Dominant design, learning effects and network externalities

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Economics of innovation

Introduction

The technology cycle almost invariably exhibits a stage in which the industry selects a **dominant design**.

- Once this design is selected, producers and customers focus their efforts on improving their efficiency in manufacturing, delivering, marketing, or deploying this dominant design, rather than continue to develop and consider alternative designs.

Why industries experience strong pressure to select a single technology design as dominant and the multiple dimensions of value that will shape which technology designs rise to dominance?

Why and how modularity and platform competition emerges in some industries?

A Dominant design

A single product or process architecture that dominates a product category—usually 50% or more of the market.

While it may not be officially enforced or acknowledged, it has become a standard (de facto) for the industry.

Alternative Definitions of a Dominant Design in the Extant Literature

Source	Definition of a Dominant Design	Empirical Method to Identify a Dominant Design
Abernathy and Utterback (1978)	A dominant design is a single architecture that establishes dominance in a product category.	Conceptual paper.
Anderson and Tushman (1990)	A dominant design is a single architecture that establishes dominance in a product category.	A design is dominant if it acquires more than 50% market share of the product category and maintains it for four consecutive years.
Utterback (1994)	The dominant design in a product category is the one that wins the allegiance of the marketplace; it is the one that competitors and innovators must adhere to if they hope to command significant market following. A dominant design is a product in a product category that gains general acceptance as the standard on technical features that other market players must follow if they wish to acquire significant market share.	No details provided.
Suaréz and Utterback (1995)	The dominant design is a specific path along an industry's design hierarchy that establishes dominance among competing design paths.	Industry experts were used to classify dominant designs in typewriters, automobiles, televisions, picture tubes, transistors, and electronic calculators.
Christensen, Suaréz, and Utterback (1998)	A dominant design emerges in a product category when one product's design specifications (consisting of a single or a complement of design features) define the product category's architecture.	Industry experts were used to identify the emergence of the dominant design in the rigid disk drive industry based on the technical elements of the product category evolution over time.

WHY DOMINANT DESIGNS ARE SELECTED

Why there is a single dominant design rather than support a variety of technological options?

1. Many industries exhibit **increasing returns to adoption**, meaning that the more a technology is adopted, the more valuable it becomes.
2. As the technology is used, greater knowledge and understanding of the technology accrue, which may then enable improvements both in the technology itself and in its applications.
3. As a technology becomes more widely adopted, complementary assets are often developed that are specialized to operate with the technology.
   - Two of the primary sources of increasing returns are (1) learning effects and (2) network externalities.

Learning Effects

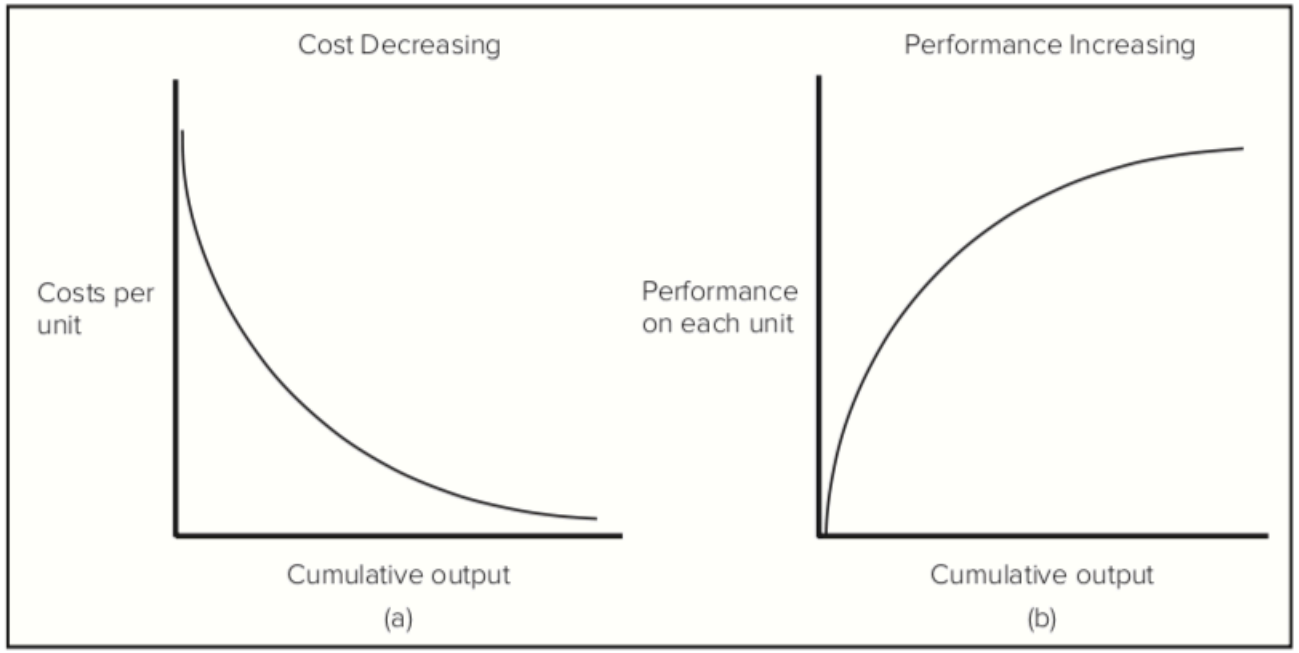
The more a technology is used, the more it is developed and the more effective and efficient it becomes.

As a technology is adopted, it generates sales revenues that can be reinvested in further developing and refining the technology.

As firms accumulate experience with the technology, they find ways to use the technology more productively, including developing an organizational context that improves the implementation of the technology. $\Rightarrow$ The more a technology is adopted, the better it should become.

Learning curve

As individuals and producers repeat a process, they learn to make it more efficient, often producing new technological solutions that may enable them to reduce input costs or waste rates.



The standard form of the learning curve

The standard form of the learning curve is formulated as:

$$y = ax^{-b}$$

y= the number of direct labor hours required to produce the *x*th unit;

a= the number of direct labor hours required to produce the first unit;
x= the cumulative number of units produced, and *b* is the learning rate;

b= the learning rate

Prior Learning and Absorptive Capacity

A firm's investment in prior learning can accelerate its rate of future learning by building the firm's absorptive capacity.

- **Absorptive capacity:** the ability of an organization to recognize, assimilate, and utilize new knowledge.

  e.g. in developing a new technology, a firm will often try a number of unsuccessful configurations or techniques before finding a solution that works well. This experimentation builds a base of knowledge in the firm about how key components behave, what alternatives are more likely to be successful than others, what types of projects the firm is most successful at, and so on. This knowledge base enables the firm to more rapidly assess the value of related new materials, technologies, and methods. The effects of absorptive capacity suggest that firms that develop new technologies ahead of others may have an advantage in staying ahead.

Network Externalities

Many markets are characterized by **network externalities**, or positive consumption externalities.

- **network externalities** occur when the value of a good to a user increases with the number of other users of the same or similar good.
  - e.g. a telephone is not much useful if only a few people can be called with it—the amount of utility the phone provides is directly related to the size of the network.

Network Externalities

The number of users of a particular technology is often referred to as its **installed base**.

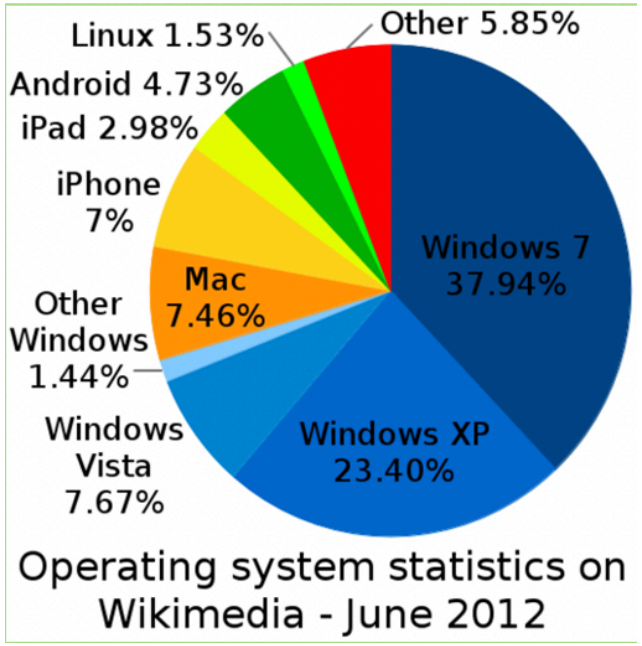
- The number of users of a particular good.
  - E.g. the installed base of a particular video game console refers to the number of those consoles that are installed in homes worldwide.

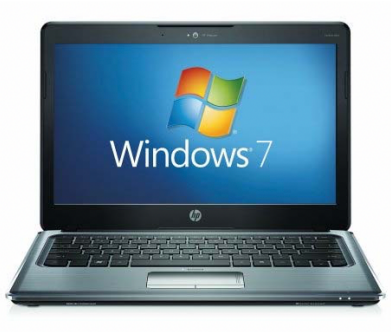
Network externalities also arise when **complementary goods** are important.

- Additional goods and services that enable or enhance the value of another good.
  - E.g. the value of a video game console is directly related to the availability of complementary goods such as video games, peripheral devices, and services such as online gaming.

Network Externalities

Installed base



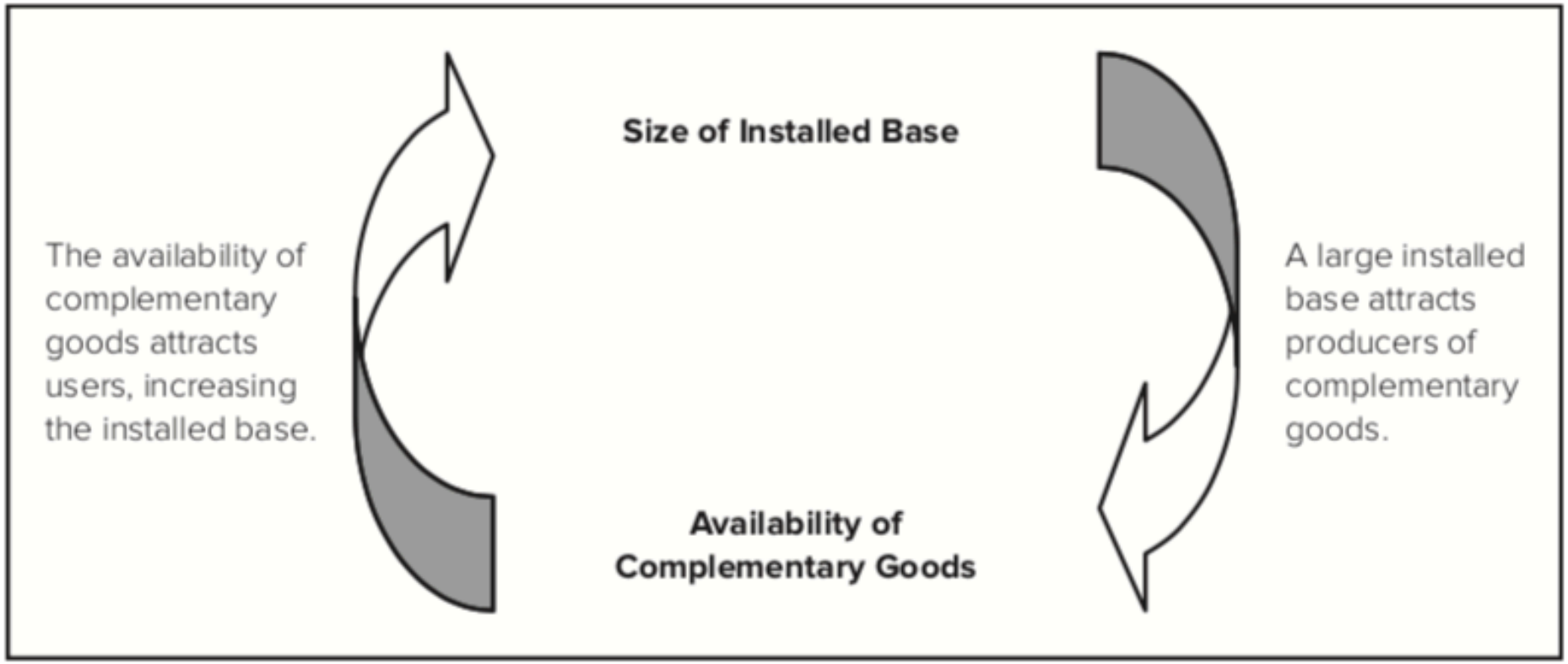


Complementary good

The Rise of Microsoft

- In 1980, Microsoft didn't even have a personal computer (PC) operating system – the dominant operating system was CP/M.
- However, in IBM's rush to bring a PC to market, they turned to Microsoft for an operating system and Microsoft produced a clone of CP/M called "MS DOS."
- The success of the IBM PCs (and clones of IBM PCs) resulted in the rapid spread of MS DOS, and an even more rapid proliferation of software applications designed to run on MS DOS. Microsoft's Windows was later bundled with (and eventually replaced) MS DOS.
- Had Gary Kildall signed with IBM, or had other companies not been able to clone the IBM PC, the software industry might look very different today!

The Self- Reinforcing Cycle of Installed Base and Availability of Complementary Goods



Why Dominant Designs are selected?

- **Government Regulation**

Sometimes the consumer welfare benefits of having a single dominant design prompts government organizations to intervene, imposing a standard.

  - E. g the NTSC color standard in television broadcasting in the US; the general standard for mobile communications (GSM) in the Europen Union.

- **The Result: Winner-Take-All Markets**
- Natural monopolies
- Firms supporting winning technologies earn huge rewards.

MULTIPLE DIMENSIONS OF VALUE

The value a new technology offers a customer is a composite of many different things.

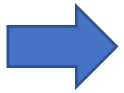
- the value of the stand-alone technology,
- how the stand-alone value of the technology combines with the value created by the size of the installed base and availability of complementary goods.

In industries characterized by increasing returns, this combination will influence which technology design rises to dominance.

A Technology's Stand-Alone Value

A Technology's Stand-alone Value Includes such factors as:

- the functions it enables the customer to perform,
- the aesthetic qualities,
- the ease of use.

To help managers identify the different aspects of utility a new technology offers customers,  "Buyer Utility Map."

The Buyer Utility Map with Dropbox Example

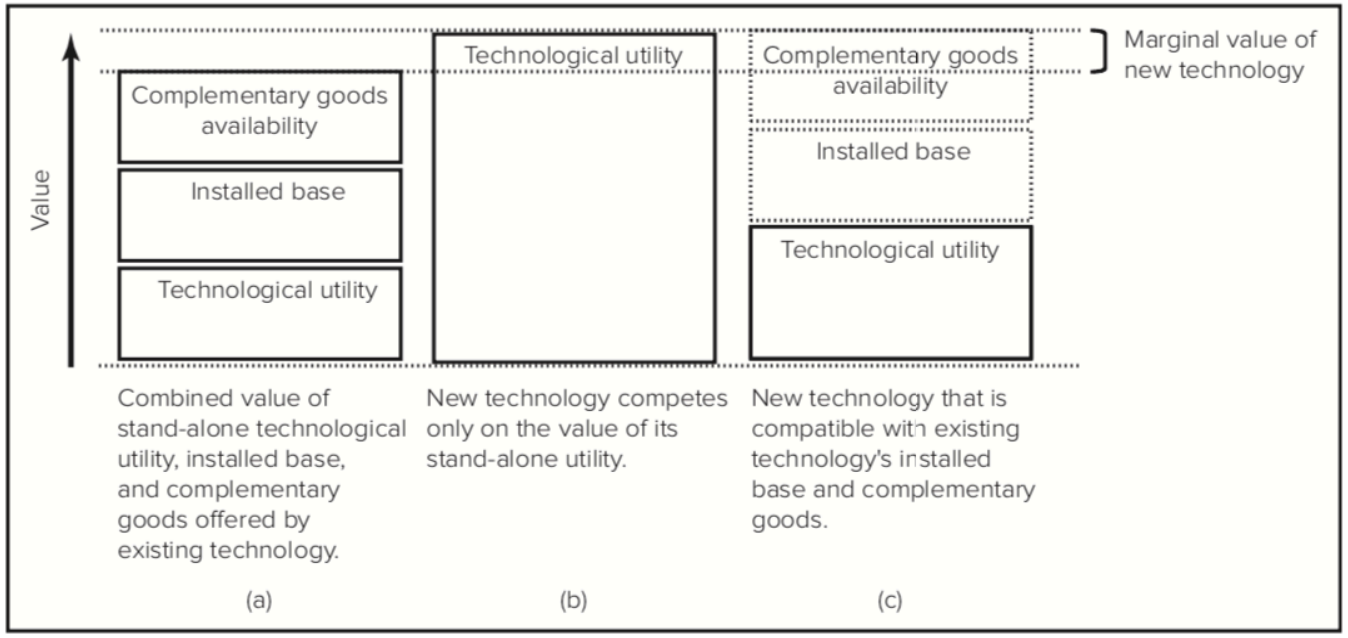
Dropbox		Six Stages of the Buyer Experience Cycle					
		Purchase	**Delivery**	**Use**	**Supplements**	**Maintenance**	**Disposal**
Six Utility Levers	**Customer Productivity**			Share files quickly - eliminates time of sharing services		Capacity limits amount that can be stored	
	Simplicity	Easy - online	Simple download	Save to appropriate folder	Can buy extra storage		Delete when desired
	Convenience	Bundled with Samsung products	Minimum effort	Likely to share more			
	Risk	Minimal	None	Low - based on reliability of Dropbox storage may be issues with privacy with remote file storage			
	Fun and Image						
	Environmental Friendliness			May reduce printing			

The buyer experience cycle

Purchase	Delivery	Use	Supplements	Maintenance	Disposal
How long does it take to find the product or service?	How long does it take to get the product or service delivered?	Does the product or service require training or expert assistance?	Do you need other products and services to make this product work?	Does the product or service need external maintenance?	Does use of the product create waste items?
Is the place of purchase attractive and accessible?		Does the product or service deliver far more power or options than needed by the average user? Is it overloaded with bells and whistles?	If so, how costly are these?	How easy is it to maintain and upgrade the product?	How easy is it to dispose of the product?
How secure is the transaction environment?			How much time do they take?	How costly is the maintenance?	
How rapidly can you make a purchase?			How much pain do they cause?		
			How easy are they to obtain?		

Network Externality Value

- To succesfully make obsolete an existing dominant technology, new technology often must either offer:
  - Dramatic technological improvement (e.g., in videogame consoles it has taken 3X performance of inumbent)
  - Compatibility with existing installed base and complements

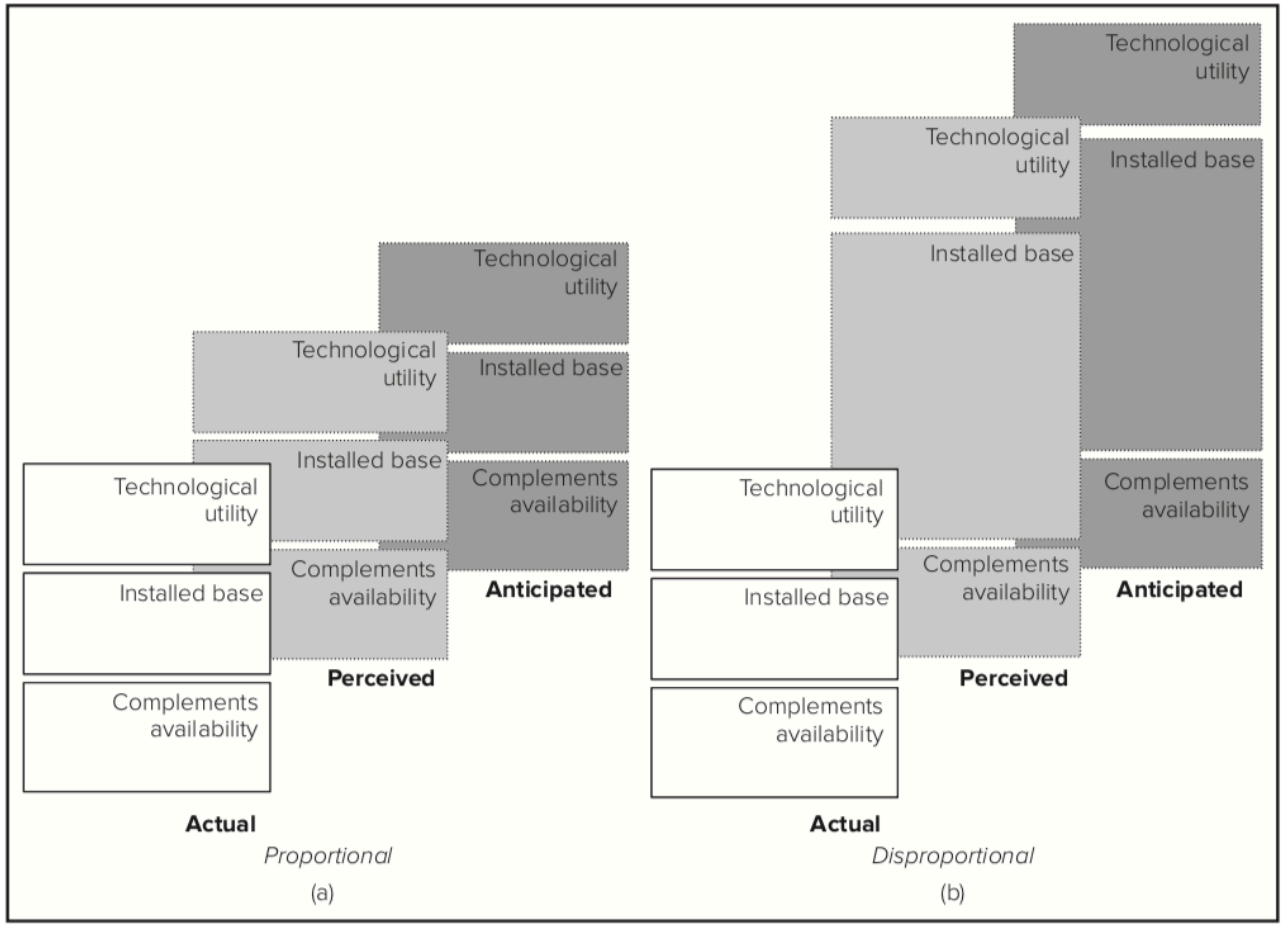


In some cases, the new technology may be made compatible with the existing technology's installed base and complementary goods as in case (c). In this case new technology with only a moderate functionality advantage may offer greater overall value to users.

A comparison between new technology and existing technology

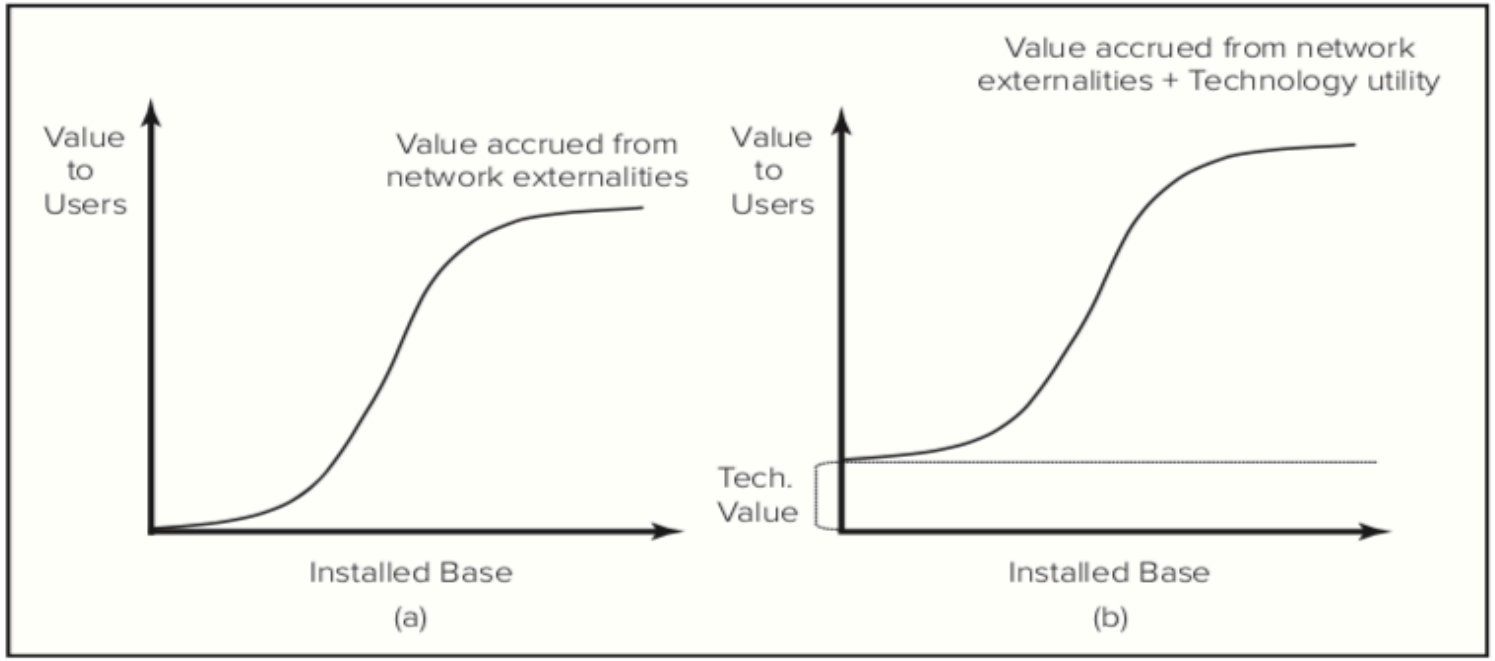
When users are comparing the value of a new technology to an existing technology, they are weighing a combination of:

- Objective information: e.g., actual technological benefits, actual information on installed base or complementary goods;
- Subjective information: e.g., perceived technological benefits, perceived installed base or complementary goods;
- Expectations for the future (e.g., anticipated technological benefits, anticipated installed base and complementary goods).
- In Figure (a), the perceived and anticipated value components map proportionately to their corresponding actual components.
- in Figure (b), installed base may greatly exceed actual installed base, or customers may expect that a technology will eventually have a much larger installed base than competitors and thus the value accrued from the technology's installed base is expected to grow much larger than it is currently.



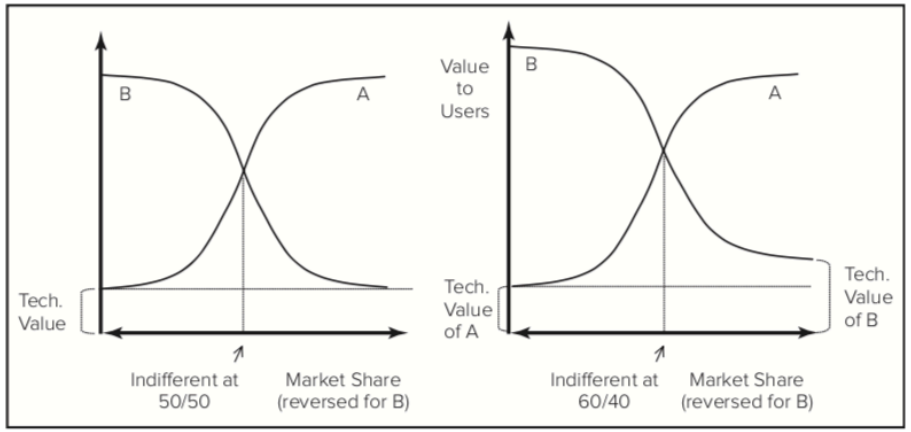
Competing for Design Dominance in Markets with Network Externalities

- When an industry has network externalities, the value of a good to a user increases with the number of other users of the same or similar good in an s-shape as shown in Figure (a).
- In figure (b), a base level of technological utility has been added to the graph, which shifts the entire graph up.



Network Externality Returns and Technological Utility: Competing Designs

When two technologies compete for dominance, customers will compare the overall value yielded from each technology.



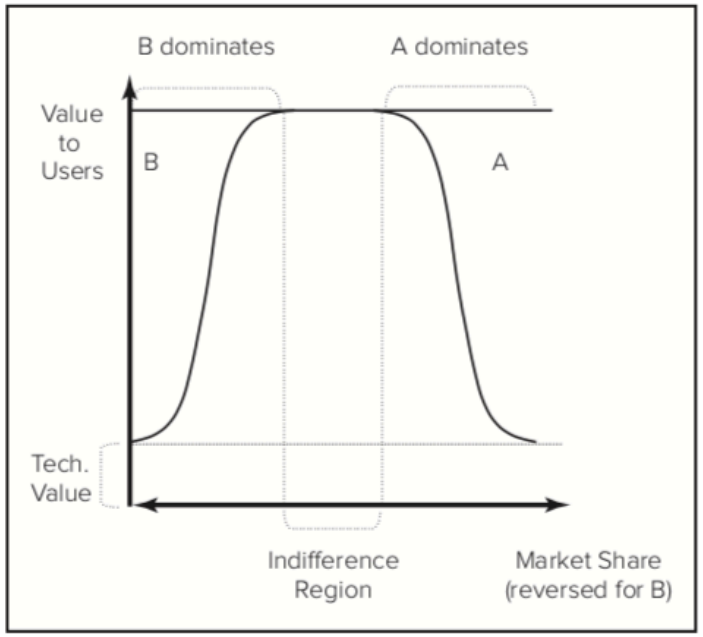
We can compare the graphs of two competing technologies, and identify cumulative market share levels (*installed base*) that determine which technology yields more value.

When two technologies compete for dominance, customers will compare the overall value yielded (or expected) from each technology, as discussed in the previous section. In Figure two technologies, A and B, each offer similar technological utility, and have similarly shaped network externality returns curves. To illustrate the competitive effects of two technologies competing for market share, the graphs in Figure are drawn with market share on the horizontal axis instead of installed base. Furthermore, the curve for B is drawn with the market share dimension reversed so that we can compare the value offered by the two different technologies at different market share splits, that is, when A has a 20 percent market share, B has an 80 percent market share, and so on. This graph shows that at every point where A has less than 50 percent market share (and thus B has greater than 50 percent market share), B will yield greater overall value, making B more attractive to customers.

Network Externality Value Is Fully Tapped at Minority Market Share Levels

Customers can attain their desired level of network externality benefits at lower levels of market share

- the curves flatten out sooner,
- the maximum amount of network externality value is obtained by customers at lower levels of market share.
- customers may face a relatively large indifference region within which neither technology clearly dominates.



When customer requirements for network externality value are satiated at lower levels of market share, more than one dominant design may thrive.

Another interesting scenario arises when customers attain their desired level of network externality benefits at lower levels of market share, depicted graphically in Figure. In this graph, the curves flatten out sooner, implying that the maximum amount of network externality value is obtained by customers at lower levels of market share. In this case, customers may face a relatively large indifference region within which neither technology clearly dominates.

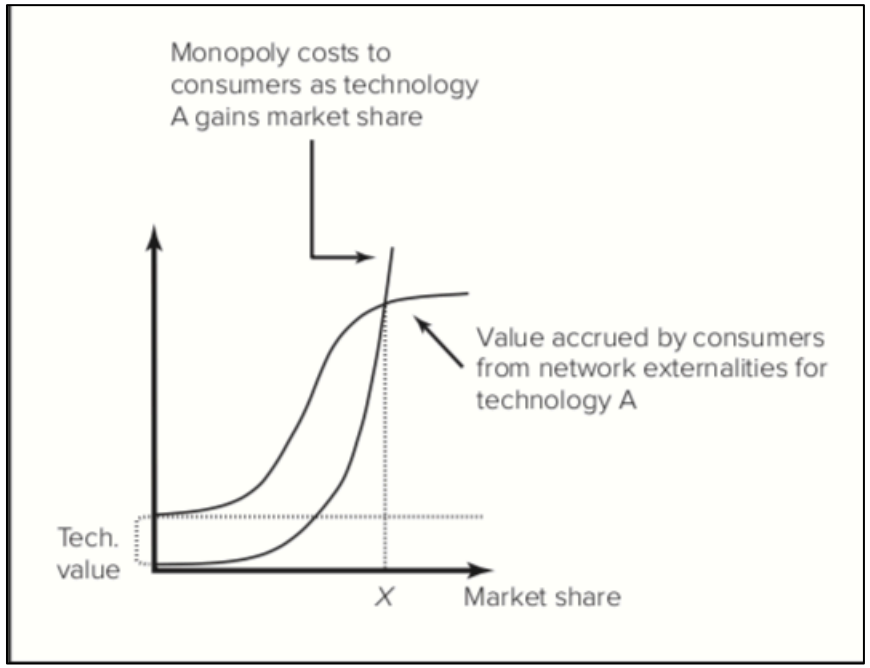
Are Winner-Take-All Markets Good for Consumers?

- Economics emphasizes the benefits of competition.
- However, network externalities suggest users sometimes get more value when one technology dominates.
- Should the government intervene when network externalities create a natural monopoly?

Are Winner-Take-All Markets Good for Consumers?

- Network externality benefits to customers rise with cumulative market share
- Potential for monopoly costs to customers (e.g., price gouging, restricted product variety, etc.) also rise with cumulative market share.

Curve shapes are different; Network externality benefits likely to grow logistically, while potential monopoly costs likely to grow exponentially. Where monopoly costs exceed network externality benefits, intervention may be warranted. Optimal market share is at point where lines cross.

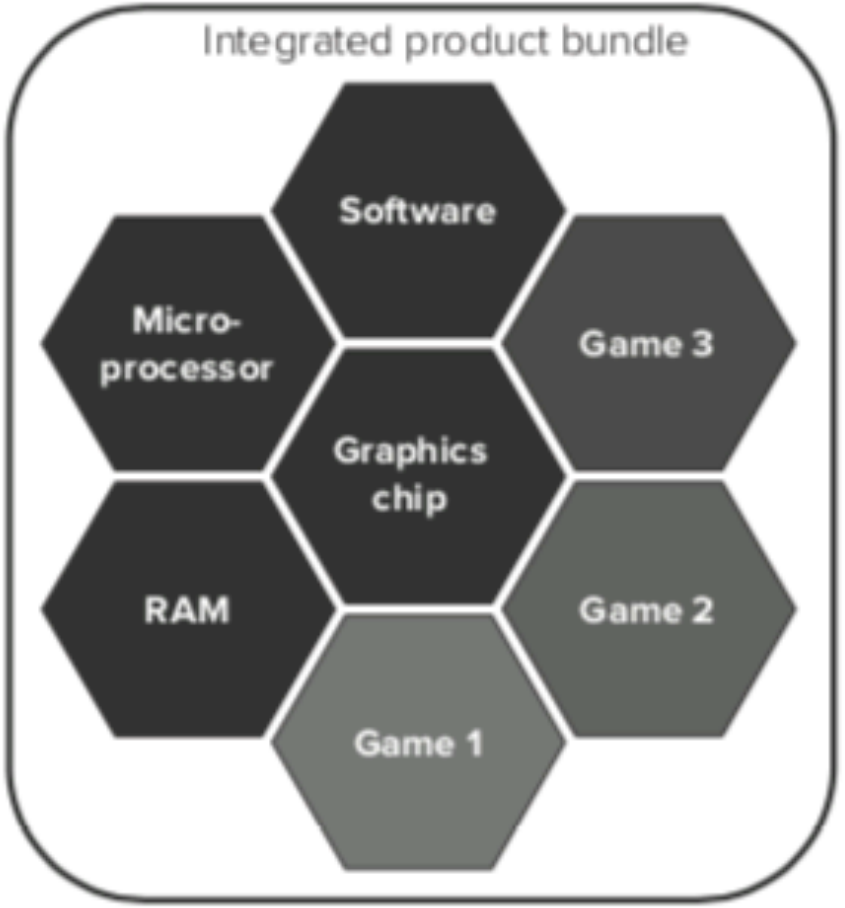


Traditional integrated product bundle

A. Traditional integrated product bundle:

- Provider tries to meet buyers needs itself
- No customization, no external compatibility

Example: Nokia E90 Communicator

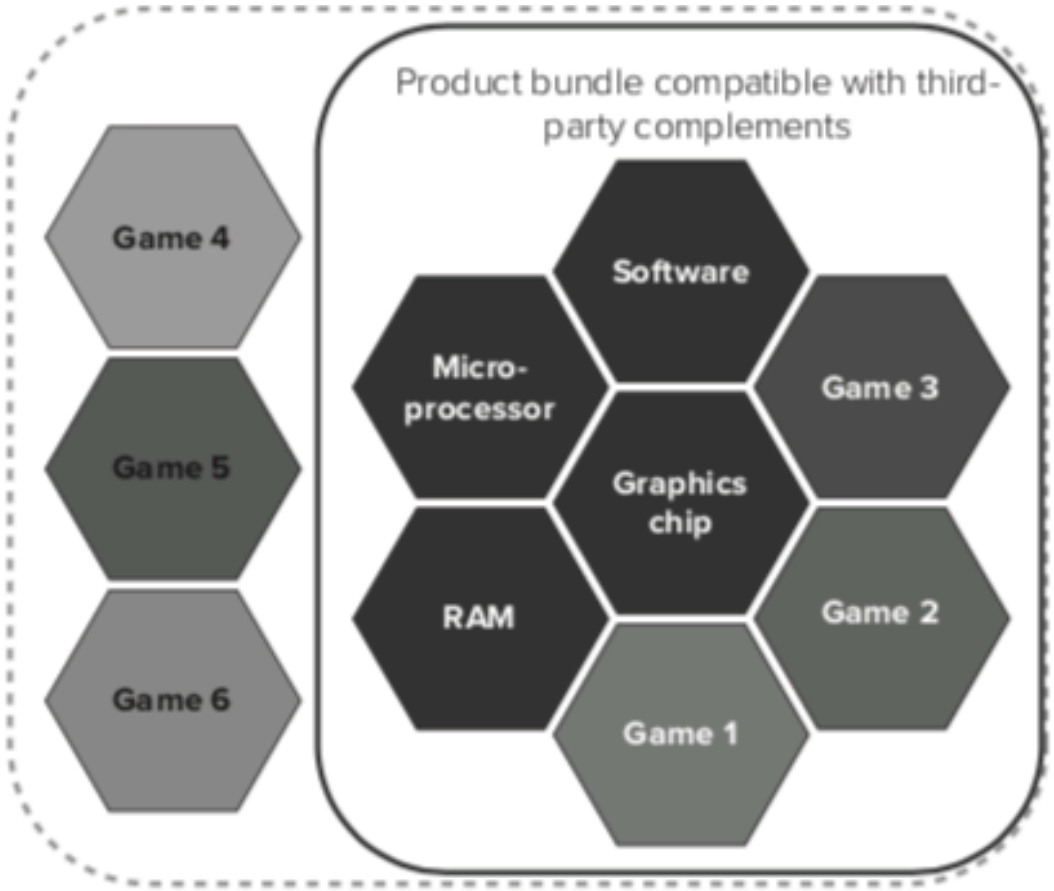


Product bundle with third-party complements

B. Product bundle with third-party complements:

- Compatibility with third-party choices expands options for customers

Example: Apple iPhone

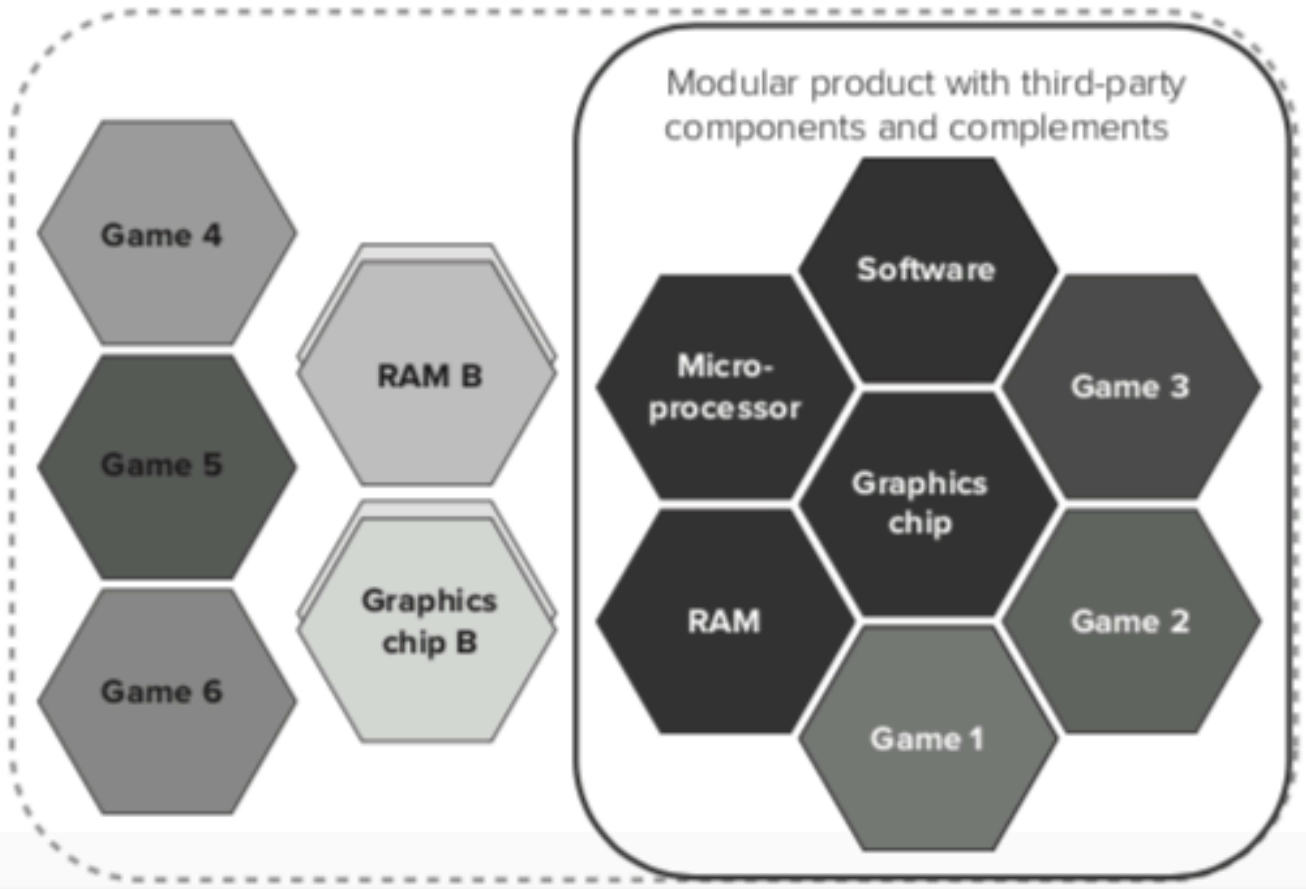


Product bundle with third-party components and complements

C. Product bundle with third-party components and complements:

- Customer has even greater range of configuration choices

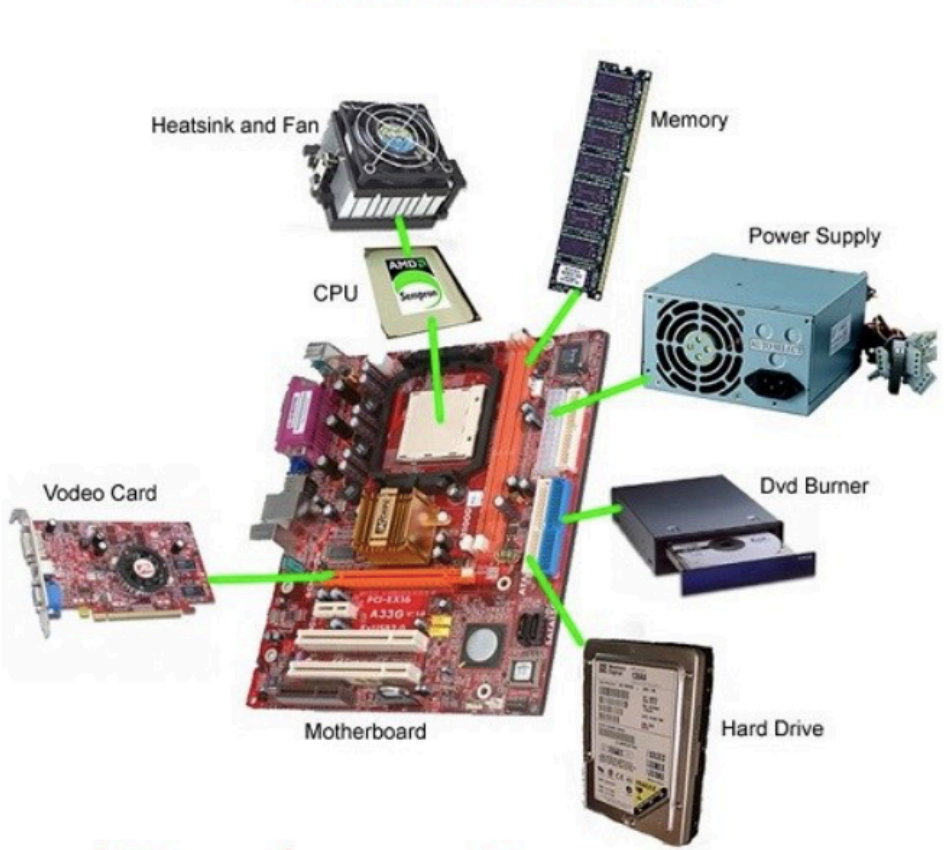
Example: Android device



Advantages: Tightly integrated product systems vs modular systems

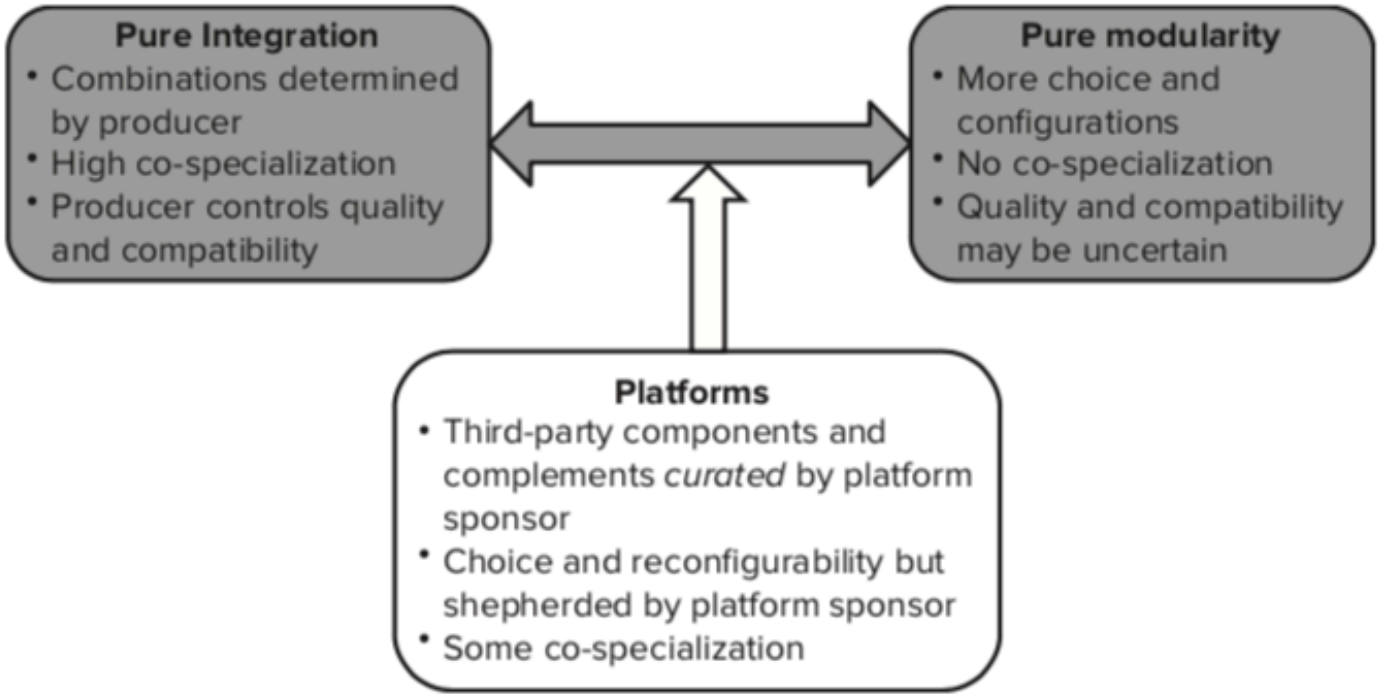
Tightly integrated product systems	Modular systems
▪ May have components that are customized to work together, which may enable a level of performance that more standardized components cannot achieve. ▪ The producer has more control over the end product, which can enable them to better monitor quality and reliability. ▪ May also be more attractive to a customer that does not want to choose or assemble components themselves.	▪ Offer more choices over function, design, scale, and other features, enabling the customer to choose a product system that more closely suits their needs and preferences. ▪ Components are reused in different combinations, this can achieve product variety while still allowing scale economies in manufacturing the individual components. This is known as *economies of substitution.*

Modularity



Computer CPU and Motherboard Hardware Components

Platforms as a Compromise between Pure Modularity and Pure Integration



Platforms, tightly integrated product and purely modular system

Platforms will be more valuable than a tightly integrated product when:	Platforms will be more valuable than a purely modular system when:
(a) customers are diverse and want more choices than a single firm can provide, (b) third-party options are diverse and high quality, (c) compatibility with third-party products can be made seamless without integration, and/or (d) when the platform sponsor is powerful enough that it can retain control over quality and the overall product architecture without producing the complements itself.	(a) complements are nonroutine purchases with uncertainty (and thus the customer prefers to have some shepherding by the platform sponsor), (b) when some integration between the platform and its complements provides performance advantages, and/or (c) when important components of the ecosystem require subsidization (e.g., the market is unlikely to provide all the complements the end customer needs at adequate quality or value).