Technology and Innovation Management: Introduction

Introduction

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: deccelerating 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-cuves 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 < 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 are 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 exisiting product.
Empirical studies confirm that drastic innovation often comes from new entrants, not from incumbents.

Advantages of newness

"Liability of newnewss" (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 completly 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 dont 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

Porters 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 Competitve 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 whats 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 exisiting firms competencies

Risks:
- Willingness to pay for idea - but implies buyer knows aboout 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)

Benefits and Costs

Benefits:
- Entry barries for rivals
- Profits from Licensing or cross-licensing (patent exchange)
- Image/signaling, especially for small firms seeking capital

Costs:
- Process costs, including attorney, research, fees (renewal fees), translation
- Invention is made public
- Detection of infringement
- Patent Assertion

Why do Firms Use Patents?

- Prevent copying
- Blocking
- Prevent suits
- Enhance reputation
- For use in negotiations
- Licensings revenue
- Measure performance

Societal Benefits and Cost of Patents

- Patents increase innovation because the innovator is "guaranted" to benefit from the innovation.
- Low use of innovation, which leads to inefficiency
- Before patents, technology progress was hindered by trade secrets

Patent Infringements

- Must be found out by patent holder

- If court rules in favor of the patentee, patentee is entitled to injunction (infringer must stop using the patented technology) and damages (infringer must pay damages)
- Legal suits are difficult and expensive, therefore settlement or enhancement of negotiation position are also options
- Patent trolls

Registered Designs

- Design must be new
- Have individual character
- Registering period: 3-4 Months
- First five years 350€
- Can be registered 12 months after market introduction
- 25 years in total, renewal fees every 5 years
- Infringement enforcement can be difficult if not directly copied design
- Cheap but not very strong protection

Trademarks

- Sign which can distinguish goods or services from on trader to another
- Can be words, logo, pictures
- Germany: 290€ fee for 10 years, can be renewed every 10 years indefinitly
- Must be used in order to maintain protection

Copyrights

- Unregistered right, arises automatically
- Artistic works, or computer software
- In contrast to patents, protects the expression of ideas, not the idea itself
- 70 years in Germany, US even longer

IP Protection in Europe

European Patent Convention (EPC), 1973, created "European Patent".
European Patent:
- Granted by European Patent Office
- After grant, group of independent national patents
- To come: EU-wide "Unitary Patent"

European Union Intellectual Property Office (EUIPO)
- European Union Trade Mark
- Registered Community Design
Cost of patenting in Europe:
- Filing fee: 125€ online, 260€ paper
- Search fee: 1,350€
- "page fee": 16€
- Examination fee: 1700€
- Designation Fee: 610€
- Fee for grant and printing: 960€
- Renewal fee: 490€ to 1640€
- Total cost: roughly 6000€, 3000€ for attorney

Designing the Innovation Process

Innovation Funnel

PSI = Product and Service Innovation
Phases:
- Capabilities/Market assessment and forecasting
- Development of goals and objectives
- Project portfolio planning
- Project management and execution
- Post-project learning and improvement
Problems in Reality:
- Unclear where to source ideas from
- Product filter disadvantages radical innovations
- Pet projects of senior management
- Products get jammed up and recirculate
- A lot of hot air at the end, but only few products make it to market

Open Innovation

Strategy that encourages organizations to collaborate with external entities like customers, suppliers and even competitors to foster innovation.

R&D Interactions with the Environment

Inbound:
- Technology purchasing
- Acquisition
- Joint Ventures
- Exchange with Universities
- Ideas from Users

Outbound:
- Technology selling
- Creation of innovative firms
- Joint ventures
- Divestment

C&D:
- Connect and Develop
- Create connections instead of own research

Stage-Gate Process

- Designed around achieving key goals and success factors defined for PSI (Process and Service Innovation)
- Stages and gates break innovation into defined stages
- All work on a stage needs to be finished before passing a gate and entering a new stage

Stages and Gates:
- Stage 0: Discovery
- Gate 1: Idea screen
- Stage 1: Scoping
- Gate 2: Second screen
- Stage 2: Build business case
- Gate 3: Go to development
- Stage 3: Development
- Gate 4: Go to testing
- Stage 4: Testing & Validation
- Gate 5: Go to Launch
- Stage 5: Launch

Post Launch review afterwards. Stage 2 (Build business case) is also called the "key homework stage".

Pros and Cons

Good:
- Good structure for decision making on multiple levels

Bad:
- Process can be politically hijacked
- Choice of criteria determines throughput
- Process can be used as a Tyranny
- Does not allow incremental improvements
- Right incentives are critical

Agile Project Management

- Accept unavoidable planning inaccuracies and unpredictable events
- Integrate backlogs with short sprints
- Learn and adjust by integrating customer feedback
- Promote collaboration

Common Failures of PSI Process

The result...
- does not meet technical specs
- competes with other products in portfolio
- lacks strategic alignment
- does not meet user needs
- is too highly priced
- is too late to market
- is not sufficiently differentiated
- does not comply with regulation

Measurable Dimension of PSI performance

- Productivity
- Speed to market
- Flexibility
- Quality
- Overall fit

Organizing R&D and Innovation

It is difficult to integrate R&D with other business sections. Many firms face reduced R&D productivity.

R&D Production Interface

Symptoms:
- Development cycles are long and expensive
- Late and unplanned changes in product design

Reasons:
- Development is too sequential
- High uncertainty when defining cost or deadlines
- Too many silos in companies, no information flow between departments
- Unclear strategic objectives of top management

Solutions:
- Overlapping development phases
- Matrix organisation (product x business function)
- Cross-functional teams (team composed of people from different functions)
- Proximity of relevant actors
- Use of suitable communication architecture

R&D Marketing Interface

- Empirical Studies confirm high importance of R&D/Marketing interface for innovation
- Many conflicts between marketing and engineering personnel

Reasons:
- Difference in culture
- Different objectives
- Lack of trust and credibility in/of information from other function

Solutions:
- Split large projects in sub projects
- Early integration of both functions into innovation process
- Clear definition of competencies
- Open discussions
- Support contacts between individuals
- Integrating task force of management
- Cross functional development teams