15.912
Technology Strategy

Professor Jason Davis
MIT Sloan School of Management
Effective strategies address three key problems:

- How will we Create value?
- How will we Deliver value?
- How will we Capture value?
Effective strategies address 3 key problems:

• **How will we create value?**
  – How will the technology evolve?
  – How will the market change?
  – How do we organize effectively?

• **How will we capture value?**
  – How do we compete to gain sustainable competitive advantage?
  – How should we compete if standards are important?

• **How will we deliver value?**
  – How should we execute the strategy?
  – How do we make strategic decisions and take decisive action?
Why have a strategy?
Why have a strategy?

1. To make choices and take actions
Is This Your Project Pipeline? (A Log Jam)
Why have a strategy?

2. To be able to change it
The strategic challenge evolves down the S curve.

Performance

Time

Ferment

Takeoff

Maturity

Discontinuity
The nature of technical work changes

Performance

We need to be responsive & flexible but *controlled*

Can we make 100,000? And service them?

Will it work? Exploration, fun, creativity key

Core Ideas: Forecasting S curves?
The marketing challenge evolves

Performance

Stay close to your customer – really close

Who needs this?

Do we have any reference customers?

Who needs this?

Time

Core Ideas:
Market segmentation
The Innovator’s Dilemma
The ways in which a firm captures value also evolve dramatically.

We may not be leading edge but you’d rather buy from us because...

We can sell it, make it, service it, ship it. Most of the time.

Speed, IP, Differentiation, Frontier performance key.

Core Ideas:
- 5 forces
- Appropriability
- Complementary assets
The organizational challenge changes significantly.

Performance

“Entrepreneurial Energy” critical

“Coordination & control” critical

“Entrepreneurial Energy” critical

Core Ideas:
Managing the organizational dynamics of discontinuity
That is, Technology Strategy is hard because it involves doing strategy in highly dynamic environments:

- high velocity
- high complexity
- high ambiguity
- high unpredictability
Strategic Challenge of Technology Markets: Unpredictability and Ambiguity

**SOURCES**

- Future S-curves and market evolution are hard to predict!
- Blurred timing and paths
- Shifting competitive basis, from products to business models
- Lack of control over key technology resources

**IMPLICATIONS**

- Planning is limited
- Reacting is insufficient
- Traditional strategies of “defend a position” and “leverage core competence” are incomplete
- Shift from “closed” internal innovation to “open” innovation with partners
How shall we create value?
Creating Value:

• Understand how technologies will evolve
  — (Both your own and those on which you rely)

• Understand how customer needs will evolve

• Organize effectively to develop world class products and services that meet customer needs
Tools for value creation

• Predicting Technological Change
  – Limits and Growth Rates
  – Trend extrapolation

• Predicting the Evolution of Customer Needs
  – Basic segmentation
  – Crossing the chasm
  – New technologies, new needs

• Utilize moderate structure and dynamic organizational processes
Trend extrapolation: Semiconductors
Issues in Trend Extrapolation

• Which parameter shall I predict?
• Do all good things come to an end?
• Exploring the difference between progress as a result of the passage of time, and progress as the result of returns to effort
• Predicting progress in complementary technologies
Do all good things come to an end?

Technological exhaustion

Performance is ultimately constrained by physical limits

E.g.:
- Sailing ships & the power of the wind
- Copper wire & transmission capability
- Semiconductors & the speed of the electron
Modeling the returns to *effort vs. time*

Performance may be a *non linear* function of effort expended: in mature industries more and more effort may lead to less and less progress, while progress in emerging industries may be “surprisingly” fast.
The Unexpectedly Long Old Age of Optical Photolithography


Image by MIT OpenCourseWare.
S-Curves, Real and Imaginary

Implications of the S-curve

• Technological performance is a function of effort, NOT time

• R&D is often less productive when focused on either early prototypes or mature technologies

• Managing the transitions between S-curves is a critical strategic task: sticking with an old S-curve can be disastrous
S-curves often challenge existing organizations severely

### Alignment Equipment

<table>
<thead>
<tr>
<th>Firm</th>
<th>Contact</th>
<th>Proximity</th>
<th>Scanners</th>
<th>Step &amp; Repeat I</th>
<th>Step &amp; Repeat II</th>
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</tr>
<tr>
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<td>61</td>
<td>75</td>
<td>99+</td>
<td>81</td>
<td>82+</td>
</tr>
</tbody>
</table>

But they also create major opportunity

• Corning glass
  – Cookware to optical fiber
• Nokia
  – Rubber boots to cell phones
• IBM
  – Mainframes to PCs to Services
• Eli Lilly
  – “Random” drug discovery to genetics and genomics
The Evolution of Markets

or

Predicting the pattern of customer needs
A Key Framework:
The industry life cycle

- Maturity
- Incremental Innovation
- Era of Ferment/Discontinuity
- “Dominant design” emerges
The Industry Life Cycle as an S-curve

- Performance
- Maturity
- Takeoff
- Ferment
- Discontinuity

Time
What is the relationship between the S curve and the diffusion curve?

=> ?
Diffusion is Hard...start with limits and growth

• Supply:
  – Technology S-curves! ...a natural constraint.
  – Effective Organization ...we’re not there yet.

• Demand:
  – Ultimate Market Limit...changes with demographic growth & changing preferences
  – Rate of Information Transfer
  – Substitutes
  – ...

• Competition:
  – Price competition can shift growth...

• ...and the interactions between Supply, Demand, and Competition!
Market Evolution over the Life Cycle

- Market segmentation
- Crossing the chasm
- New markets, new needs:
  - The Innovator’s Dilemma
The Key Question:
Who buys a technology as it evolves?
Understanding market dynamics: Basic segmentation (Rogers)

Adopters differ by, for example, social, economic status -- particularly resources, affinity for risk, knowledge, complementary assets, interest in the product.
Understanding market dynamics: Crossing the chasm: (Moore)

Making the transition from “early adopters” to “early majority” users often requires the development of quite different competencies: e.g. service, support capabilities, much more extensive training.
Managing customers at moments of discontinuity

Who buys a technology when it is first introduced?

New technologies sell to:
- New customers
- With new needs
- Often at lower margins
Initially, PDAs did not seem to be a threat to PCs:
PDAs sold to customers with different needs:

- PCs
- PDAs

Graph with axes:
- Speed, Power, Memory
- Weight/cost
But as PDAs improve they may come to challenge PCs.
Or consumer preferences may change?

Speed, Power, Memory

PCs

PDAs

Weight/cost
“Disruptive” technologies may threaten established firms

Clay Christensen: *The Innovator’s Dilemma*
Managing the change in customer groups may be the hardest task!

Leading edge customer focused research may be a critical capability
What can be done?

• “Ready, aim, fire”
• Small scale experiments
• Virtual products
• Lead user research

} Significant resources required!
Creating Value:

• Understand how technologies will evolve
  – (Both your own and those on which you rely)
• Understand how customer needs will evolve

• **Use technologies** to develop world class products and services that **meet customer needs**
  – How?
    • Get lucky…works once or twice
    • Do it consistently with effective Organization Structures and Processes
      – e.g., Apple, Google
Effective Organization changes during discontinuities

- How do we manage incremental innovation?
- How do we manage discontinuous innovation?
Strategic Challenge: Changing Environments are Unpredictable and Ambiguous!

**SOURCES**

- Future S-curves and market evolution are hard to predict!
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**IMPLICATIONS**

- Planning is limited
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- Traditional strategies of “defend a position” and “leverage core competence” are incomplete
- Shift from “closed” internal innovation to “open” innovation with partners
Potential Solution: Organizational Structures that respond to change

Organizational Structures enable coordinated responses to environmental change by shaping action in real-time.
Amount of Organizational Structure can vary greatly!

Hierarchy

Low

Medium

High

Rules

Unit Networks

Alliance Networks
Inverted U-shaped Relationship between the Amount of Structure and Performance

- Fundamental Relationship illustrates the tension between efficiency and flexibility.
- Observed in multiple industries and for multiple types of structure:
  - Hierarchy
  - Roles
  - Rules
  - Networks
New Modeling and Evidence suggests Asymmetry and Dependency on Market Dynamism

- **Asymmetry**: more forgiving on the side of too much structure
- **Optimum is less structured and more severe in less predictable environments**

![Performance versus Structure Graph](attachment:image.png)
# Examples: Simple Rules in Dynamic Markets

<table>
<thead>
<tr>
<th>Company</th>
<th>Simple rules</th>
</tr>
</thead>
</table>
| Intel®            | • Priority Rules helped Intel shift from DRAMs to Intel® Microprocessors  
|                   | • Simple Rules about minimum project size  
|                   | • Copy Exactly                                                                                                                                 |
| Pfizer®           | • Clear ranking molecules types as research priorities  
|                   | • Maximum number of molecule types pursued at any one time  
|                   | • Projects “killed” according to step charts                                                                                     |
| Miramax Films®    | • Movies must  
| The Crying Game   |   – Center on a basic human condition and flawed, but sympathetic character  
| Pulp Fiction      |   – Have a clear beginning, middle, and end  
| The English Patient | • Disciplined financing (50% more efficient than industry standard)  
| Life is Beautiful |                                                                                                                                                  |
| Shakespeare in Love |                                                                                                                                                  |
Explains mysterious organizational phenomena:

• Liability of newness: less structured entrepreneurial firms can “collapse from within” while large firms with more structure can “muddle through” with little innovation

• Maintaining optimal structure is more precarious (more V-like than U-like!) in unpredictable markets:
  – Emerging markets
  – High-technology industries

• Effective strategy is more simple in highly dynamic markets
  – Less structure enables more flexible responses
Key Lessons about Organization Structure

• Managers need to manage not only the Content but the Amount Structure
• Employees can (and sometimes should) subvert structures!
• Structure is merely a constraint on action...the right side of the inverted U-shape suggests that improvisation and creativity must be combined with structure to produce innovations.
• Organizational Processes that change over time are as strategically important as Organizational Structures that do not...
How shall we capture value?

Uniqueness, Complementary Assets & the Structure of the Value Chain
Or:
What determines the Inventor’s Share?

- Suppliers
- Customers
- Imitators, followers
- Inventor
Is it the case that great ideas = pots of money?

Value captured

Value created (through “raw” invention)

- Viagra
- Nylon
- Xerox (early)
- Xerox (late)
- Apple
- Coca Cola
- Wal Mart
- Dell
- RC Cola
Three key ideas:

• Uniqueness
  – Controlling the knowledge generated by an innovation: being the only game in town

• Complementary Assets
  – Controlling the assets necessary to exploit the knowledge generated by innovation

• Five Forces & the Value Chain
  – Understanding the dynamics of power in the value chain
Uniqueness and Complementary Assets

Complementary assets are:

<table>
<thead>
<tr>
<th>Available</th>
<th>Tightly held</th>
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<tbody>
<tr>
<td>Easy to maintain</td>
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</table>

Uniqueness is:

<table>
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<tr>
<th></th>
<th>Hard to maintain</th>
</tr>
</thead>
<tbody>
<tr>
<td>Easy to maintain</td>
<td></td>
</tr>
<tr>
<td>Hard to maintain</td>
<td></td>
</tr>
</tbody>
</table>
Uniqueness & Complementary Assets over the Life Cycle:
Managing discontinuities means managing complementary assets:

Which of my complementary assets are useful?
Using the model to dive deeper:

• Taking advantage of positive feedback to build strong complementary assets:
  – In marketing & R&D (Novartis)
  – In process technology (Intel)
  – In network externalities (Google, Nokia)

• Building an understanding of which assets may be available:
  – Are there spillovers?
  – What is the shape of the learning curve?
  – What is the structure of demand?
  – Do network externalities create value?
An example

- Demand
- Volume
- Capacity Utilization
- Scale Economies
- Learning
- Price
- Average production costs
Managing discontinuities means managing complementary assets:

Which of my complementary assets are useful?
Industry Structure and the Value Chain
Porter’s “5 (actually at least 7) Forces”: Thinking about the balance of power

- Entrants
- Substitutes
- Rivals
- Suppliers
- Buyers

“Complementors”

Political, regulatory and institutional context
C.Assets/Uniqueness speak to Rivalry and the Threat of Entry.
Porter reminds us to think about the structure of the value chain:
Powerful suppliers and buyers may constrain profitability
Making money from Innovation: Summary

• Creating value is not enough:
• It is important to capture value as well
• Value can be captured through a variety of mechanisms, including uniqueness and complementary assets
• Value capture strategies change over the life cycle
• Technology strategy and business strategy should thus be intimately linked
Make vs. Buy
Comparing “make” vs. “buy”
Key Considerations:

- How easy is it to write contracts?
  - How tight is the IP regime?
  - How much uncertainty is there?
  - “Specificity” of the asset – how “thick” is the market?

- What will happen to “entrepreneurial energy”? 

- What will be the key complementary assets going forward?
Make vs. Buy over the life cycle
So “make” (i.e. do it in-house) if:

- There are significant IP worries
- There are likely to be contractual problems
  - We can’t be sure of getting the “fair” price
  - We can’t be sure they’ll do the work “right”
  - *I.e., when market are “thin” or there is limited information*
- We have unique competencies that are relevant
  - Or could create them
- And if buying won’t destroy everyone’s incentives to be creative and energetic
But remember...

• One cannot “buy” profit – if everyone knows it is there – it will be in the price
• Besides, shouldn’t we “stick to our knitting”? 
• Wouldn’t you rather deal with an independent firm, whom you could fire, than an internal subsidiary?
Standards and Strategy: Competing in Increasingly Open Worlds
Thinking about the dynamics of the strategic space

**Access is:**

<table>
<thead>
<tr>
<th></th>
<th>Open</th>
<th>Closed</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Public</strong></td>
<td>Details of standards are available to all: no single firm has control over how they evolve: no charge for their use</td>
<td>Standards are owned and controlled by the public sector but are not freely available</td>
</tr>
<tr>
<td></td>
<td>E.g. TCP/IP, HTML</td>
<td>E.g. Cryptography</td>
</tr>
<tr>
<td><strong>Private</strong></td>
<td>Details of standard are made available to all: but owner has control over how the standard evolves and may charge for use</td>
<td>Technology may be standard, but details are not made available beyond the firm</td>
</tr>
<tr>
<td></td>
<td>E.g. Nintendo, Palm OS</td>
<td>E.g. Landmark Graphics, IBM 360</td>
</tr>
</tbody>
</table>
In practice these boundaries are fuzzy:

**Access is:**

- More Open
- More Closed

**Control is:**

- More Public
- More Private

- **Linux**
- **Symbian**
- **CDMA**
- **Windows**
- **IBM 360**
- **Mercury/Corba**
There are two sources of network effects

• Direct network effects
  – Network size
  – *Value increases with the number of other individuals who own the same product*
    • E.g.: Telephones, fax machines

• Indirect network effects
  – Complementary products/services
  – *Value increases with the number of complementary products that are available*
    • E.g.: CDs, software, VHS/Beta
  – Learning by using
  – *Standards mean customers invest only once in learning to use the technology:*
    • E.g.: Qwerty keyboard, Autocad
With Strong Network Effects Market Share Itself Creates Value

Value to consumer

Actual (or anticipated) size of the installed base

Value of standards Driven product

Conventional product
If network effects are important, markets may "tip"

Probability the next consumer chooses to buy A

A's share of installed base
Tipping dynamics differ with the strength of network effects.
Markets with moderate network effects only tip once critical thresholds are reached.
# Business models in the different quadrants

The **technology** is:

<table>
<thead>
<tr>
<th>Public</th>
<th>Private</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Closed</strong></td>
<td><strong>Open</strong></td>
</tr>
<tr>
<td>Compete on a level field</td>
<td>Deliver a best in class system</td>
</tr>
<tr>
<td>Move to “soft” standards?</td>
<td>Encourage the “ecosystem” Embrace/extend</td>
</tr>
</tbody>
</table>

**Control is:**
Strategic Management of Platforms and Ecosystems
Managing Platforms Involves Industrial and Technological Leadership in Four Areas

• Four Levers of Platform Leadership:
  – Scope of activities: in-house vs. ecosystem activities
  – Technology design and IP: features/functions in platform
  – Encouraging relationships with complementors
  – Internal organization that facilitates platform changes

Ecosystem dilemmas of Platform Leaders

• On the one hand, platforms create enormous incentives to “squeeze” your ecosystem:
  – Extending the platform into their space – e.g., envelopment
    • e.g. Microsoft: Windows platform now includes important middleware not originally part of the platform
  – Releasing your own complementary products in the critical areas (high growth, or strategic control points)
    • e.g., Microsoft: enters key complementor markets that are high growth (Office suite) or offering strategic control points (IE & the browser wars)

• But complementors must have an incentive to innovate... if you squeeze them they’ll exit! They create much (if not most) of the value for the platform!
How to resolve this dilemma? We’ll examine Intel’s solution, 1990-2004

• Dilemma: Capture value from Microprocessor platform, but don’t curtail value Creation by Ecosystem in many complementary markets...
  – E.g., Security, PCI, USB, DVD, Video, Motherboards, Audio, and many others...

• Step 0: Consider entering markets where you have competencies
  – Avoid markets where Intel has no competency, no matter how tempting at the time (e.g., internet software)
    • Hard to resist temptation: 5 failed entries into internet software became quick exits
  – Consider entering some complementor markets... but do so carefully... (the rest of the strategy is about how to do so)

The rest of this deck adapted from:
Journal of Economics and Management Strategy, Vol 16, Number 1, 1-34
Value Delivery
What went wrong at Medtronic?

- Declining Performance
- Overload
- Pressure to meet short term targets
- No time for thinking through strategy
- No decisions
Remembering Organizational Change in Medtronic; How did they fix things?
“Best Practice”

• Clear, committed leadership
• Well articulated strategic goals
  – “He cleaned up the front end…”
• Coherent management philosophy
• Measures and incentives
• Processes and practices
• A sense of urgency

• That reinforce each other
Product Development
Processes and Practices

• Speed
  – “Being fast eliminates so many other problems...”
  – Clear product definition process, rooted in strategy

• Platform strategy
  – Leverage technology across the range
  – Clearly differentiate technology development from product development

• Cross-Functional Teams
• Project documentation
• Phase definition
• Rhythm
• Market inputs
Funnels & Project Plans
The innovation funnel

Phase I  Phase II  Phase III  Launch
An Innovation Funnel Example

**Idea Generation**
Initial marketing and technical concepts

**Feasibility**
Concept refinement and prototype creation

**Capability**
Product optimization

**Launch & Rollout**
Commercialization Production & Distribution

**Post Launch Review**
Tracks success of and key learnings from launched products

**Gatekeeper**
Guardian for each phase

**Charter**
One page description of proposed project including objective, rationale and development routes. Early Commercial Assessment

**Contract**
Cross-functional development plan including project plan as contract between team and Gatekeeper.

**Launch Proposal**
Launch Plan including CEP approval request.

**KEY**

- Diamond = GATE
- Circle = DOCUMENT
Less Is More:
Medical Products Co.

Before vs. After

# of Projects in Portfolio

Before: 36
After: 21

# of Projects Launched /Year

Before: 5
After: 8
Develop the ability to manage *ambidextrously*

Different expectations, control systems, incentives. “High conflict, high respect” conversations
Building the ambidextrous organization

• **Lead:**
  – Build the “ambidextrous” senior team: communicate the strategy, allocate resources

• **Structure:**
  – Explore transitional and intermediate forms

• **Incent:**
  – Explain “just what’s in this for me?”

• **Build:**
  – Lay the foundations for a new culture, new expectations
Summary
Effective strategies address three key problems:

- How will we **Create** value?
- How will we **Deliver** value?
- How will we **Capture** value?
Effective strategies answer 7 critical questions:

• **How will we create value?**
  – How will the technology evolve?
  – How will the market change?
  – How do we organize effectively?

• **How will we capture value?**
  – How do we compete to gain sustainable competitive advantage?
  – How should we compete if standards are important?

• **How will we deliver value?**
  – How should we execute the strategy?
  – How do we make strategic decisions and take decisive action?
Understanding the life cycle is critical:

- Takeoff
- Maturity
- Ferment

Components:
- Technology
- Markets
- Competition
- Organization
Technology strategy on one slide:

- Startup
- Asset
- Supplier

Create

Deliver

Capture

Performance vs. Structure
Good Luck!