

# Technology and Innovation Management:

## Introduction

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#### Why Does Innovation Matter?

- main driver of growth
- OECD estimate is 60-70% of labour productivity growth
- under capitalism innovation becomes mandatory

#### Product or service innovation:

- to generate/increase Sales
- must be established on the market

#### Process innovation:

- to enable/improve production of goods or services
- must be established inside the organisation

#### Business model innovation

- Reshuffling of value proposition, processes, products, services, ...
- Example: Ikea selling unassembled furniture

### The Vasa

- Failed Innovation
- Lack of communication, nobody dares to voice concerns

### Patterns in Innovative Activity

#### Long-term patterns of technological change

- Technological change is cumulative and evolutionary
- Most innovations are new combinations of existing technologies or the introduction of new elements into existing systems
- some changes can be identified as revolutionary

#### Innovation shifts socio-economic paradigms

K-waves/Schumpeter's waves: Long cycles of economic growth and decline (50 years), where new inventions start new cycles of growth

## **Patterns in Technological Evolution**

### **S-curve**

- X-axis: Aggregate R&D spending (or time)
- Y-axis: Performance over time
- 1. Emergence: low performance
- 2. Rapid improvement: accelerating performance
- 3. Declining improvement: decelerating performance
- 4. Maturity: saturated performance
- Often, a technology follows the S-Curve
- New technology at some point surpasses old technology's s-curve
- S-curve does not always represent reality (e.g. lithography)

### **Sailing ship phenomenon**

- S-curves of sailing ships and then steam ships
- Right before steam ships overtake sailing ships in performance, new better sailing ship technology (the Cutty Sark)
- Final sprint of old technology motivated by accelerating performance of new technology

### **Product Life Cycle (PLC)**

Fluid Phase:

- In the early phase of a new product, frequent product changes occur
- diverse design
- Unspecified focus of R&D
- entrepreneurial organisation
- Much competition, more players enter market than exit

Transitional Phase:

- Major process changes
- One product design
- One R&D focus
- Organisation through project and task groups

Specific Phase:

- Incremental changes and innovations
- Only standard products
- R&D on incremental product technologies

- Well structured organisation
- More players leave market than enter

### **Adopter Categories**

- Innovators
- Early adopters
- Early majority
- Late majority
- Laggards

Jeffrey Moore: Crossing the Chasm:

- Chasm is hurdle between early adopters and early majority
- Central question in marketing of new technology

### **Who Innovates, and Why?**

Costs and benefits of innovation are the dominant drives of innovative activity

- Whoever gains the most is most likely to perform it
- Whoever has the lowest cost is most likely to do it

Schumpeters classical question: What market structure is most conducive to innovation?

- Schumpeter I: Entrepreneurs and new firms drive innovation => fragmented markets
- Schumpeter II: Large firms drive innovation => markets with some monopoly power

### **Arrow's Model**

What price would the innovator be willing to pay for the innovation?

- $q$ : Quantity
- $p$ : Price
- $p(q) = 100 - q$ : Linear demand curve. Higher price causes less demand (reversed linear function).
- $c_0$ : Cost before innovation
- $c_1$ : Cost after innovation
- $TR = q \times p$ : Total revenue if selling  $q$  products at price  $p$ .
- $MR$ : Marginal Revenue when selling one more product at price  $p$ . Ideally, this should be equal to marginal cost  $c_0$ , to maximize the potential profit. We can find the marginal revenue by substituting the price by the demand function in the total revenue formula, and then finding the zero point by deriving by  $q$ .

$$TR = q \times (100 - q)$$

$$TR = 100q - q^2$$

$$MR = \frac{\partial TR}{\partial q} = 100 - 2q$$

The point where the resulting line from  $MR = 100 - 2q$  intersects  $c_1$  tells us how much how much quantity  $q_1$  we should sell to maximize profits.

Definition radical innovation:

New Monopoly Price  $p_1 < \text{Old Marginal Cost } c_0$

**Case A: Ex-ante perfect competition => ex-post monopoly:**

Profit ex-ante: 0

Profit ex-post:  $area(ABCD) = D - A \cdot C - D = (p_1 - c_1) * q_1$

-  $A = (0, c_1)$

-  $B = (q_1, c_1)$

-  $C = (q_1, p(q_1))$

-  $D = (0, p(q_1))$

**Case B: Ex-ante monopoly => ex-post monopoly**

Profit ex-ante:  $area(EFGH)$ . Calculation is the same as for  $area(ABCD)$  but with  $c_0$  instead of  $c_1$ .

Profit ex-post:  $area(ABCD)$

**Case C: Ex-ante social planner, ex-post social planner**

Profit ex-ante: 0, because social planner sets  $p = c_0$

Profit ex-post: 0, because  $p = c_1$

Conclusion: Incentive to invest is lower for private companies than for social planners, because potential profit is always less than social incentive.

Welfare ex-ante:  $area(EJK)$

Welfare ex-post:  $area(AIK)$

which fills the whole area under the demand curve, which means the social planner gains more from the innovation.

This means case A, the ex-ante monopolist, has the lowest incentive due to replacement effect. Followed by case B, the firm in ex-ante perfect competition. The Social planner has the highest incentive.

## **Market Structure**

- Efficiency Effect: The monopolist is willing to pay more for the innovation (than a entrant) to remain the monopolist even in case of a non-drastic innovation.

- Cannibalization Effect: By innovating (drastic innovation) the existing firm would lose profits from existing product.

Empirical studies confirm that drastic innovation often comes from new entrants, not from incumbents.

## **Advantages of newness**

### **”Liability of newness” (increased failure rate vs older firms):**

- roles and tasks need to be assigned
- lack reputation
- lack experience
- no relationships
- have to rely on strangers
- limited resources
- low variety of skill in the firm, some critical skills are lacking
- no buffer for crisis
- disadvantage in the job market
- low market power
- no organizational slack (resources beyond current need)

### **Advantages of new firms:**

- can pursue completely new approaches
- more lean structure
- flexible and open culture
- can hire people exactly for task (no re-training)
- more younger and entrepreneurial employees
- more flexible processes
- company structure easier to identify
- direct communication
- fast decision-making

- job satisfaction higher

## **Disruptive Innovation**

In some industries big firms bring most innovation, both incremental and radical ones:

- These innovations are technologically straightforward
- Initially don't satisfy customers in established markets, sold to niche or new markets
- Performance of new technology grows
- New tech supplants old tech even in established markets

Disruptive innovation is difficult for market-related reasons. Incumbents also focus too much on existing customers.

## **Innovation Strategy**

Strategy is determination of long-term goals of a business as well as suitable steps and the allocation of resources to attain them. It intends to establish a long-term competitive advantage.

Change of strategy is typically very costly and not possible in the short run.

## **Strategy Development**

### **Internal/Resource based-View**

- Strengths
- Weaknesses

### **External/Market based-View**

- Opportunities
- Threats

### **Porter's Five Forces**

- Threat of new entrants
- Threat of substitute products
- Bargaining Power of Suppliers
- Bargaining Power of Buyers
- Existing Industry Rivalry

### **Potential (Re-)Sources of Competitive Advantage**

- Valuable
- Rare

Sustainable Competitive Advantage:

- Inimitable
- Non-substitutable

Resources/capabilities are difficult to imitate if they are:

- Tacit (Tacit knowledge = difficult to transfer written/verbally)
- Path dependent
- Socially complex
- Casually ambiguous
- Protected by effective IP
- Unique in their nature (e.g. location)

### **Resources for Innovation**

- Financial resources
- Human resources
- Technological resources
- Marketing resources
- Organizational resources
- Networking resources

## **Key Pillars of Successful Innovation Strategy**

### **Objectives**

An innovation strategy defines specific and precise innovation objectives in line with long-term goals.

### **Areas of Focus**

Innovation strategy defines what's in-bounds and out-of-bounds.

### **Type of innovation and accepted risk**

Three positions under uncertainty:

- Taking big bets (aiming for radical innovation)
- Hedging bets (diversifying, incremental innovation)
- Wait and see (imitate later)

### **Budget and Resources**

The allocation of resources to the various strategic or project types ensures strategic alignment.

### **R&D Organization**

E.g. Decentralization of R&D efforts based on local expertise.

## **Types of Innovation Strategies**

- Proactive
- Active
- Reactive
- Passive

## **Technology Push vs Market Pull**

Market Pull:

- Look for market needs
- Then look for technology to fulfill these needs

Technology Push:

- Look for new technologies with potential
- Question of needs comes second

...Or combination

Problems with Technology Push:

- Focus on easy problems
- Narrow focus on own solution
- Mismatch between own ideas and corporate interest

Problems with Market Pull:

- Focus on most easily identified needs but only minor potential
- Too much focus on a particular application
- Locked into present products, only incremental improvements

## **Profiting from Innovation**

### **Who Benefits from Innovation**

#### **Customer Benefits**

In Arrows model, everything under the demand curve, above the new monopolists price is "Consumer surplus".

### **Conditions for Profitable Innovation**

- Appropriability regime
- Life cycle phase
- Complementary Assets



## **Appropriability Regime**

Denotes all factors that influence the possibility of profitable imitation of an innovation.

- Legal Protection
- Viability of Secrecy
- Characteristics of innovation/technology

Further Factors:

- Network effect
- Switching costs
- Scale effects
- ease of market entry

## **Life Cycle Phase**

- When number of product innovations peak, dominant design is established
- Product innovations decline afterwards
- After dominant design is established, number of process innovations increases

Pre-paradigmatic design phase (before dominant design was established):

- Innovators success depends on their ability to make their technology the dominant design

Paradigmatic design phase (after dominant design was established):

- Innovators success depends on the control of the complementary assets

## **Complementary Assets**

- Competitive manufacturing
- Distribution
- Service
- Complementary technologies

## **Examples**

Specialized assets (unilateral dependence of asset on innovation or vice-versa):

- Dedicated service teams
- Specialized distribution channels

Co-specialized assets (bilateral dependence):

- Smartphone app eco-system
- Electric car charging stations

Generic assets (not specialized):

- Office space

- Off-the-shelf software

### **Combination of AR (Appropriability Regime) and CA (Complementary Assets)**

- Strong AR + Strong CA: Innovator and owner of CA profit
- Strong AR + Weak CA: Innovator profits
- Weak AR + Strong CA: Owner of CA profits
- Weak AR + Weak CA: Customers profit

### **Contract or Integrate?**

Contract:

- Lower capital needs
- Dependence on partner
- Imitation becomes easier

Integrate:

- Make imitation more difficult
- Capital intensive
- Time consuming

### **Cooperate?**

Benefits:

- Share potential benefit with other Firms, less competition
- Allow new firms to build on existing firms competencies

Risks:

- Willingness to pay for idea - but implies buyer knows about idea already
- Need for IP Rights

## **Protecting Intellectual Property**

### **Why care about IP Rights (IPR)**

- Help appropriate profits from innovation
- Increases incentive to innovate
- IPR of other firms can make operation/innovation difficult
- IPR contain valuable information

## **Formal vs Informal Information Protection**

Formal:

- Patents
- Registered Designs
- Trademarks
- Copyrights
- Confidentiality Agreements

Informal:

- Trade Secrets
- Lead time or first mover advantage
- Complexity of design
- Switching cost
- Network externalities

## **Patents**

- The main form of IP protection "Technological Invention"
- Right of ownership over an invention, granted by a government
- Patents are territorial rights; a German patent only relates to Germany

Whats patentable:

- Has to be novel
- Contain an "inventive step" compared to whats already known, something not obvious
- Be capable of industry application

Whats not patentable:

- Purely scientific discovery (without industry application)
- Scientific or mathematical method
- Asthetic creation like art or literature
- A device contrary to accepted physical laws

Special cases that cannot be patented in Germany and Europe:

- Computer program without physical effect
- Business method
- Invention of new animal or plant variety
- Treatment or Diagnosis of humans or animals

## **Patent Application**

- Describes invention

- Defines area of protection
- Application is made public after 18 months (1.5 years)
- Average time from application to decision: 4 years
- Patents last 20 years (25 for pharmaceutical)
- Have to be renewed (fee)