement, will depend on the particulars of the industry.
- One standard assumption that captures many industries is that in case of disagreement probe lower than those of either standard, $e, c < g$; $d, f < b$.
- There is no guarantee that the highest joint profit standard will be adopted
- Since consumers surplus does not appear in the matrix, there is no guarantee of profit maximization at equilibrium

Standards war leading to incompatibility

- Compatibility with competitors brings higher network externality benefits ("network effect") and therefore is desirable.

- At the same time, compatibility makes product X a closer substitute to competing products ("competition effect"), and it is therefore undesirable.

- In making a choice on compatibility, a firm has to balance these opposing incentives.

- Firms want to differentiate their products because they want to avoid intense competition.

- In a network industry, the traditional decisions of output and price take special importance since higher output

- Inequality in market shares and profitability is a natural consequence of incompatibility.

- Under incompatibility, network externalities act as a quality feature that differentiates the products.

Inequality of market shares, prices, and profits under incompatibility

- Markets with strong network effects where firms can chose their own technical standards are "winner-take-most" markets.

- In these markets, there is extreme market share and profits inequality.

- The market share of the largest firm market share can be a multiple of the market share of the second firm, the second firm's market share a multiple of the market share of the third, and so on.

- This geometric sequence of market shares implies that, even for a small number of firms the nth firm's market share is tiny.

- Why?

- A firm with a large market share has higher sales of complementary goods and therefore its good is more valuable to consumers.

- This feeds back resulting in even higher sales.

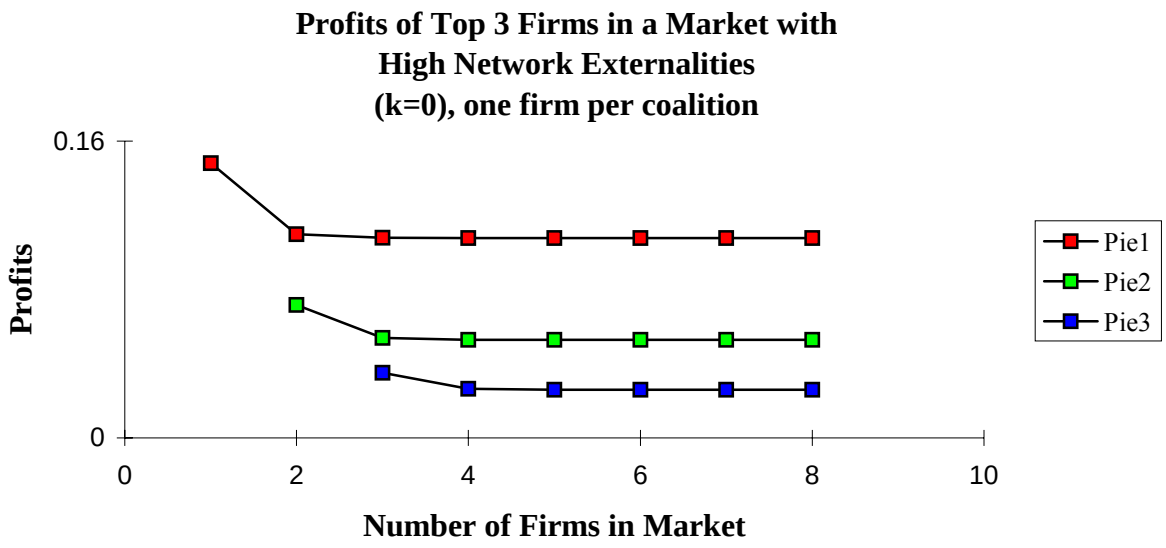
- A firm with small market share has lower sales of complementary goods, and the feedback results in even lower sales.

- Low sales firm is not necessarily driven out of business because that would require too low a price by the high sales firm.

- When fixed costs are small, a very large number of firms can survive, but there is tremendous inequality in market shares, prices, and profits among them.

- Examples of this market structure are the PC operating systems market and many software applications markets.

- Setup of Economides and Flyer (1998).
- All firms produce identical products, except for what quality is added to them by network externalities.
- No firm has any technical advantage in production over any other with respect to any particular platform and no production costs.
- "Pure network goods" where there is no value to the good in the absence of network externalities.
- Consumers are differentiated in their willingness to pay for the network good


Profits of Top 3 Firms in a Market with
High Network Externalities
(k=0), one firm per coalition
0.16
0
Profits
0
2
4
6
8
10
Number of Firms in Market
Pie1
Pie2
Pie3

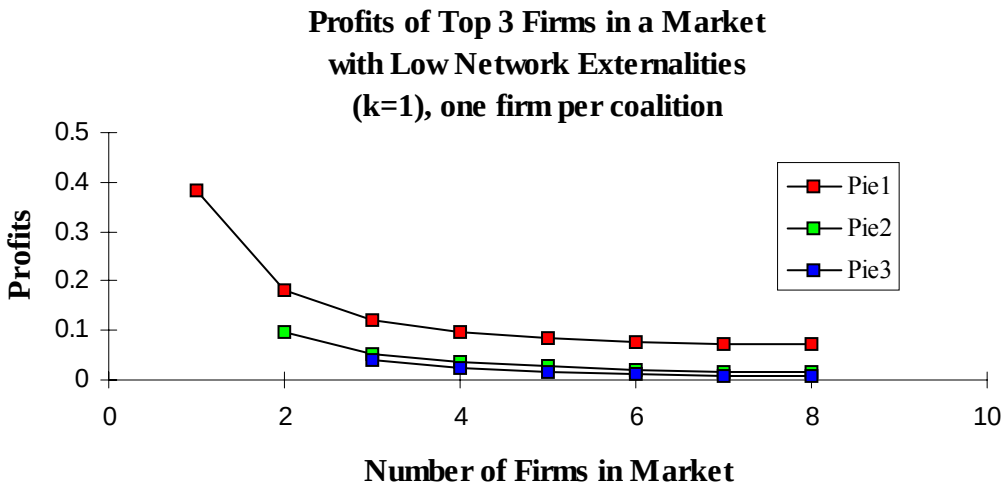

Profits of Top 3 Firms in a Market
with Low Network Externalities
(k=1), one firm per coalition
0.5
0.4
0.3
0.2
0.1
0
Profits
0
2
4
6
8
10
Number of Firms in Market
Pie1
Pie2
Pie3

Table 1: Herfindahl-Hirschman (H) Index for Different Intensities of Marginal Network Externality 1/k and Numbers of Firms S Under Incompatibility

		Intensity of Marginal Network Externality 1/k				
		∞	2	1	0.5	0.2
Number of Firms S	3	.510	.415	.363	.339	.334
	5	.470	.331	.248	.207	.201
	10	.464	.287	.172	.106	.100

Table 2a: Market Coverage and Prices under Incompatibility for Pure Network Goods (k = 0)

Number of firms S	n_1	n_2	n_3	Market coverage $\sum_{j=1}^{S} n_j$	p_1	p_2	p_3	Price of lowest-ranked firm p_S
1	0.6666			0.6666	0.222222			2.222e-1
2	0.6357	0.2428		0.8785	0.172604	0.0294		2.948e-2
3	0.6340	0.2326	0.0888	0.9555	0.170007	0.0231	0.0035	3.508e-3
4	0.6339	0.2320	0.0851	0.9837	0.169881	0.0227	0.0030	4.533e-4
5	0.6339	0.2320	0.0849	0.9940	0.169873	0.0227	0.0030	7.086e-5
10	0.6339	0.2320	0.0849	0.9999	0.169873	0.0227	0.0030	9.88e-11
$\propto$	0.6339	0.2320	0.0849	0.9999	0.169873	0.0227	0.0030	0

Table 2b: Profits, Consumers' and Total Surplus Under Incompatibility for Pure Network Goods (k = 0)

Number of firms bS	Π_1	Π_2	Π_3	Profits of Lowest-Ranked Firm Π_S	Total Industry Profits $\sum_{j=1}^{S} \Pi_j$	Consumers' surplus CS	Total Surplus TS
1	0.1481			0.1481	0.1481	0.1481	0.29629651
2	0.1097	7.159e-3		7.159e-3	0.1168	0.1732	0.29001881
3	0.1077	5.377e-3	3.508e-4	3.508e-4	0.1135	0.1752	0.28878819
4	0.1077	5.285e-3	3.096e-4	1.474e-5	0.1132	0.1754	0.28868321
5	0.1077	5.281e-3	2.592e-4	8.44e-7	0.1132	0.1754	0.28867817
10	0.1077	5.281e-3	2.589e-4	1.18e-14	0.1132	0.1754	0.28867799
$\propto$	0.1077	5.281e-3	2.589e-4	0	0.1132	0.1754	0.28867799

- Price ratios of consecutive firms are significantly higher, ranging from 5.85 to 7.7

- Ratios of profits of consecutive firms range from 15 to 20

Strategic Choice of Compatibility in Duopoly

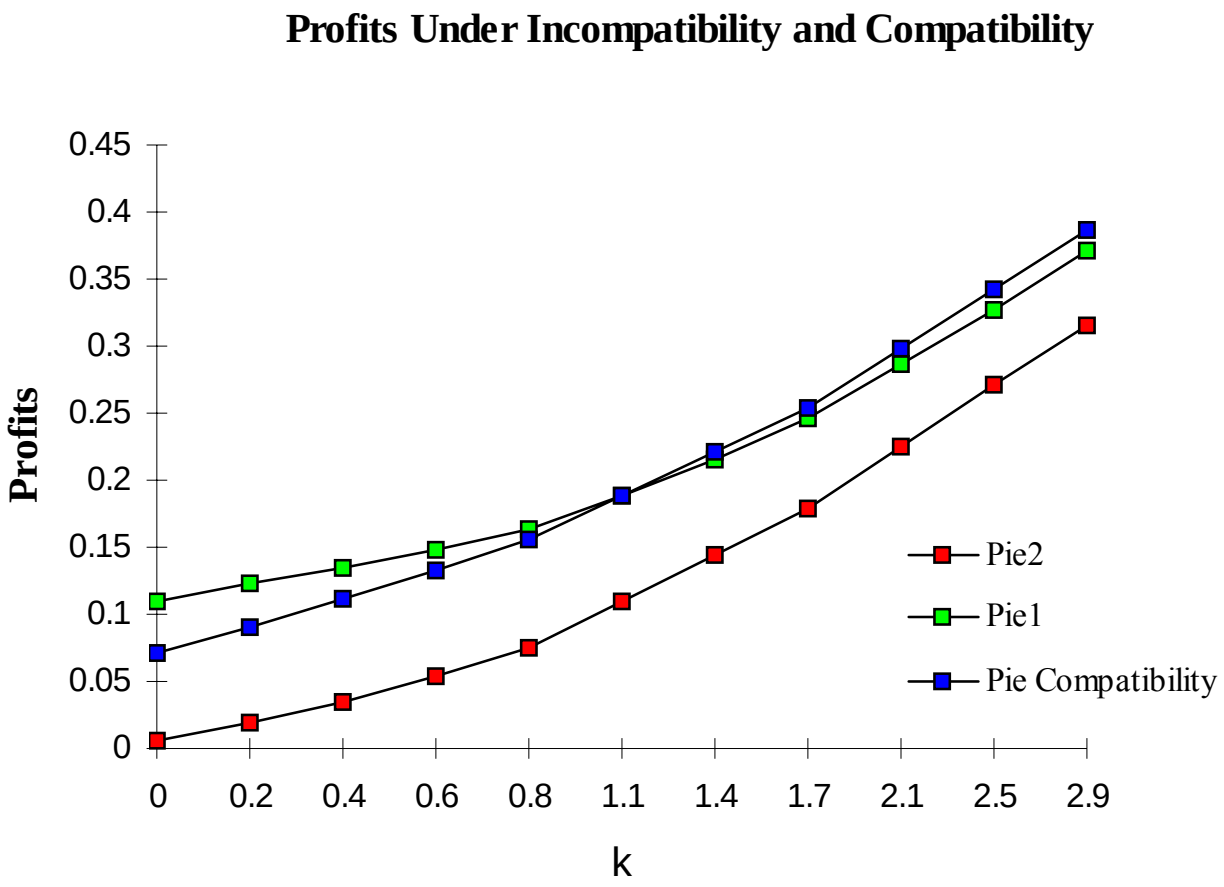


Table 3: Equilibria in a Two-Firm Industry

Range of k	Intensity of Marginal Network Externality 1/k	Non-Cooperative Equilibria	Consensual Equilibria
[0, 1.1]	[0.909, ∝]	None	(1, 1)
[1.1, ∝]	[0, 0.909]	(2, 0)	(2, 0)

Monopoly May Maximize Total Surplus

- When here are fewer firms in the market there is more coordination and the network effects are larger.

- As the number of firms decreases, the positive network effects increase more than the dead weight loss, so that total surplus is maximized in a monopoly!

- Total surplus is highest while consumers' surplus is lowest in a monopoly.

- This poses an interesting dilemma for antitrust authorities
    - Should they intervene or not?
    - In non-network industries, typically both consumers' and total surplus are lowest in a monopoly.
    - In this network model, total maximizing consumer's surplus would imply minimizing total surplus.

- No Anti-Competitive Acts are Necessary to Create Market Inequality

- In Network Industries, Free Entry Does Not Lead to Perfect Competition

- Antitrust and competition law have placed a tremendous amount of hope on the ability of free entry to spur competition, reduce prices, and ultimately eliminate profits.

- In network industries, free entry brings into the industry an infinity of firms but it fails miserably to reduce inequality in market shares, prices and profits.

- Entry does not eliminate the profits of the high production firms.

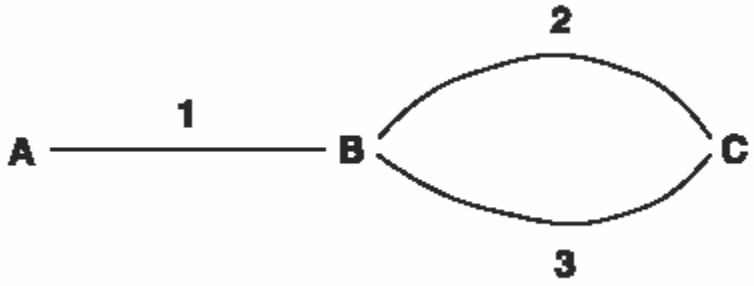
- Imposing a "competitive" market structure is likely to be counterproductive

- Nature of Competition is Different in Network Industries
    - In network industries, often competition *for the market* takes precedence over competition *in the market*.

- **Path Dependence**

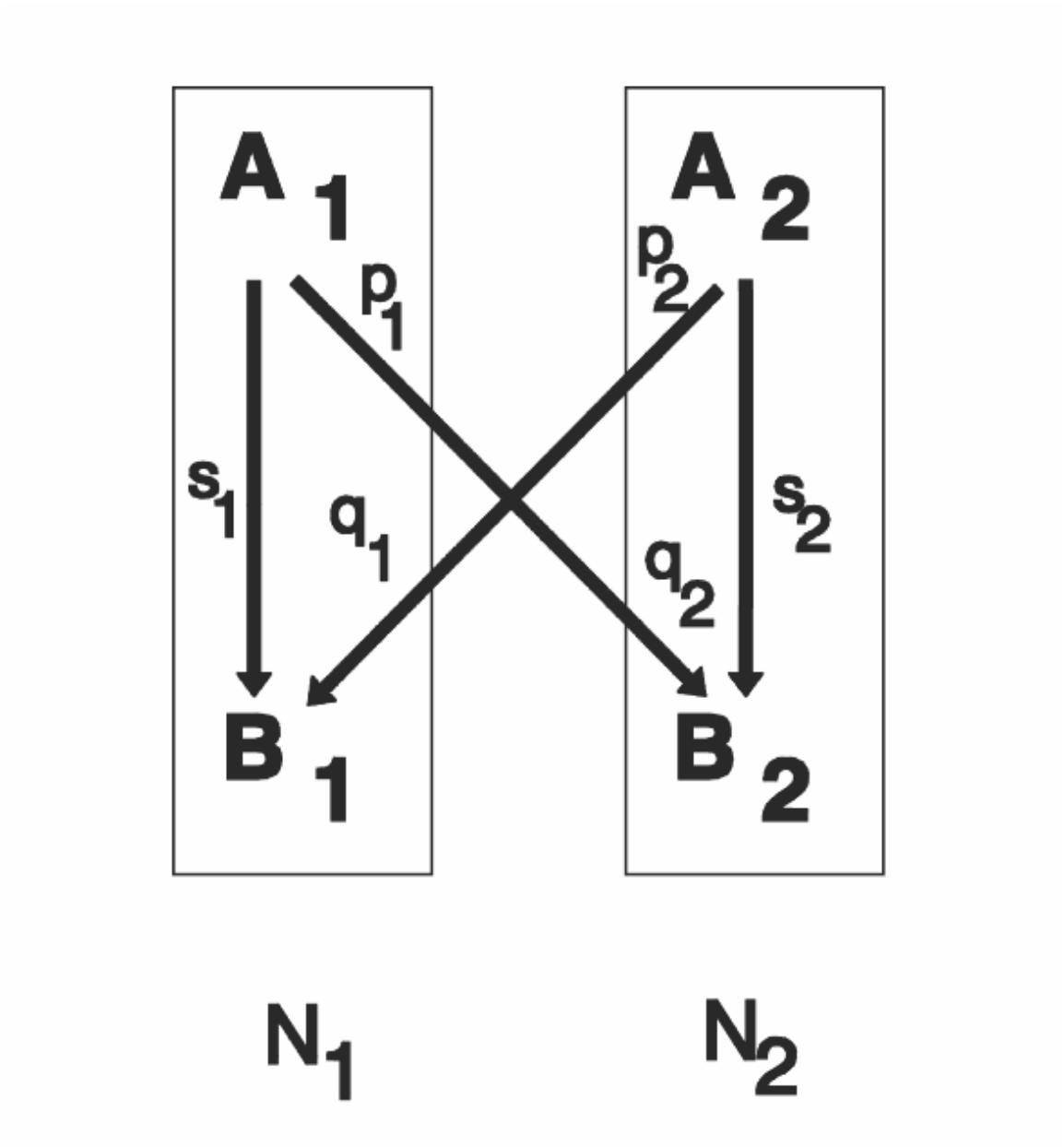
- Examples:
    - QWERTY vs. Dvorak
    - VHS vs. Beta
    - PC vs. Mac
    - Internet search engines

- **One-sided Bottlenecks**



- Consequences:
- Foreclosure
    - Example: early AT&T
- Appropriate pricing
    - Problems with the ECPR

- **Two-Sided Bottlenecks**



- In the US, cost-based reciprocal compensation is the rule.

- If cost- based reciprocal compensation were not the rule, and firms were able to set termination at profit maximizing levels, a large network will try to impose very high termination charges on an opponent's small network so that no calls terminate from the small network to the large one.

- Without the possibility of such across-networks calls, a small network will only be able to provide within-network calls, and, being small, will be of little value to potential subscribers.

- As a consequence, large networks are able to provide more value to subscribers, and the small network is foreclosed.

- Starting from a regime of a large local incumbent and a small potential entrant, the large incumbent can set up termination access fees so that the entrant is kept out of the market.

- Such strategies were used in New Zealand by the incumbent Telecom New Zealand

- **Market Power Creation Specific to Networks: The Importance of Technical Standards**

- Nintendo example

- Investment in complementary goods

- **Vertical Control Issues in Network Industries**

- Aftermarkets
    - Kodak
    - Cellular phones

- **B2B and Other Exchanges Issues**

- **Dynamic Efficiency Issues**

- **Innovation Issues**

- **Criteria to be Used for Antitrust Intervention in Network Industries**

- **Criteria to be Used for Remedies**