2024 ASA SPRING FAIR VALUE CONFERENCE

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Estimating Technological Obsolescence Moving One Step Forward

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Obsolescence - Overview

- Many valuations require the valuation of technology
- Part of that valuation process is estimating an economic life and obsolescence
- However, there is not a lot of useful guidance on this matter
- To quote U2 “I still haven’t found what I’m looking”
- Hopefully this presentation moves us one step forward

What is Obsolescence?

- The process of becoming obsolete, i.e.
  - No longer in use or no longer useful

Source Merriam-Webster Dictionary; www.merriam-webster.com

Examples of Obsolescence

- Sony Walkman
- CD Player
- Blockbuster Video
- Fax Machine
- Taxi Medallions
- Pagers
- PCC Election on Valuation?
- Telephone Books
- Paper Maps (Thomas Guides)
- Floppy Disks
- Dial-up Internet
- Slide Projector
- Pay Phones
- Barnes and Noble

Many Factors Impact Obsolescence

- "The speed with which a substitution takes place is not a simple measure of the pace of technical advance, or of manufacturing, marketing, distribution, or any other individual substitution element. It is, rather, a measure of the unbalance in these factors between the competitive elements of the substitution."

J. C. Fisher, R. H. Pry

A Simple Substitution Model of Technological Change

Types of Obsolescence

- Technological obsolescence
  - Reach the point where it makes economic sense to replace the existing technology with a new one
- Functional obsolescence
  - Does not work properly with other, new components (e.g. new cell phone features)
- Planned obsolescence
  - Products deliberately designed to push customers to replace them after a certain period of time
  - E.g., cell phones, light bulbs, disposable razors, etc.

Types of Obsolescence (cont.)

- Optional obsolescence
  - Improvements not applied even if they can be
  - For example, a manufacturer may develop a new feature for its machines but not apply it to its cheapest products (e.g. treadmills, televisions, "smart" refrigerators, etc.)
- Economic obsolescence
  - External factors render a technology obsolete
  - Due to competition, changes in market dynamics, technological obsolescence, regulatory, etc.
  - Perhaps the most important factor to consider for valuation purposes

Economic Obsolescence - Example

- In April 2023, Intel cancelled its bitcoin-mining Blockscale chips after just debuting them in June 2022. What factors may have led to this decision?

Economic Obsolescence - Example

- In April 2023, Intel cancelled its bitcoin-mining Blockscale chips after just debuting them in June 2022. What factors may have led to this decision?
  - New, more energy-efficient processors from its competitors
  - Low price of bitcoin decreases demand for product
  - Better opportunities emerge (e.g. Generative AI)
  - Concerns about potential regulatory actions

Fair Value Guidance - Useful Lives

- While the accounting standards do not provide guidance related to obsolescence, they do provide thoughts on useful lives for intangible assets
- While useful lives are accounting estimates and not direct measures of obsolescence, the concepts presented in ASC Topic 350-30-35-3 do provide some insights on the topic.
- Factors to consider for useful lives according to ASC Topic 350 are cited on the following slide.

ASC 350 – Useful Life Considerations

- The expected use of the asset by the entity.
- The expected useful life of another asset or a group of assets to which the useful life of the intangible asset may relate.
- Any legal, regulatory, or contractual provisions that may limit the useful life...
- The effects of obsolescence, demand, competition, and other economic factors (such as the stability of the industry, known technological advances, legislative action that results in an uncertain or changing regulatory environment, and expected changes in distribution channels)
- The level of maintenance expenditures required to obtain the expected future cash flows from the asset.

Technology Adoption – Key Factors (Rogers)

- Relative advantage (accelerates)
- Compatibility (e.g., with consumer needs, behavior, lifestyles, etc. - accelerates)
- Complexity (a barrier to use – decelerates)
- Trialability (ease of use - accelerates)
- Observability (being able to see and understand the benefits – accelerates)
- Communication channels, social systems, and promotion efforts
  - Think for example the launch of the iPod

Rogers EM, *Diffusion of Innovations*

Important Factors to Consider - Obsolescence

- Need to *consider multiple factors together* vs. focusing on one factor
- Obsolescence is often *not linear*
- *Stage of life cycle* matters
- Type of technology matters - *routine* vs. *pivotal* vs. *disruptive*
- *Valuation methodology* can impact thinking and approach
- *A portion* of the technology may have a *longer life* that extends to future products and service offerings

Obsolescence - Analyzing New and Old Technologies Together (Adner and Kapoor)

- Analyzed 10 new technology generations (semiconductor lithography equip)
- In each case the new generation was clearly superior, and customers were well informed and eager to use the technology.
- However, adoption rates ranged from rapid (1 year), to slow (10 years), to not ever achieving dominance
- Found that the interaction between the old and new technology was a key factor affecting the adoption rate; specifically, emergence challenges for new technology and extension opportunities for the older technology

New-Old Technology Dynamic - Findings

- Cases with low emergence challenge and low extension opportunity resulted in fast adoption (on average 3 years)
- Cases with high emergence/high extension opportunity faced the slowest adoption
- Mixed cases of low/high are in the middle of adoption rates
- Emergence challenge could be based on references in a lead technical publication and compared to the average across generations
- Extension opportunity based on technical knowledge of the product

		Ecosystem Extension Opportunity (Old Technology): Low	Ecosystem Extension Opportunity (Old Technology): High
Ecosystem Emergence Challenge (New Technology)	Low	*Quadrant 1* Baseline pace of substitution (fastest pace)	*Quadrant 2* Intermediate pace of substitution
	High	*Quadrant 3* Intermediate pace of substitution	*Quadrant 4* Slowest pace of substitution

How can we model technological obsolescence?

- "… [A model for forecasting technological change] should be based upon easily understood assumptions that are not available for unconscious or invisible tampering by the forecaster in his efforts to make the future what he wants it to be. The model should be easy to apply to a wide variety of circumstances, and should be easy to interpret."

J. C. Fisher, R. H. Pry

A Simple Substitution Model of Technological Change

How to Estimate Rate of Obsolescence

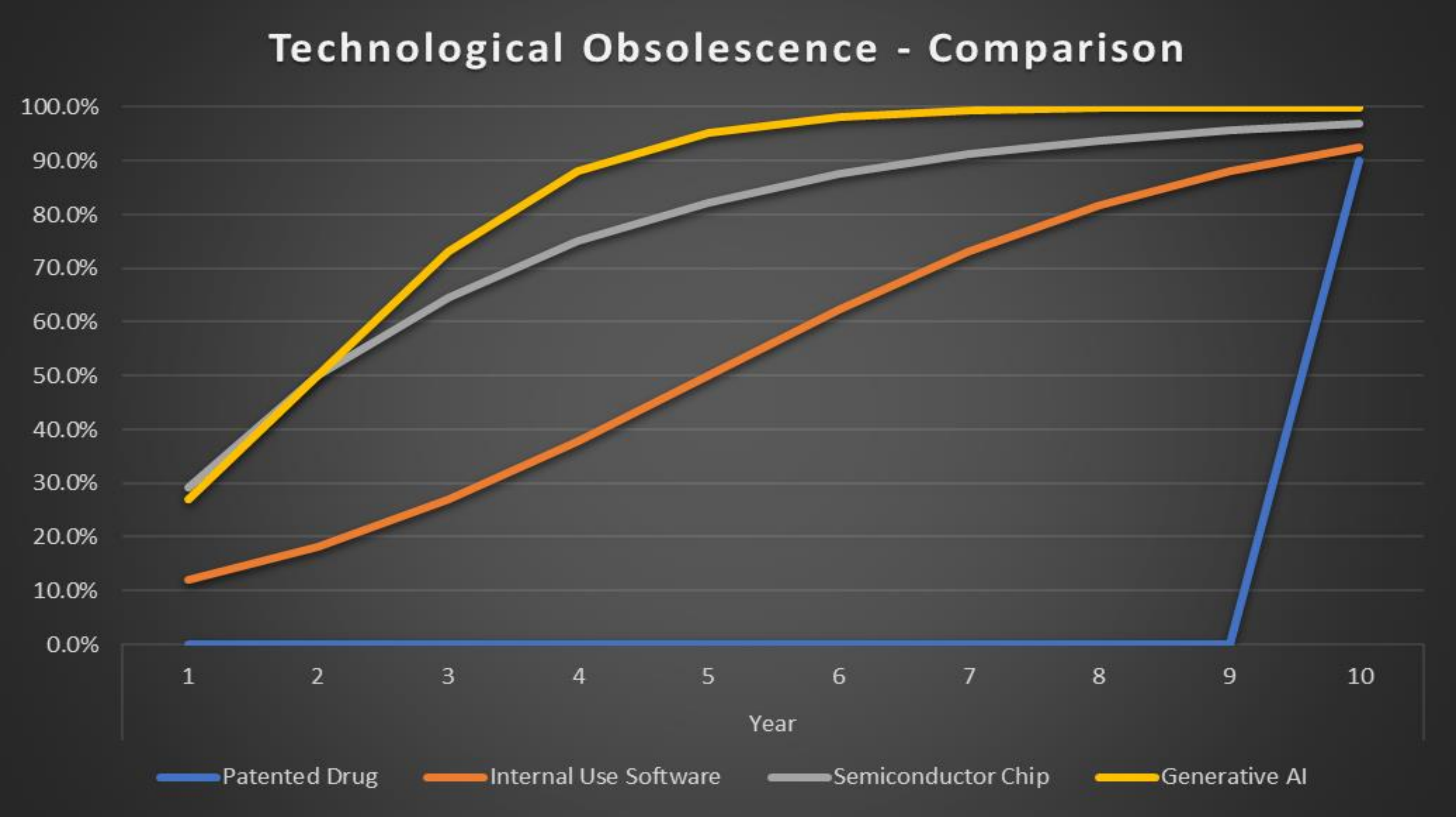
- Determining obsolescence for technology is similar conceptually to estimating attrition for customers in some ways, i.e.
  - Analyze historical data
  - Consider qualitative factors
  - Consider impact of future expectations
  - Develop a forecasted pattern of obsolescence
- If the data seems to fit, then you should use it

What data could be considered?

- Think about what is most relevant to your technology for example:
  - Performance metrics (processing power, battery life, size)
  - Sales/market adoption rate
  - Investment trends (VC investment in space)
  - R&D expenditures
  - Production or implementation costs (decreasing as matures?)
  - Pricing and profit margins
  - Maintenance costs (rising in later years?)
  - Emergence of new technologies (competing and complementary)
  - Patent analysis

The Data Often Tells Different Obsolescence Stories

- For example, compare the following technologies
  - Patented drug (market-dominant, no foreseeable challengers)
  - Semiconductor chip
  - Internal use software
  - Generative AI
- The patented drug may experience no obsolescence until the patent expires
- Internal use software may not be impacted much by external forces and have a slower rate of obsolescence
- Semi-conductors/generative AI exposed to technological obsolescence



Technological Obsolescence - Comparison
100.0%
90.0%
80.0%
70.0%
60.0%
50.0%
40.0%
30.0%
20.0%
10.0%
0.0%
1
2
3
4
5
6
7
8
9
10
Year
Patented Drug
Internal Use Software
Semiconductor Chip
Generative AI

Valuation Methods and Obsolescence

- Cost approach valuation
  - Asset more routine in nature
  - Heavier emphasis on planned and functional obsolescence
  - Valuation assumptions can impact the obsolescence assumptions
- Income approach valuation
  - Asset more pivotal in nature
  - Heavier emphasis on economic obsolescence
  - More likely to have a faster rate of obsolescence

Quantitative Approaches to Obsolescence

- Researchers have provided a number of quantitative methodologies to approach technological obsolescence:
  - Moore's Law
  - Replacement Cost Analysis
  - Failure Rate Analysis
  - Patent Analysis
  - Substitution Analysis
  - Logistic S Curve Analysis (Fisher Pry)

Moore’s Law

- Formulated by Intel co-founder Gordon Moore in 1965.
- States that the number of transistors on a microchip doubles approximately every two years.
  - This rate implies an annual obsolescence of 29.3%. ([1-.293]^2 = .50)
- Using Moore's Law, you could estimate technological obsolescence
  - However, the technology you are valuing might not follow this pattern; the devil is in the detail.

Replacement Cost Analysis

- Helps determine the optimal time to replace equipment before it becomes too inefficient and expensive.
- Can also be applied to certain kinds of technology that may have similar attributes
- Calculate the present value of future replacements based on historical replacement cycles and projected technology advancements.

Examples of Replacement Strategies

- At fixed intervals
  - Approach to asset replacement that minimizes the present value of the total asset costs by choosing the optimal sequence for each sequentially replaced asset.
- At first failure
  - Reactive approach where equipment is only replaced when it completely breaks down, potentially leading to higher downtime risks and missed opportunities for efficiency gains with newer technology.
- Cuckoo Optimization Algorithm
  - Uses optimization algorithms that determine when the optimal components should be replaced by the new generation units.
- K strategy
  - A system with N identical and independent components, constant failure rate, corrective and preventive maintenance actions to keep a constant failure rate, and the broken-down components are replaced by newer units with lower failure rates.

Failure Rate Analysis

- This approach analyzes the frequency of failures within a technology.
- By tracking historical failure rates and modeling future trends, you can estimate when a technology might become unreliable due to component degradation.
- This is particularly useful for mechanical or infrastructure technologies.

Patent Citations as a Measure of Obsolescence

- Song Ma paper (Technological Obsolescence) uses patent citations to determine obsolescence
  - Defines a firm's technology base as the number of patents that it cited for its own innovation (as of a certain year).
  - Defines technological obsolescence as the rate of change in citations made to the firm's technology base over a certain time period.

Patent Citation Analysis Observations

- Sample consists of US public firms between 1986 and 2016.
- Looks at obsolescence measure for different ω horizons, ω = 1; 3; 5; 10.
- Using $\omega = 1$ as the illustrative case, on average, a firm's technology base 7.84% fewer citations in year t compared to the year before
- For $\omega = 5$, the mean of 19.39% means that the five-year obsolescence scores on average, roughly 3.9% per year over the 5-year period.

	count	mean	std	10%	25%	50%	75%	90%
Obsolescence, Horizon $\omega = 1$ (%)	32,697	7.843	13.384	-8.039	-0.414	7.438	15.667	24.201
Obsolescence, Horizon $\omega = 3$ (%)	32,697	12.900	26.557	-19.860	-3.336	13.346	29.456	44.765
Obsolescence, Horizon $\omega = 5$ (%)	32,697	19.390	34.965	-22.924	-1.626	19.065	40.465	62.388
Obsolescence, Horizon $\omega = 10$ (%)	30,644	34.126	51.844	-28.776	0.867	32.694	65.796	100.857
Stock Market-Based Patent Value (SM) (%)	32,697	15.322	33.402	0.000	0.251	3.699	15.612	41.488
Citation-Weighted Patents (CW) (%)	32,697	7.788	20.317	0.000	0.095	1.484	5.926	17.737
Competitors' Patent Value (%)	31,107	26.301	32.828	1.397	6.466	18.629	32.218	51.627
Competitors' Citation-Weighted Patents (%)	31,107	3.027	2.684	0.227	0.786	2.135	4.718	7.111

Patent Citation Analysis – Other Observations

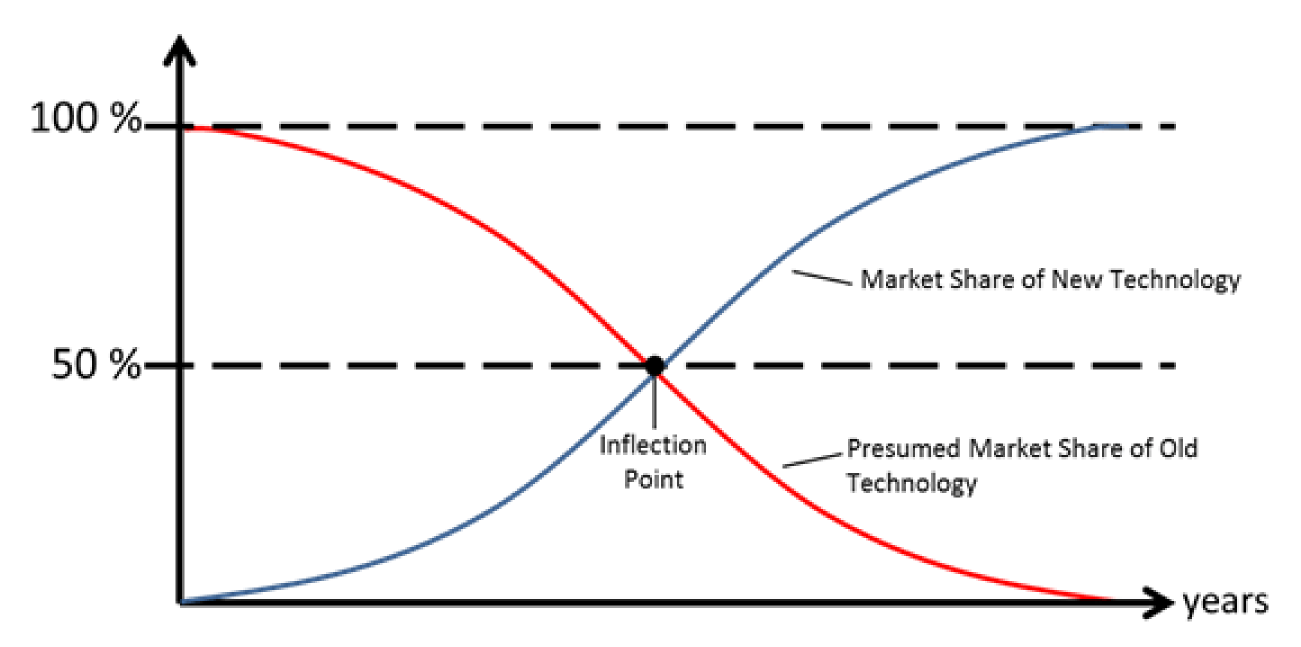
- Do the results suggest an understatement of obsolescence? Or are we overstating it?
- The expansion rate of a firm's technology base is roughly 10% per year.
  - This suggests that subsequent innovation often is a continuation of the prior foundation captured by the technology base.
- More than 90% of companies within an industry have a technology patent citation overlap ratio of zero.
  - This suggests that even firms in the same narrowly defined industry are exposed to very different innovation paths and their potential disruptions.

Substitution Analysis

- A technique to project the adoption of a new technology.
- Examines how a technology gets displaced from the market when a newer version enters the market.
- The new technology provides improved capabilities, performance, and/or economies.
- A number of studies have examined patterns of technology substitution.
  - Often the pattern was consistent from one substitution to another and was characterized by an S-shaped curve.

Substitution Analysis

- The adoption of a new technology starts slowly because it is usually expensive, unfamiliar, and imperfect.
- As the new technology improves, it finds more and more applications, it achieves economies of scale and other economic efficiencies, and it becomes generally recognized as superior.
- The old technology, because of its inherent limitations and falling market share, cannot keep pace with the new technology.
- Toward the end of the substitution, adoption of the new technology slows down again as the old technology becomes obsolete.



Rate of Adoption – Further Insights

- "When a substitution begins, the new product, process, or service struggles hard to improve and demonstrate its advantages over the dominant product, process, or service. As the new substitution element becomes recognized by commanding a few percent of the total market, the threatened element redoubles its own efforts to maintain or improve its position. Thus, the pace of technical innovative effort--indeed, the competitive pace of all aspects of the substitution--may increase markedly during the course of the substitution struggle. "

J. C. Fisher, R. H. Pry

A Simple Substitution Model of Technological Change

Logistic (Fisher Pry) S Curve Model

- Estimates the adoption rate of technologies using an S-shaped pattern
- Model assumes:
  - New technologies are competitive substitutes (satisfy the same need)
  - Early stages: Substitutions proceed exponentially as technology gains awareness
  - Adoption: Rapid acceleration in this phase
  - Maturity/late stages: Adoption flattens as technology reaches its limits or saturation
- Can be used as a proxy for obsolescence of the technology you are valuing

Advantages of Logistic S Curve

- Fits data well in a wide variety of circumstances (including technology)
- Flexibility to capture the dynamics of different technologies
- Relatively easy to implement (a more realistic option for use in valuation)
- Can capture varying rates of adoption from early to late stages

Disadvantages of S Curve

- Lack of sufficient data makes the analysis more subjective
- May not account for new external factors or disruptions
- May be difficult to explain in a fair value/audit environment
- Requires thought about the consistency between inputs and the economic life of the technology

Logistic S Curve Equation

$f(x) = L/(1 + e^{(-k(x-x_0))})$

Where:

e ≈ 2.71828 (Euler's constant; base of the natural logarithm)

L = Maximum market penetration (assume 1 for this purpose)

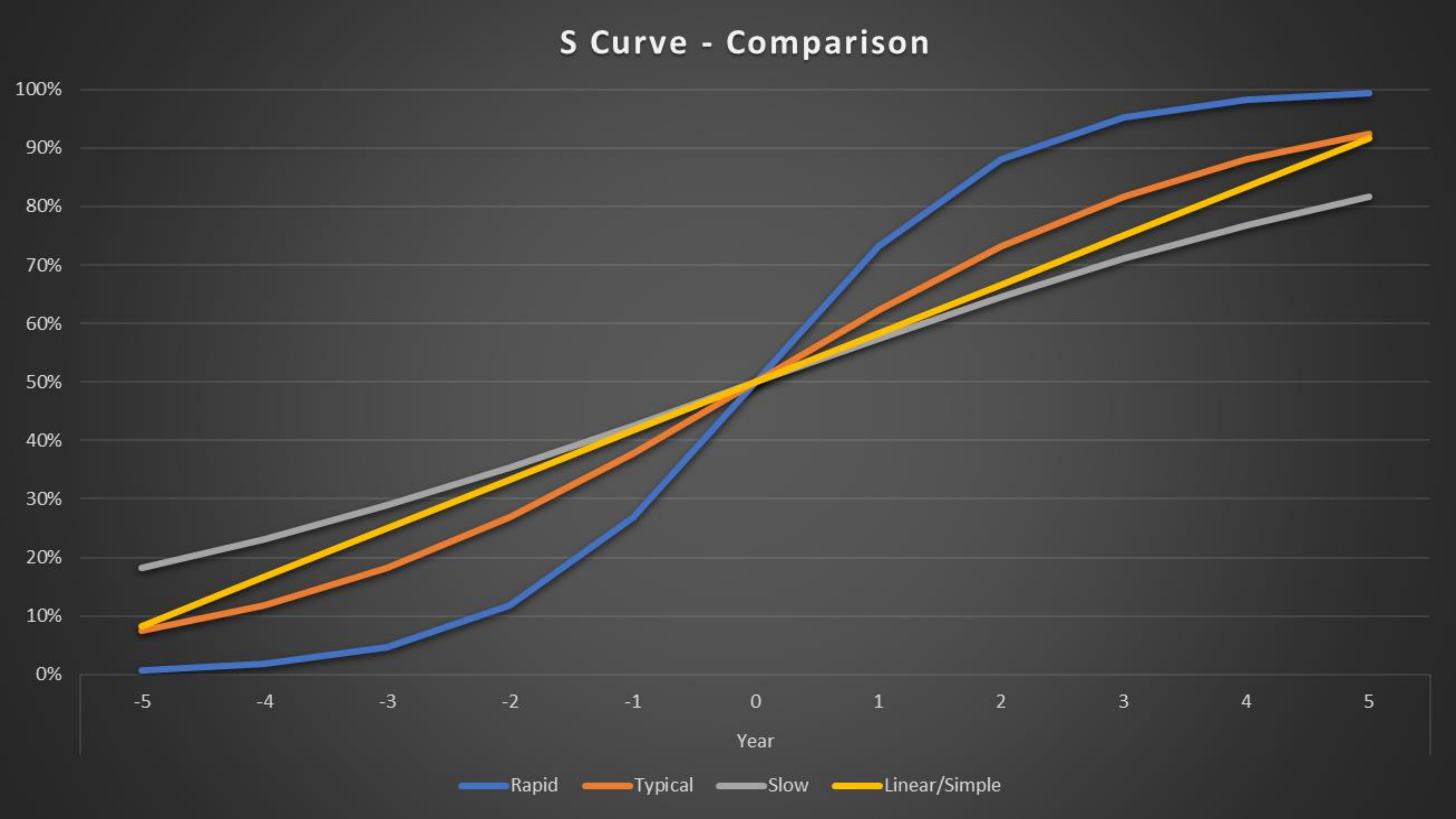
k = steepness of curve (1 = steep/rapid change; 0.5 neutral, 0.1 slow)

x = year for which you are estimating obsolescence

X_0 = midpoint (year reach 50% market penetration/obsolescence)

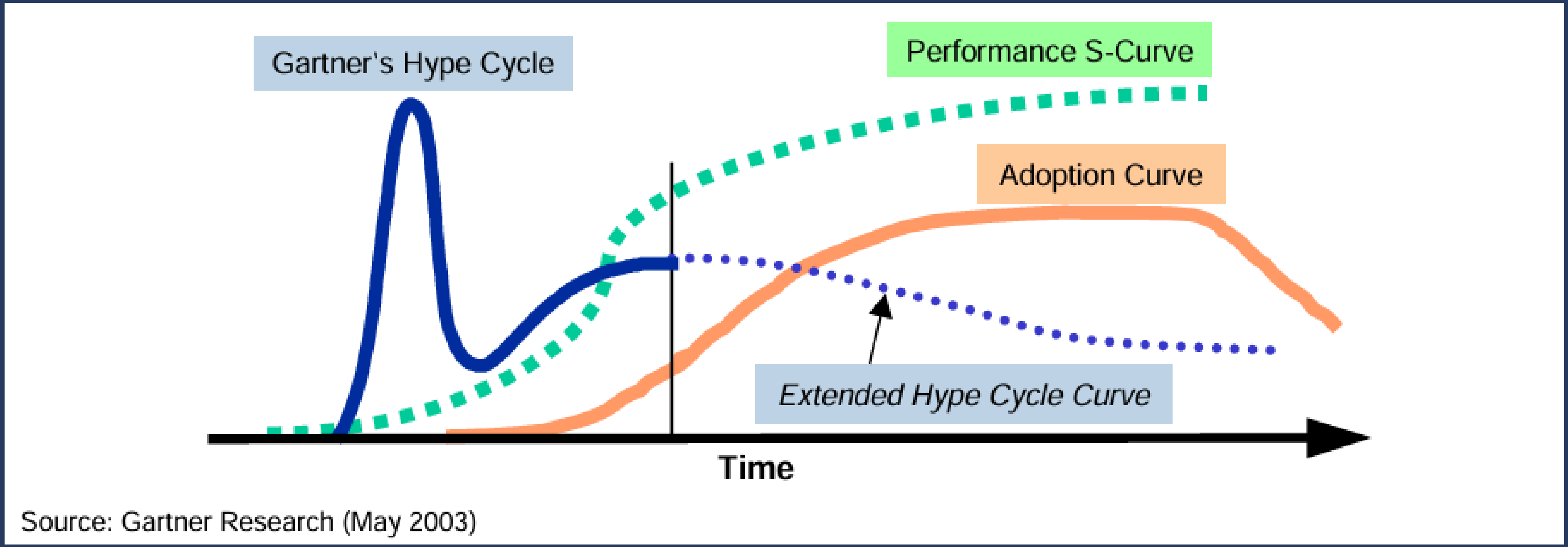
Examples of Obsolescence Pattern

- Pattern and rate of migration assumptions have a major impact
- For example, consider the following comparison for a software product
  - S curve with rapid adoption (steep curve)
  - S curve with standard adoption rate (curve is average steepness)
  - S curve with slow adoption (flatter curve)
  - Linear pattern

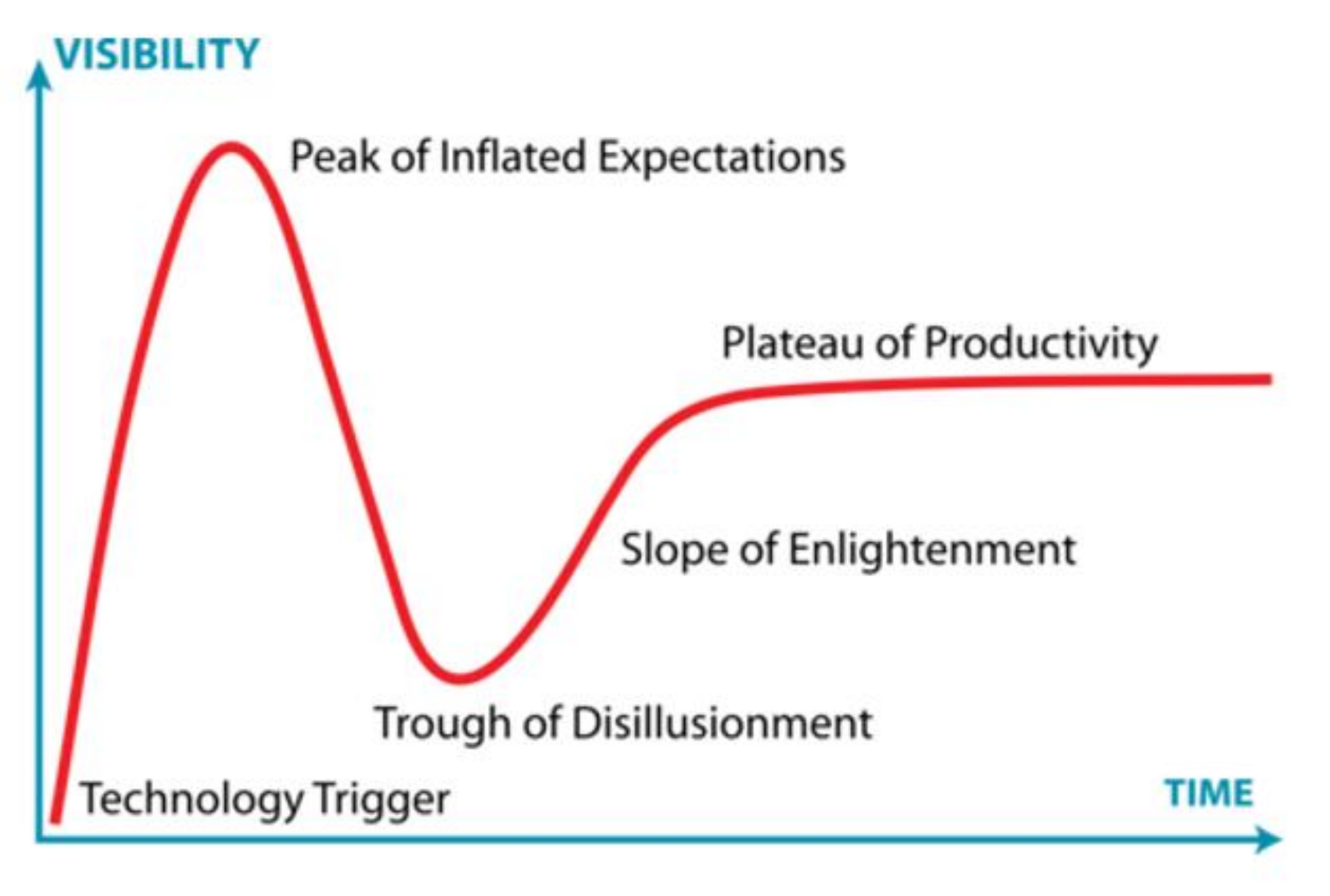

S Curve - Comparison
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
-5
-4
-3
-2
-1
0
1
2
3
4
5
Year
Rapid
Typical
Slow
Linear/Simple

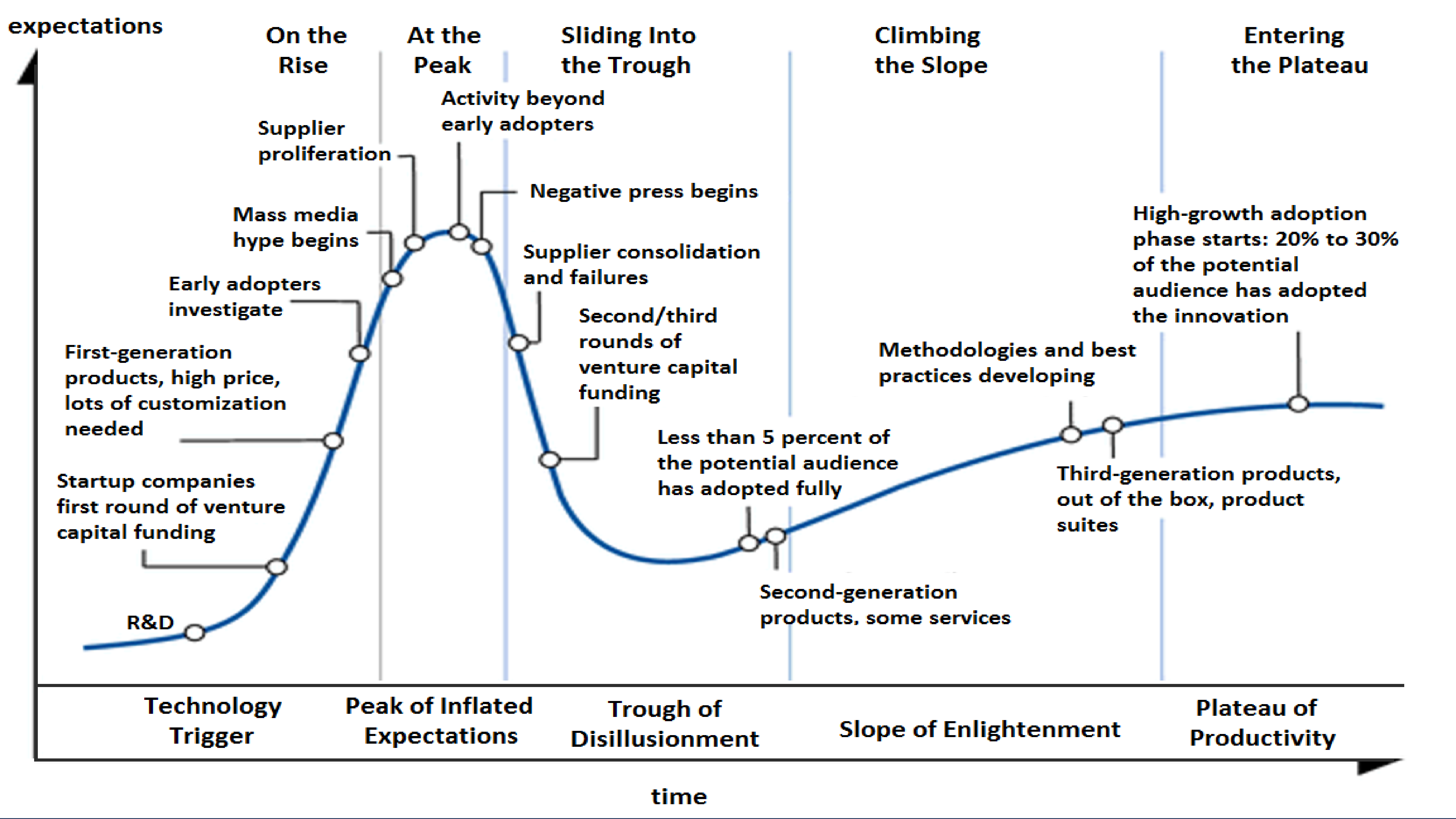
Gartner Hype Cycle

- The Hype Cycle adds another dimension to traditional models, particularly for disruptive technologies in high demand. In addition to charting technology maturity, Hype Cycles also reflect human attitudes to technology.



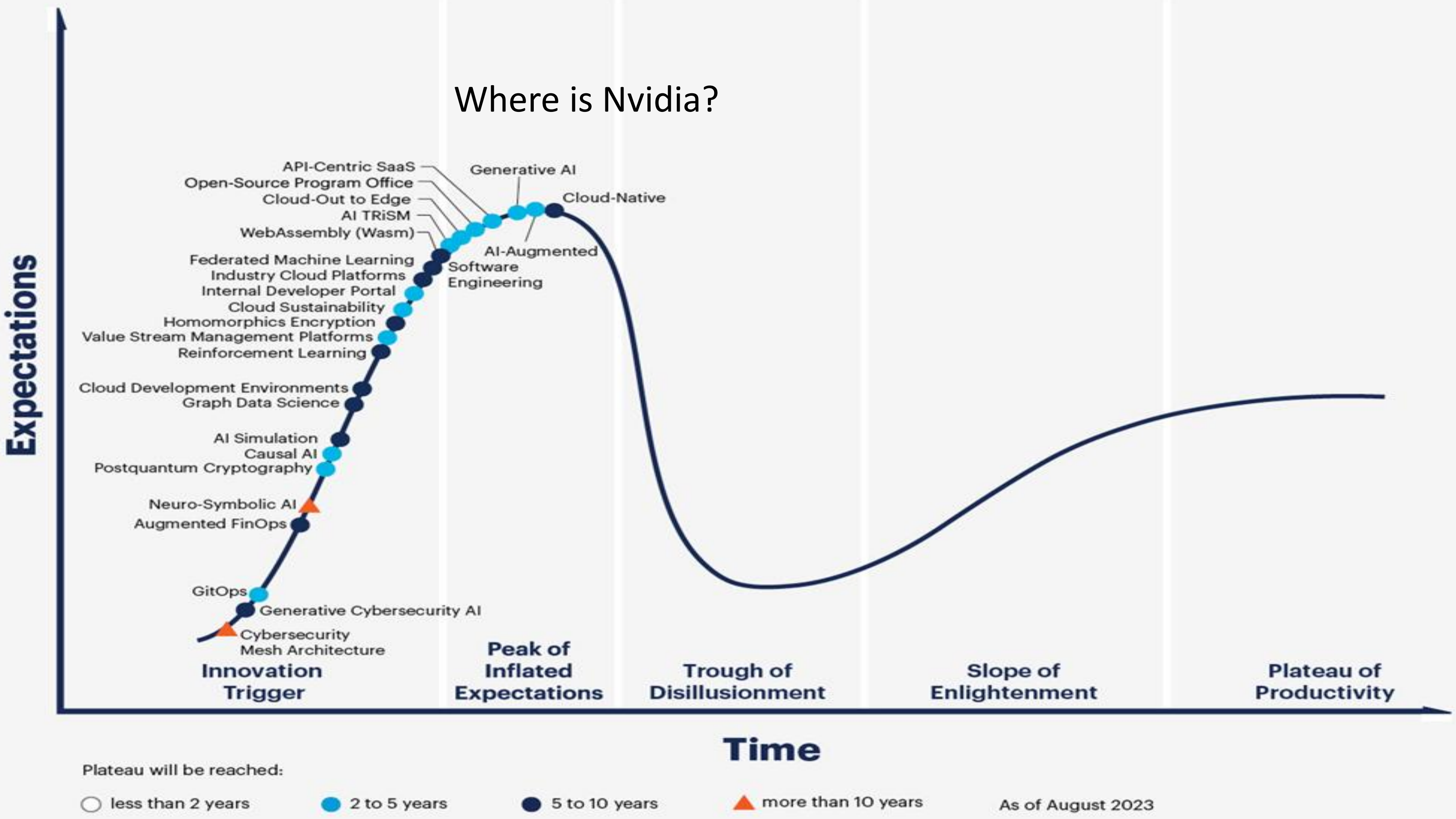
Gartner Hype Cycle




expectations
On the Rise
At the Peak
Sliding Into the Trough
Climbing the Slope
Entering the Plateau
Activity beyond early adopters
Supplier proliferation
Negative press begins
Mass media hype begins
High-growth adoption phase starts: 20% to 30% of the potential audience has adopted the innovation
Supplier consolidation and failures
Early adopters investigate
Second/third rounds of venture capital funding
First-generation products, high price, lots of customization needed
Methodologies and best practices developing
Less than 5 percent of the potential audience has adopted fully
Third-generation products, out of the box, product suites
Startup companies first round of venture capital funding
Second-generation products, some services
R&D
Technology Trigger
Peak of Inflated Expectations
Trough of Disillusionment
Slope of Enlightenment
Plateau of Productivity
time

Hype Cycle for Emerging Technologies, 2023

Where is Nvidia?



gartner.com

Source: Gartner

Gartner.

Obsolescence – Final Thoughts

- There is no "one size fits all" approach to estimate obsolescence
- Like valuation, there are a myriad of factors to consider – together
- Understanding the technology, selecting the right approach, and considering all key factors is the key to success