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KATHOLIEKE

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Innovation Management and Strategy

Summary papers

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1. Entrepreneurial Enterprises, Large Established Firms and Other Components of the Free-Market Growth Machine - *William J. Baumol*

Overview

This paper studies the influences accounting for unprecedented growth and innovation performance of the free-market economies:

- Oligopolistic competition (particularly in high-tech industries) forces firms to keep innovating in order to survive => They internalize innovative activities rather than leaving them to independent inventors.
- The bulk of private R&D spending comes from tiny number of very large firms but breakthroughs come predominantly from small entrepreneurial companies.
- Large industry provides streams of incremental improvements to also add up to major contributions.
- These large firms voluntarily disseminate technology widely and rapidly both as a revenue source and in exchange for complementary technological property of other firms.
- This helps to internalize externalities of innovation and speeds elimination of obsolete technology.
- Four contributory sources to innovation:
    - entrepreneurs and small firms,
    - large firms with internal R&D capacity,
    - universities,
    - government.

* Future prosperity of any economy depends to a considerable extent on its success in promoting entrepreneurship, innovation, and the effective and prompt importation of technological advance from abroad.

1. Introduction

- Joseph Schumpeter defines **entrepreneur** as “the partner of the inventor”:

    Businessperson who recognizes the value of the invention, determines how to adapt it to the preferences of prospective users and whose tasks include bringing the invention to market and promoting its utilization.

- Economies with a lot of entrepreneurs tend to grow faster.
- Schumpeter believes **day of the entrepreneur is waning because expanding role of the routinized innovation by big business** was threatening to make the entrepreneur obsolete.
- Baumol (author) agues with Schumpeter, believes entrepreneur continues to play a critical role in growth process and no reason to expect the role to disappear, but in modern economy entrepreneur who's working alone cannot be effective. He needs partners and those are provided by the new market mechanims
- Market mechanism that explain today's growth of free-market economies; four sectors:
    - Small new enterprises: major breakthroughs
    - Larger firms: invaluable incremental improvements that multiply capacity and speed, increase reliability and use-friendliness.

      => Together they have contributed more than either would have done by itself.

- + Governments and universities have their own personal contributions too.

2. Market pressures for an enhanced large-firm role in technical progress

- Free competition was critical in growth of the capital economies. It also promotes rivalry of oligopolistic firms (large firms in markets dominated by a small number of sellers).
- These oligopolists use innovation as main battle weapon to beat competitors.
- Each firm is driven to conclude that its very existence depends, at the least, on matching its rivals' efforts and spending on R&D/innovation process.
  => Therefore firms do not dare relax their innovation activities.
  - The apportionment of the task of supplying the resources invested in innovation has changed!
- In US, 70% of R&D expenditure carried out by private business, and most of this is provided by larger firms.
- In these large firms, innovation activities are designed to prevent unwelcome surprises and reduce risk
  >< Free-wheeling, imaginative, risk-taking approach of the entrepreneur.
- They run R&D in accord with bureaucratic rules and procedures!
  => This is what Schumpeter states: innovation responsibility of the entrepreneur is narrowing.
  !Baumol will argue in this paper that this is a **mischaracterization**!

3. Revolutionary breakthroughs: A small-firm specialty

- Breakthroughs left to small enterprise, guided by its enterprising entrepreneur. Cumulative incremental improvements are done in large firms which tend to avoid great risk and the unknown.
- Small firm = businesses with fewer than 500 employees
- Small firm patent is more likely than a large firm patent to be among the top 1% of most frequently cited patents (geciteerd in literatuur).
- Small patenting firms are roughly 13 times more innovative per employee than larger firms.
- Unlikely disappearance of the innovative role of the entrepreneur and small firms
  ! Baumol: this image is too far, as now it seems that there is no role anymore for the large entreprise and that everything comes from the small entrepreneur!

4. Revolutionary consequences of aggregated incremental improvements

- Big firms provide incremental improvements (= conservative approach, seeking results whose applicability is clear and whose markets are relatively unspeculative). But one should not undervalue this role of large firms!
- Routine activity can, however, add even more to growth than revolutionary breakthroughs.
- Small improvements added together can become significant and of enormous magnitude.
- ex: computer invented by entrepreneur. BUT big business (Intel Corporation) progressed computer chip manufacture
  - combined work of the two together made possible the powerful and inexpensive apparatus that serves us so effectively today

<u>5. On the role of government and the university in innovation</u>

- Public sector's role in promotion of economic output and its expansion (besides the emphasis on the importance of oligopolistic competition). Government has 2 critical roles:
- Government: passive contribution
    - provided primarily through the **legal infrastructure** that encourages entrepreneurship, formation of new firms and investment in the innovation process by larger competing enterprises:
        - property rights, enforceability of contracts.
        - absence of government acts of interference in the exchange of technical information and access to patented intellectual property.
        - avoidance of rules on employment and rental that inhibit the formation of new firms.
- Government: active contribution
    - **support of basic research** as such research is not attractive to private enterprise but can be critical for innovation and growth in the long run.
    - basic research = 'wasteful' expenditure, impossible to predict if there is any financial benefit so firms will not invest.
    - Through universities and government agencies.

End of innovation nowadays is nowhere in sight but it is all because of the different contributions of all four sectors: small and large private enterprises, governments and universities.

<u>6. Dissemination of invention and rapid termination of the obsolete</u>

- Key activity for growth: incentive for rapid dissemination and widespread utilization of new or improved products and processes
- **Conflict between encouragement of growth and rapid dissemination**:
    - innovator: financial gain derived from the temporary acquisition of monopoly power through the improved product or process in his possession (encouragement of growth)
    - BUT encouragement of growth also requires rapid dissemination of improved techniques and products and their widespread adoption by others beside the innovator. This rapidity and ease of dissemination can threaten the innovator's reward
    - **free market has helped this problem**
- Many firms try to guard their technology (patents, secrecy)
    - hurts economic progress: consumers who purchase from other firms are forced to accept obsolete features in the items they buy
    - two firms' common product is rendered inferior in terms of what is currently possible technologically by the obsolete features that it is forced to provide --> product could be better if built on each other's improvements
        - Happily in practice this is not what we observe! There is widespread voluntary licensing of access to propriety technology.

- firms derive substantial incomes from the sale of these licenses. So the problem is solved (innovator is rewarded and consumers have access to best possible product)
    - a firm B would only buy a license from a firm A, if firm B can produce the widget more effectively than firm A can
    - inventive activity will be undertaken primarily by the more effective inventor (firm A), while production of the resulting products will be undertaken predominantly by the more efficient producer (firm B) (**Specialization**)
- **Incentives for voluntary exchanges**:
  - Enter into a consortium to deal with high cost of R&D activity one firm could not pay alone.
  - Reduction of risk:
    - a firm's R&D can fail to come up with anything significant
    - technology-sharing agreements serve as effective insurance policies, protecting each participant from catastrophes.
  - Trading of technology protects the firm from entry
    - a new firm will not enter if it is not included in the existing R&D sharing consortium that exists in the industry.
    - benefits: all firms undertake compensation equalization payments to any other member of the consortium if the latter's innovations are of market value significantly superior to its own.
    - dangers: can serve as camouflage for anticompetitive behavior
      - price fixing
      - restriction of R&D (free rider problem, relying on the other companies in consortium to come up with the new inventions)
      - patent thickets (large number of patents for a complex item, f.e. computer, held by a large number of different firms. They can al put manufacturing of the others to a halt. Solution is patent pools in which each makes the use of its patents available to the others)
- Overall, a lot of benefits of licensing, coordination of R&D and trading of technology, but antitrust agencies are also aware of the danger of anticompetitive behavior.

<u>7. Indicators of the magnitude of the free-enterprise growth miracle</u>

- Improvement in growth performance of the industrial economies is enormous
- 20th century, growth and GDP/capita in U.S. has been estimated at 700%
- After WW2, the U.S. has a near-exponential growth path when it comes to real private business expenditures on R&D activity. (This follows the exponential growth in GDP/capita)
- Recessions of the postwar period had little effect on real growth in innovation, they're only little deviation in the exponential growth path.

<u>8. The invaluable contribution of "mere imitation"</u>

- Predictable that most innovation that a small industrial economy can expect to introduce will be contributed by other countries R&D activities, since all major technological development takes place in some 25 countries.
- Average country should expect some 24/25ths of its new technology to come from abroad
- However, Baumol believes that this **imitation process** has attributes of a truly innovative process
    - must adapt the technology to local conditions, including differences in size of the market, consumer preferences, climatic conditions
    - there is nothing inferior about a process of organization imitation of foreign technology
    - *"Every invention contains some borrowing and every borrowing some invention"*
- Every advanced nation must derive a substantial portion of their new technologies from elsewhere, otherwise they run the risk of falling behind (even US and Japan!)
- Country must be a **skilled imitator as well as an effective innovator**.

9. On governmental policy for promotion of innovation and growth

- Baumol offers suggestions to improve public policy: role of the government as facilitator of the innovative work of others.

Funding and execution of basic research:
- Public sector and universities do basic research (private industry = applied research)
- Governmental funding of basic research must be carried out by its agencies, most notably the universities, because it's unattractive to private industry.
- Basic research elicits long-term growth and is absolutely necessary!

A governmental role in acquisition of foreign technology

- Governments can provide socially valuable goods and services for which private enterprises lack the incentive to supply optimal quantities of such outputs (such as basic research f.e.)
- Encouragement of technology transfer from abroad is another example
    - small economies must recognize that rapid acquisition and absorption of technological information from elsewhere contributes to their growth
    - Opportunity to gain differential advantage in monitoring and adoption of foreign technology
- It may be profitable for a government to establish a special Office of Technology Transfer to monitor, translate, and disseminate pertinent materials in foreign publications
    - steps to be taken to carry out such a program:
        - Education and training: abroad scholarships in countries leading in innovation.
        - Subsidies for immigration of foreign technicians and related personnel.
        - Establishment of observer staff in the country's embassies.
        - Study of measures taken by governments in other countries to facilitate absorption of foreign technology by their industry.

Conclusion: prosperity of an economy depends on **entrepreneurship**, **innovation** and **immitation**.

2. Innovation over time and in historical context: patterns of industrial innovation

The characteristics of innovation changes as a successful enterprise matures; how companies may change themselves to foster innovation as they grow and prosper. For a company the method of innovation (product and/or process), depends on the stage of evolution (small technological company → high volume producer)[1]. The 2 extreme cases:

- <u>High-volume products (Specific Pattern)</u> (paper, steel, light bulbs,…): The **market is well defined**; product characteristics understood or **standardized**; low unit profit margin; **efficient production technology**, change to system is costly; competition is primarily on the basis of price.
In this environment **innovation is typically incremental**, and has a gradual cumulative effect on productivity (example: incremental innovation → larger railroad trains → reduced costs of moving large quantities of material).

- First major system innovation (before this stage) followed by countless minor product and system improvements, the latter accounts for more than half of the economic gain, due to the much greater number.
- Cost is the major incentive, but also major advantage in product performance coming from small engineering and production adjustments.
- Incremental innovation results in specialized systems, where economies of scale because of mass market are important. (One has to overcome the high fixed charges ➔ high volume.) Unit loses flexibility and is **vulnerable to demand changes** and obsolescence of technology

- <u>New products (Fluid Pattern)</u>: not consistent with pattern of incremental change but a more fluid pattern of **product change**. Superior functional performance over predecessor gives them competitive advantage. These **radical** innovations have higher unit profit margins.

- These new product innovations occur in disproportionate numbers in companies as units located in or near affluent markets with science based universities, research institutions or entrepreneurially oriented financial institutions.
- Users play an important role in suggesting ultimate form of innovation as well as the need. Performance requirements are still ambiguous at this early stage so most innovations come from input of users.
- Because of diversity and uncertainty of performance requirements for new products **small adaptable organizations** with flexible technical approaches and good external communications have advantage over large firms

<u>Transition from radical to evolutionary innovation</u>
Two extremes above are not independent categories, firms in specific category where originally small (fluid category).

[1] In the paper p.26 take a quick look at this **table**! p.27**, figure 1**, look at it for a minute, it's the evolution of process and product innovation.

Example semiconductor industry:

- 1950, established units reacted to new entrees by **process innovation** (facts show that they were responsible for 25% of major new product innovations. 18 years later these companies only had 18% market share.
- New entrees sought entry and strength through product innovation (facts show that they were responsible for 50% of major product innovations and for only 1/9 of major process innovations. After 18 years their market share had increased to 42%.
- => Process innovation, wasn't the effective competitive stance in the beginning.
- 1968, basis of competition changes. Cost and productivity become more important, rate of major product innovations decreased, process innovation more important for competitive success.

Example airline industry:

- 1936, DC3 (type of aircraft) made major changes in the industry. It was an accumulation of prior innovations.
- No major innovations for next 15years (then came the jet engine), until then simple **incremental** refinements of dc3. During this period of incremental change, airline operating costs dropped significantly

Example food industry:

- New products such as frozen vegetables, canned foods, soluble coffees, etc. came from individuals and small organization where research was is progress and which relied on information from users.
- Products won acceptance and the productive unit increased.
- Innovation started to concentrate on improving manufacturing, marketing, distribution which **extended rather than replaced the basic technologies**.

Common: Evolution starts with a few major innovations, out of these experiences comes a dominant model, the model is incrementally adapted towards a highly standardized product. This **shift from radical to evolutionary product innovation** is related to:

- development of **dominant product design**,
- higher price competition,
- increased emphasis on process innovation,

But this incremental innovation may have equal or even greater commercial importance → cheaper due to productivity improvements associated with process improvements.

Managing technological innovation

What does this shift imply for management?

Unit moves towards large scale production: goals of innovation change from ill-defined and uncertain targets to well articulated design objectives:

- **Initial fluid stage:** market needs are ill-defined, stated with broad uncertainty (**target uncertainty**), technologies little discovered (**technical uncertainty**). These two types of uncertainty, the decision-maker has little incentive for major investments in R&D.

- **Middle stage (between fluid and specific)**: uncertainty reduced and still in stage before competition erodes profits so larger R&D budgets are justified and R&D investments' benefits are very high.
  => **Science based firms**: invest heavily in formal research and engineering departments with emphasis on process innovation and product differentiation through functional improvements.
- **Fully mature:** entire processes designed as integrated systems specific to particular products. Major process innovations are likely to originate outside the unit, since firm is fully specialized.

Organization method of coordination and control change with standardization of product and process innovation. Because of task uncertainty in fluid stage, the unit must emphasize its capacity to process information by investing in vertical and lateral information systems and in liaisons and project group. When the productive unit has achieved standardized products and confronts only incremental change, then it has to deal with complexity (because of larger enterprise) by reducing need for information processing. The firm has the impulse to divide in homogeneous productivity units as its product and process technology evolves.
=> the change in control and coordination imply that the structure of the organization will also change as it matures: more formal and more levels of authority.

Dominant Model: features that a dominant design is likely to display:

- technologies that lift fundamental technical constraints
- design that enhances the value of potential innovations in other elements of a product or process
- products that assure expansion to new markets.
-

Fostering innovation by understanding transition

In different stages of evolution firms will respond to different stimuli, and undertake different types of innovation.
Barriers to innovation in fluid stage: factors that impede standardization and market aggregation, ...
Barriers in specific stage: uncertainty over government regulation.

Transition from product to process innovation

Transition from small innovative firm to large mass production of a standardized product is sometimes invisible = too rapid transition.

- **Continuous flow processes**: specialized equipment already necessary from the beginning to make it work
- **Low unit values**: cigarettes, small plastic parts,… where availability of a process technology may have made the product feasible in the first place.

In other cases, transition, where it's predicated, has not come about: home construct, nuclear power,…

Consistency of management action

Unsuccessful innovation ➔ certain conditions necessary to support a sought after technical advances were not present. The model may help to discover how to increase innovative success.

3. The Social Construction of Facts and Artifacts: Or How the Sociology of Science and the Sociology of Technology Might Benefit Each Other - *Trevor J. Pinch and Wiebe E. Bijker*

Abstract

- one of the most striking features of the growth of science studies has been the separation of science from technology
- science and technology may be essentially different and may warrant different approaches to studying them but until the attempt to treat them within the same analytical endeavor has been undertaken, we cannot be sure of this
- the study of science and technology should and can benefit one another

ARGUE: the **social constructionist view** that is prevalent within sociology of science and also emerging within the sociology of technology provides a useful starting point

3 main sections

1. outline various strands of argumentation and review bodies of literature that we consider to be relevant to our goals
2. discuss 2 specific approaches from which our integrated viewpoint has developed: the Empirical Program of Relativism and a social constructivist approach to the study of technology
3. bring the two approaches together with empirical examples

1. Some relevant Literature

Sociology of Science

- This paper only concerned with the recent emergence of the **sociology of scientific knowledge**
- Studies in this area take the actual content of scientific ideas, theories, and experiments as the subject of analysis
- This is opposition to earlier work in the sociology of science that was concerned with science as an institution and the study of norms, career patterns and reward structures
- Differing explanations should not be taken to be scientific truth/falsehood
- All **science is socially constructed** and the explanation for genesis, acceptance, and rejection of knowledge claims are sought in the domain of the social world rather than in natural world
- This sociology of scientific knowledge has led to empirical research that made it possible to understand the processes of scientific knowledge construction
- Widespread agreement that scientific knowledge has been socially constituted = **social constructivist approaches**

Science Technology Relationship

- Research to the relationship between science and technology is heterogeneous:

  - On the one hand there are the philosophers' over idealized distinctions between the two: **science** is about **discovery of the truth** and **technology** is about the **application of the truth**
  - On the other hand, innovation researchers have attempted to investigate empirically the **degree to which innovation incorporates and originates from basic science**. For example, some studies have shown that most technological growth came from mission-oriented projects and engineering R&D rather than from pure science, other have showed the opposite.
- Simplistic model like 'science discovers and technology applies' (unidirectional relation) do not work, truth somewhere in between, that is science and technology have become intermixed.
- **New social-constructivist view**: more **sociological conception of the science-techn. relation** (science and techn. are not monolithic structures, they have been socially constructed themselves). Scientists and technologists can be regarded as constructing their respective bodies of knowledge and techniques with each drawing on the resources of the other.

Technology Studies

Literature can be divided in 3 parts:

Innovation Studies

- Economists looking for success in innovation: R&D effort, management strength and marketing capability, etc., or just macroeconomic factors as whole
- In this analysis, everything is included except the technology itself: Layton: *"What is needed is an understanding of techn. from the inside, both as a body of knowledge and as a social system. Instead, technology is treaded a black box whose contents and behaviour may be assumed to be common knowledge"*
- The failure to take into account the content of technological innovations results in the widespread use of simple linear models to describe the process of innovation.
- However, these studies have contributed a lot to the understanding of the factors contributing to innovative success. Nevertheless because they ignore techn. content they cannot be used as a basis for social constructivist view of technology.

History of Technology

- Many finely crafted studies of the development of particular technologies based on historical examples. There are however two problems with these studies for the purposes of building a sociology of technology:
  1. Generalizing: difficult to discern overall patterns on which to build a theory for the future.
  2. Asymmetric focus: focus on successful innovations only and not on the many failed technologies.

Sociology of Technology

- Recent years, limited attempts to build such a sociology but these are just promising starts and do not provide a satisfying framework.

2. EPOR and SCOT

Two approaches to the study of science and technology:

The Empirical Program of Relativism (EPOR)

- The **empirical program of relativism** (EPOR) is an approach that has produced several studies demonstrating the social construction of scientific knowledge in the hard sciences
- EPOR has emerged from recent sociology of scientific knowledge
- Distinguished from other approaches because of its focus on empirical study of contemporary scientific developments and the study in particular, of scientific controversies
- EPOR represents a **continuing effort by sociologists to understand the content of the natural sciences in terms of social construction**
- 3 stages in the explanatory aims of EPOR:
    1. The interpretative flexibility of scientific findings is displayed = **scientific findings can be open to different interpretation** (controversies, differing opinions over scientific findings). This shifts the focus of explanation of scientific developments from natural world to social world
    2. **Social mechanisms that limit interpretative flexibility** and thus allow scientific controversies to be terminated are described
    3. (This stage has not yet been carried through in any study of contemporary science) Relate closure mechanisms (= limiting interpretative flexibility) to the wider social-cultural milieu

SCOT

- **The social construction of technology**
- The sociology of technology is an embryonic field with no well-established traditions of research. EPOR is much more advanced already.
- In SCOT the developmental process of a technological artefact is described as an alternation of variation and selection
- This results in a **multidirectional model** (in contrast with the linear models used explicitly in many innovation studies and implicitly in much history of technology)
- Such a multidirectional view is essential to any social constructivist account of technology
- ***Example the development of the bicycle***:[2]
    - In a multidimensional model is it possible to ask why some of the variants died and others survived (>< History of technology studies) = selection part of the development process, considering all problems and solutions each artifact has.

[2] See figures p.29 an onwards

- A problem can be defined as relevant when the social groups concerned with the artefact consider it a problem.
- So the relevant social groups have to be found: the users/consumers of the artefact (but also other groups, for which the word bicycle always has a different specific meaning, have to be considered: f.e. anticyclist, etc.)
- Once the relevant social groups have been identified they are described in detail: such as power and economic strength
- We need to have detailed description of the group in order to define better the function of the artefact in respect to that group, because without this we cannot explain the development process of the product (which models become successful and why or why not?)
- Then we must describe the different problems each group has with respect to the different model/artefact: these can be technological (f.e. safety/speed) but also judicial or moral ones (f.e. woman had to wear trousers in order to be able to ride a bike, but for social conventions this might have been strange at the time)
- In this way it can be determined how the models will be adapted and which ones will become dominant (= multidirectional character approach, it is more than just a description of the improvement in technology, it's a whole social explanation)

<u>3. The Social Construction of Facts and Artifacts</u>

Parallels between EPOR and SCOT:

Interpretative Flexibility

- The first stage of EPOR shows that different interpretations of nature are available to scientists and hence that nature alone does not provide a determinant outcome to scientific debate
- In SCOT the interpretative flexibility lies in the fact that artefacts are culturally constructed (designed) and interpreted. This first stage is equivalent to the first stage of EPOR: different ways in interpreting a scientific finding.
  f.e. For some engineers the air tire was a solution to the vibration problem, for others is was a way of going faster. So a different interpretation of a scientific discovery.
- Also different social groups can have a different interpretation of a technological artefact (f.e. bike for sport in one group, for transport in other group).
- Different interpretations (and problems) lead to different designs.

Closure and Stabilization

- The second stage of EPOR concerns the mapping of mechanisms for the closure of debate
- SCOT this is **stabilization** of an artefact (dominant model) and disappearance of problems.

Rhetorical Closure

- To close a technological controversy one needs not to solve the problems in the common sense of that word, the key point is whether the relevant social groups see the problem as being solved
- In technology advertising can play an important role in shaping the meaning that a social group gives to an artefact. (f.e. advertisement that says that the new bike is perfectly safe to solve the problem for the social group who saw the bike as unsafe)

Closure by Redefinition of the Problem
- f.e. air tire: for different groups this was different problem/solution (f.e. ugly-problem for one group, a vibration solution for the other).
- The problem of ugliness was redefined because of all the advantages of the air tire and soon after ugliness was not a problem anymore for the social group who considered the tire ugly in the first place. They saw is helped against vibration and was faster. = **closure** was reached

The Wider Context
- 3rd stage of EPOR/SCOT
- The task here in the area of technology would seem to be the same as for science: to relate the content of a technological artefact to the wider socio-political milieu
- No science case yet (no EPOR studies with stage 3 yet) but SCOT model seems to offer an operationalization of the relationship between the wider milieu (political and social situation in the groups) and the actual content of technology

4. Conclusion
- In this chapter we have been concerned with outlining an **integrated social constructivist approach** to the empirical study of science and technology
- Social constructivist approach is a flourishing tradition within the sociology of science and science and technology
- Innovation studies and much of the history of technology are unsuitable for our sociological purposes
- EPOR: approach in the field of science and technology
- SCOT: approach in which we base our integrated perspective
- Finally we indicated the similarity of the explanatory goals of both approaches. We have seen that the concepts of interpretative flexibility and closure mechanism and the notion of social group can be given empirical reference in the social study of technology
- Sociology of technology is underdeveloped in comparison with the sociology of scientific knowledge
- Distinction between science and technology is unfruitful. Better to study them in an integrated way.

4. Moving Beyond Schumpeter: management research on the determinants of technological innovation - *Ahuja, Lampert & Tandon*

Abstract

- **Schumpeter**: large monopolistic firms were the key source of innovation in modern industrial economies
- **This paper** moves beyond firm size and market structure (Schumpeter) as the primary determinants of innovation:
  - Distinction made between **innovative efforts** and **innovative output**.
  - For both groups, the determinants of innovation put into 4 broad headings:
    1. Industry structure
       - horizontal market structure (reflects influence of competition and collaboration
       - role of buyers, suppliers and complementors
    2. Firm characteristics (externally observable attributes of a firm)
       - size, scope, access to external sources of knowledge (f.e. alliances) and performance
    3. Intra-organizational attributes
       - organizational structure and processes
       - corporate governance arrangements: compensation and incentive structures
       - managers' background
       - organizational search processes
    4. Institutional influences
       - supply of science (nature and degree of science-industry relationships)
       - appropriability regime
- Paper gives overview of all **management literature** in all the above categories (work of economists is already summarized in other reviews)

Introduction

Schumpeter's basic questions relating innovation to firm size and market structure have dominated the topic the last decades. However, there are many additional determinants of innovation, although the literature on those is limited. The focus in this paper is on the determinants that influence the **generation of technological innovation** and not on the diffusion of innovations, or on non-technical innovations (administrative or organizational innovations)

The paper makes a distinction between **innovative efforts** and **innovative output**:

1. Innovative inputs/efforts: what factors affect the incentives or the ability to support research?

- *Research production function*: innovative effort is a function of all determinants that affect the research effort of a firm
2. Innovative output: given a research effort, however determined, what factors determine the resultant level of output?
    - *Innovation production function*: innovative output as a function of all determinants affecting the innovative output of a firm.

    (Of course there are factors that influence both)

For each of these questions, determinants are grouped into 4 broad headings (see abstract)[3]. The paper first gives an overview of the Schumpeterian theses in order to open up consideration of these many additional arguments.

1. Industry Structure and Innovation

1.1 The Schumpeterin Legacy: Market Structure and Innovation

Schumpeterian **hypotheses**:

1. Innovation (effort) increases with market concentration
2. Innovation increases more than proportionately with firm size

(Only first hypothesis in discussed here, firm size issue is examined in a later section of this paper)

=> Vast body of research on the relation between market concentration and innovation has proved inconclusive: market structure was not found to be strongly related to innovation.

Market Structure and the research production function

- Market power has been argued to both enhance and depress the incentives to invest in innovation. Final effect is unclear
- Innovation incentives may go up with market power to a certain point and then dip again (relationship presumably not linear but inverted U-relationship)
- Three main arguments to suggest that superior market power provides greater incentives to innovate:
    1. market dominance (ex ante) provides firms with profits and security to finance risky activities
    2. firms are under threat of losing their market power (ex ante) to innovative entrants. They have more to lose than competitive firms and therefore more motivated to invest in R&D.
    ><(immediate counterargument **'Arrow replacement'**: monopolies have fewer incentives because innovation cannibalizes profits of their existing products and thus simply move the firm from one monopoly into another (so in the end it gains nothing from replacing its products by new more innovative ones).

[3] See figure 1.1 p.5

Also monopoly firms might invent new techn. but strategically choose to launch them only when threatened by a challenger.

3. By creating innovations, firms can alter the market structure and gain market power (ex post) which ensures superior profits.

- Conclusion: Schumpeterian market structure arguments are not unidirectional: arguments pro and contra.

Market Structure and the innovation production function

In the Schumpeterian sense, market power does not find a place in the innovation production function. The previous arguments that link lacking or possessing market power with the level of innovation efforts do not provide reason to believe that they have an impact on the **productivity** of research effort.

- 1 argument suggests that the oligopolistic structure of an industry may negatively influence innovative productivity an industry:
    - ➔ Only a few ongoing lines of research yield productive results. Then research efforts by several firms improve the possibility that at least some efforts will be successful. Successful efforts may in turn provide information on more productive research trajectories and help to improve innovation performance even in firms whose efforts were initially unsuccessful. Oligopolistic markets result in fewer uncorrelated research efforts and thus less positive results/productivity.
- 1 argument suggests that the presence of many inter-firm alliance relationships ('hidden industrial structures') aids research productivity
    - ➔ These links are formed for the explicit purpose of sharing resources and knowledge. So industries characterized by well-connected networks may lead to increased knowledge spillovers which aid innovative productivity.
      >< counterargument: industry networks that are very cohesive lead to greater homogeneity in research. In contrast, less cohesive networks may generate more variegated research efforts and thus more chance to find positive results (first argument)

Summary

Market structure in the Schumpeterian sense cannot be strongly linked to innovative productivity but can on behalf of two other effects: number of independent research efforts and the presence of a substructure of inter-firm linkages providing speedy access to knowledge spillovers.

1.2 Collaboration Networks

Networks and the research production function

Two broad arguments suggest why networks might be useful in the context of innovation:

1. Division of labor: task of innovation can be sub-divided among a number of interconnected firms such that the appropriate locus of innovation in now this network

rather than an individual firm. To understand innovation, one must study these cliques rather than standalone firms.
2. There are distinctive effects that arise additionally from the network. Network has economic content on its own beyond the sum of content of all individual firms in the network: f.e. information flows, advice, trust,...

Arguments that suggest impact of networks on firms' motivations to invest in innovation:

1. Inter-firm networks are a good source of information about opportunities and threats that exist in the market (reducing uncertainty). This increases the probability that firms can create innovations that serve market demands. Therefore networks can spur firms to invest in innovation by increasing their probability of profiting from it.
2. Networks can lead to the diffusion of practices through imitation. Firms imitate innovative decisions and the processes of making decisions. Decision to expand (contract) R&D expenditures may be imitated throughout the network affecting the overall rate of innovation.

Networks and the innovation production function

- Inter-firm networks present a low-cost and flexible possibility to share information and technical know-how and to facilitate joint problem solving, which in turn promotes innovation productivity **directly**.
- Networks promote innovation productivity **indirectly** by facilitating increased specialization and division of labor, which leads to more focused expertise development.

Still limitations in the literature on the link between networks and innovation. Also, different types of inter-firm networks might seem important, but so far this distinction has not yet been made in the literature:

- Horizontal: network composed of ties between competitors
- Vertical: between firms and their buyers, suppliers or complementors

1.3 Buyer/User Innovation

Most research started from the point of view that firms are the originators of innovation and that innovators are driven by the possible profit of innovation. However, users have made significant contributions to innovations in a wide range of industries and they can be of great value to firm for a number of reasons:

1. Serve as a source of marketing data: with the help of **lead users** firms can gauge trends.
2. Are a source of valuable product ideas which enable the firm to launch new products or improve the existing ones.

Realizing this potential, some firms set up '**open systems**' and **user groups**.

Buyer innovation and the research production function

Research on how user innovation affects the innovation production function are sparse. Therefore paper concentrates on the factors that motive users to innovate (research production function). They can be classified into three categories:

1. User have **inherent characteristics** that motivate them to innovate
   - Hobbyist: reveal their ideas free of charge, not driven by monetary reward, they are intrinsically motivated.
   - Lead users: they expect innovation-related benefits from a solution and they experience the need for a given innovation earlier than the majority of a target market. That's why they don't wait for the firm to supply them the innovation and are motivated to innovate themselves. The market for innovation may not yet be large enough for the firm to invest because only the small group of lead user experience the innovative need.
2. Users may gain **psychological benefits** from the recognition given by the firm that motivates them to innovate: pride among other users or gratification
3. **Reputation gains** among peers and **signalling benefits** which help them on the job market motivate them. Especially relevant when the user's contribution is visible (such as in open source environments)

1.4 The Role of Suppliers and Complementors

The suppliers, complementors and the research production function

Two reasons why **suppliers** of an industry may be motivated to invest in innovations and increase the technological opportunities in the downstream industry:

1. Conditions in the downstream industry may induce lesser innovation effort than is optimal from the supplier's perspective. F.e. innovative efforts down the stream rendered inadequate to take advantage of the greater pace of innovations in the supplier's industry. Then the supplier might be motivated to augment the downstream industry's research by investing in R&D activities that improve the quality of the final good or better utilize the faster technological growth upstream.
2. Barriers to entry in concentrated downstream industry (limited competition). Supplier then might be motivated to invest in R&D in downstream industry which will foster competition (this is better for him)

Complementors' role in innovation is under-researched. F.e. if innovation in complementary products stay behind, innovation in a firm's product might be useless cause profits depends partially on innovation in the complementary products.

2. Firm Characteristics and Innovation

Schumpeter: focus on firm size. However, there are many other relevant characteristics that are important to understand innovation outcomes.

2.1 Firm Size

Size as an argument to the research production function

1. Large firms can secure finance for risky R&D projects (+)
2. Returns to R&D are higher if the innovator has a large volume of sales over which to spread the fixed costs of innovation (+)

- **effect of size on innovative effort is unambiguously positive**

Size as an argument to the innovation production function

1. Scale economies in the R&D process benefit firms with larger R&D budgets (+)
2. R&D is more productive in large firms due to complementarities between R&D and other activities (+)
3. Bureaucratization of inventive activity in large firms stifles the creative instincts of researchers (-)
4. Incentives of individual scientist become attenuated as their ability to capture the benefits of their efforts diminishes (-)

- **Size effects on innovative output are ambiguous**, and relation is far more complex than the hypothesis of Schumpeter ('innovation increases more than proportionately with firm size')

Two contingencies in previous research that are important to understand the size-innovative output relation:

1. Distinction must be made between firm size, size of R&D effort and the scope of the firm. Size is indicator of bureaucratic structure and thus has a negative effect of innovation. Size of R&D effort reflects the actual input and should be unambiguously positive on innovation output. Firm's scope reflects the ability of complementary resources within a firm. If these are not available than even large firms might lack the advantages attributed to complementarities (argument 2).
2. Firm size can also be obtained through cooperation between firms (networks) rather than necessarily within a single firm. Inter-firm cooperation might also mitigate the bureaucratization problem.

2.2 Firm Scope (diversification)

A prominent factor through which size influences innovation (complementary benefits) might be firm scope. Firm scope is argued to influence **both innovation efforts and productivity.**

The positive influence of firm scope on innovation

1. **Diversification hypothesis**: firms with a broad product base have greater incentives to invest in **basic research** because basic research is more likely to yield knowledge which can be applied to multiple domains. Firms with a broad product base are more likely to benefit from basic research. This hypothesis applies more to basic research than to applied research (firm scope no effect of applied research).

2. Scope of a firm indicates a **mindset of exploration** and therefore leads to greater R&D activities/efforts.
3. Diversification can influence innovation output by facilitating cross pollination of ideas across domains = **interdivisional knowledge transfer**

The negative influence of firm scope on innovation

1. Inventions from one division may not be implemented because of substitute inventions from a related division. Thus the threat of substitute inventions in diversified firms reduces the chance of implementing an invention and consequently the chances of compensating the employee for innovation efforts. This reduces incentives to exert efforts for the employee.
2. In diversified firms, management has greater difficulty in monitoring (information overload). This **loss in control** leads firms to move from strategic control (subjective evaluation of performance based on decisions taken by managers) to financial controls (evaluation of performance based on financial targets such as ROI). This makes the division managers more **short-sighted and risk-averse** and they focus their attention on achieving short-term financial targets, thereby reducing expenditures to research with a long-term focus. (This argument makes the assumption that managers are being punished for not meeting short-term financial goals but ignores the possibility that they may be rewarded for spectacularly exceeding the goals, which is possible due to R&D efforts. Also sometimes not investing in research might be more risky than investing!)

Summary

Research on firm scope has not provided conclusive results: arguments for and against the diversification hypothesis. But diversification hypothesis applies more to basic research than to applied research, however most of the research conducted by firms is applied. Maybe the relationship between scope/diversification and innovation is U-shaped.

2.3 Access to external knowledge: alliances and networks

Three distinct effects of inter-firm collaboration on firm innovation performance (both effort and output):

1. Collaborations (**dyadic** level = benefit from pure inter-firm cooperation and not from the extra economic value that the network itself has) provide **direct benefits** to the participating firms through scale economies in research, reduction of wasteful efforts, sharing of knowledge and combining complementary skills.
2. Linkages within an industry form an **information network** and thus facilitates knowledge spillovers.
3. The **structure of the network** affects the rate at which knowledge travels between firms.

- 2 different effects: impact of inter-firm collaboration and the implications of a firm's presence in a network.

Dyadic alliances (= impact of individual linkages, not network advantages)

3 effects:

1. Collaboration increases a firm's knowledge inputs into the innovation process by enabling it to leverage its contributions to an **R&D pool** (knowledge = public good). Each partner receives greater amount of knowledge than it has to contribute to the pool.
2. Cooperation between partners that bring together dissimilar skills can enhance this leveraging effect significantly.
3. Minor enhancements in the knowledge of firms through collaboration can lead to significant increases in innovation output.

- **Dyadic alliances should have positive impact on innovative output** by affecting the effective levels of innovative input (although the relation might not be pure linear).

However remark on the first argument:

- There are reasons to belief that the full benefits of the R&D pool are unlikely to become true. A firm's **effective R&D** (sum of internal R&D and cooperate R&D) might be less than the sum of all collaborator's efforts. Because of **coordination costs**; info from pool still has to **internalized** by the firm and this is costly; some elements in the pool still have to be **redone** within the firm, they cannot be easily duplicated; **free rider problem**.

Dyadic alliances, effective R&D and complementarity

To be efficient and to perform well, firms prefer to use only a limited set of closely similar skills and build a specialized competence in them. However, technology may demand the simultaneous use of different sets of competencies. They then face a choice of buying them, developing the dissimilar competencies or obtaining them though collaboration. It is clear that it's more efficient and less expensive to collaborate instead of each firm developing the competencies on their own (**cost reduction through complementarity** of resources within both firms). This collaboration leads to an increase in both firm's effective R&D and to a positive impact of innovation performance.

Dyadic alliances, effective R&D and scale

To which degree results enhanced effective R&D (input/effort) in enhanced innovation output? Firms can benefit from scale economies in R&D, if they exist, when larger projects generate significantly more qualitative and quantitative innovative output than smaller projects. However, these scale economies are sufficient but not necessary for collaboration to result in higher output.

Dyadic alliances: key conceptual conclusions

Even in the absence of scale economies or complementary advantages, collaboration can have a positive impact on innovative output. An increasing effect in effective R&D (input) is sufficient for collaboration to be beneficent. To the extent that scale economies and complementary advantages exist, innovation performance is further enhanced. **Therefore a positive impact of collaboration on innovation performance can be expected**! (this is also what most of the empirical studies find)

However inter-firm linkages may also generate diseconomies:

1. Collaboration may undermine a firm's distinctive competence
2. loss of focus because bigger range of projects

Network position

This section analyzes the significance of a larger entity, the network comprised of all such inter-firm linkages (dyadic alliances), for innovation performance. The network serves as an information conduit for the industry. Firms with higher centrality and range in the network enjoy greater access to the information flowing relative to peripheral firms.

- Dyadic alliances: R&D pool => more effective R&D => better innovation output
- Networks: Access to knowledge spillovers => increasing effective R&D => better innovation output
- **Knowledge spillovers**: knowledge flows between firms are constituted of both contractual knowledge transfers and relatively informal, uncompensated knowledge (= spillovers, leakages).
- Effective R&D in a network thus includes not only internal and cooperative R&D (from dyadic alliances) but also its access to knowledge spillovers!
- A firm's **position on the network** provides a measure of a firm's access to these spillovers.

Network as information-conduits

Process by which information flows through the network can be stated in four central premises:

1. people meet and talk
2. the context in which people meet determines the issues they talk about
3. each person carries away from a conversation at least some new information
4. to the extent that a person engages in conversations with many partners, he carries to each conversation a memory of some elements from conversations with other partners.

Collaborative linkages are even stronger is this because their interactions are focused, intense and repeated often. According to this process, an inter-firm linkage is also a firm's link to many indirect partners, because partners bring to the conversation experiences with their partners who might be indirect partners to the firm. So a firm, through its own partners, has access to all the knowledge in the network.

The impact of position in the network

- **Superior access** (central network position) implies that firms can receive information on the success and failure of many more research efforts than other firms with a more limited access. Both the number of direct linkages (partners) as well as their distribution across partners (diversity among partners) is relevant.
- **Timing benefits** of network: early recipients of information can have a significant advantage (f.e. trends, gossip leads => getting patent first)
- **Referrals advantage** of network: having a favorable position in identifying potentially good employees (especially in high-technology industries, one single individual can have an important impact on company value)

Linkage formation and networks are thus associated with superior innovation performance.

However also costs associated with networks but these need much more examination by the literature. (maintaining relationships involves costs, free riding, limiting flexibility: change in a highly linked system may be more difficult than change in an independent firm.

2.4 Firm Performance and Slack (cash reserves)

Firm Performance

- **Problemistic search**: performance below aspirations motivates firms to undertake search for new solutions and thus invest more effort in R&D.
- **Prospect theory**: decision makers become more risk-seeking when facing losses. Assuming that risk-taking is positively correlated with investments in innovation, poor performance then leads to greater effort in R&D and innovation.
  - Problem with this assumption: not investing may sometimes be riskier than investing in innovation because risk of investing is limited to the investment while the risk of not investing may be complete erosion of the market
- **Threat rigidity**: threat, such as poor performance, results in rigidity and conservative behavior. Therefore, innovative efforts are reduced.

It is **unclear** what the relation between performance and innovation effort and innovation output is.

Cash slack

- Cash slack is a result of accumulated performance.
- On the one hand, slack is argued to allow experimentation of ideas that would not have been approved in times of resource crunch and thereby foster innovation.
- On the other hand, others argue that slack affects the productivity of innovative efforts by tolerating waste and reduced monitoring

Effect of cash slack on innovation effort and performance is **unclear**.

3. Intra-Organizational Attributes

3.1 Organizational Structure and Processes

Organizational Structure

Basic idea:

- **Organic structures** (fluid job descriptions, loose organization charts, low degree of formal, centralized control) are considered better than **mechanistic**, bureaucratic organizational structures (defined roles, responsibilities and strict control) from the perspective of innovation.

However **two problems** with basic idea:

1. Organic structures may be better for smaller firms rather than larger firms and superior only when the technological system is complex.
2. Distinction between incremental and radical innovation has to be made: a structure appropriate for one may not be ideal for the other and yet organizations need to conduct both type of activities.
   - ➔ Solutions proposed to this problem:
   1. **Cycling organizational structures**: use organic design in exploration phase of the project and then switch to mechanistic to execute the innovation.
   2. **Ambidextrous organizations**: organization is split up into differentiated sub-parts that are connected only at top-level management. Some sub-units focus on exploration and get organic structure, others focus on exploitation and get mechanic structure.
   3. **Skunkworks**: select group of employees is separated from the rest of the organization to provide it with greater autonomy to develop a new product or service and is then usually brought back into the organization to be commercialized.
   4. **Spin-outs**: part of the organization is separated to run a business entirely outside the organization (not just the development part)
   5. **Corporate venture capital investment**: investment directly in a new external start-up firm.

Other findings:

- **Decentralization**, the diffusion of decision-making rights is argued to affect positively the initiation of innovation activities.
- Decentralization increases the efficiency of information sharing and thus innovative effort
  - o Problems with this finding:
    - Centralized authority, which hampers information sharing, has been positively linked with the implementation of innovation and thus the productivity of innovation efforts
      - But this counterargument has been in turn challenged.

    - Decentralization may lead to monitoring through financial controls that may make managers risk-averse and reduce innovation.
- Formalization's impact on innovation is unclear but is seems to hamper informal transactions and thus innovative effort.

Organizational Processes

1. Importance of **social ties**: social connections among employees and units serve as information channels which help complementary strengths in the organization to come together. They help in knowledge sharing and in the generation and implementation of ideas and thus also have a positive impact on the productivity of innovation.
2. Establishing **processes to investigate the future and to scan the environment**: creating systems to scan the future rather than waiting to respond until events occur helps innovations.
3. **Processes that help product development projects** boost innovation. Processes to boost initiative among employees and an organizational climate that promotes risk help in innovation.

Summary

Decentralized control, lack of formalization and informal communication are conducive to innovation but their effect depends on many contingent factors.

3.2 Corporate Governance, Compensation, Incentive Structures

Basic idea:

- risk-averse managers are likely to invest less in innovation than the less risk-averse shareholders would want them to. Indeed stockholders can diversify away idiosyncratic risk but manager's futures are tied to the firm and their rewards are affected when risky ventures are not successful.
- Owners should therefore influence the incentives for managers to align manager's interests with theirs.

However, remark on this idea:

- It's not always true that shareholders are less risk-averse than managers. Institutional investors f.e. have a more long-term focus than normal stockholders who are primarily interested in short-term returns.
- So the overall influence of owners on innovation may depend on the mix of shareholders and their investment objectives.
- Also sometimes, not investing is more risky than investing...

Findings:

- Short-term cash rewards for managers reduce risk-taking
- Reward such as stock options (which are longer-term and confer ownership to the manager) reduce risk-aversion and thus boost investments in innovation.

➔ Giving managers ownership promotes innovation

- Rewarding managers on the basis of financial returns (= short-term performance) negatively affects the motivation of managers to innovate.
- Evaluating them on subjective criteria such as the quality of strategy adopted (or just on long-term performance) encourages innovation.

➔ long-term performance evaluation promotes innovation.

3.3 Background of managers

Individual characteristics

1. Age
   - ➔ 2 reasons to expect the age of top managers to affect the motivations to invest in innovation **negatively:**
     1. Aging causes mental abilities such as learning and memory to decrease. Further, younger managers are more likely to be trained in new technology. Since innovation involves creation of new ideas and combining existing elements in new ways, older managers are less able to invest in innovation.
     2. Nearer to the end of their careers, older managers are more worried about the short-term negative consequences of innovation.
   - ➔ Reasons to belief age affect the motivations to invest in innovation **positively:**
     1. Managers learn with experience and have a broader view of the industry.
     2. They have a significant network of relationships which may increase the availability of resources that can be used for innovation.
     3. Learning makes older managers more informed about the success of certain paths.
   - ➔ **Inconclusive** research about the relationship between manager's age and innovation productivity. Relation may be contingent on other factors.
2. Organizational tenure (their time within the company)
   - ➔ Affects innovation **negatively** because they have psychological commitment to organizational processes and values and this makes them resistant to change.
   - ➔ Affects innovation **positively** because they become more effective, they learn from experience, have increased power to get things done,...
   - ➔ These two countervailing forces suggest an **inverted U-shaped relationship** between innovative output and the average tenure of their top managers.
3. Education
   - ➔ **Positively** influences innovation because it increases their cognitive ability to understand and initiate new solutions, which in turn makes their attitudes towards innovation more favorable.

Top management composition

Heterogeneity in the top management team promotes innovativeness and innovative efforts because it helps firms to account for a larger set of problems and solutions, induces a more exhaustive analysis of problems and prevents group think.

- o However, heterogeneity may adversely affect the productivity of innovative efforts. Because of different opinions, it takes more time to come to a solution and may hinder the implementation of the ideas.
- o Studies have shown that diverse team were **more innovative but** they were **slower** in generating and implementing new actions

3.4 Organizational Search Processes

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4. Institutional Influences

Institutional environments are a key determinant of innovation efforts and the productivity of those efforts. Paper touches only a few aspects of this topic:

- The **role of science**: its interaction with corporate investment decisions affects both the incentives to conduct R&D and the productivity of the conducted R&D.
- The **set of appropriability conditions** in the industry which determine how much a firm can hope to get as return form its innovation investments.

4.1 Science and Innovation

Progress in science and technology motivates firms to invest in R&D activity through both **direct** and **indirect** mechanisms.

- Direct: providing knowledge inputs to the innovation process
- Indirect:
    - o Scientific progress motivates a firm to invest in R&D by increasing the need for prior knowledge necessary to profit from the progress in science. Indeed, knowledge generated by science usually cannot be applied directly but needs to be understood, modified and assimilated to produce commercializable products (= **absorbative capacity**). This capacity can't been attained easily as firms need sustained investments in R&D to understand and evaluate external knowledge. Thus scientific progress motivates the firm to invest in research indirectly by increasing the need for absorbative capacity.
    - o Scientific progress can identify which paths are dead-ends and which paths are more likely to succeed. This way the firm can narrow its search
    - o Scientific progress can also open up new search-paths for firms.

The **relationship** between science and innovation is, however, **far more complex**. The pursuit of good science does not naturally coincide with the pursuit of valuable innovations.

4.2 Appropriability Conditions and Innovation

Basic Argument

Appropriability Conditions refer to the environmental factors, apart from firm and market structure, that enable an innovator to capture the rents of innovation by creating barriers to imitation by competitors

- **Legal protection** provided by the **patent** regime of the country: this protection against imitation by competitors provides the innovator with incentives to innovate. He is now able to recuperate the initial invention costs because he gets a monopoly on the invention for a certain amount of time.

Challenges to the basic argument

1. Patent protection may not be necessary to stimulate innovation if imitation is costly or difficult (f.e. knowledge once created is not always easy to appropriate by imitators)
2. Danger of imitation does not always have to lead to disincentives to invest in innovation:
   ➔ When innovation in sequential and complementary, competitors may build on the original innovation by pursuing different lines of research. The different approaches may yield valuable ideas not available for the original innovator. Later the original innovator may benefit from the new ideas and generate new innovations.
   ➔ This increases the overall pace of innovation. In this case imitation may spur innovation and patent protection may hurt innovation
3. In many sectors, legal protection was not the preferred mode of preventing imitations. Other market-based mechanisms such as trade secrecy and first mover advantages were preferred.
   ➔ efficacy of patents in motivating firms to invest in innovation differs across industries (f.e. in pharmaceutical and chemical industry, patents are essential!)

Qualifications to the argument

Furthermore, a **threshold** an innovation has to cross exists, before it can actually be granted a patent. Raising this threshold can have two countervailing effects:

1. Innovation efforts are reduced because innovation has a greater chance of not receiving protection.
2. Patents lasts for a longer time because generating an innovation which crosses the threshold and replaces the original innovation is more difficult. Further a bigger innovation is likely to yield better returns.

- This leads to an inverted-U-shaped relationship between innovation efforts and patentability requirements

Strategic implications

With a patent come disclosure requirements, so patents are also codifications of knowledge. This facilitates the internal exploitation of knowledge but may also lead to higher diffusion. This has both positive and negative implications for the firm.

- Positive: strong patent regime encourages transfer of knowledge and technology because of disclosure requirements
- Negative: strong patent regime has significant costs:
    1. discourages and prevent follow-on inventions, which slows down the overall rate of technical change.
    2. may reduce the variety of search paths and prevent cross-pollination of ideas, which may reduce the quality of innovations
    3. may provide distorted incentives which may lead to diversion of resources from productive activities to unproductive ones such as litigation.

5. Innovation Management Outline: “Patents as an Incentive to Innovate” – *Dominic Guellec*

Questions Addressed:

1. What is the justification for society to have patents in the first place?
2. What role do patents play in society?
3. How is the patent system articulated with other policy tools fulfilling similar or complementary roles?
4. What is the economic impact of patents, on patent holders, on third parties, on the economy at large?

3.1 The Rationale for Patents

I. ***Moral Justification for Intellectual Property***

1. **The natural rights approach**, rooted in **John Locke**’s work and pursued recently by Nozick (1974)
    - ➔ States that an inventor, like any other worker, is entitled ‘naturally’ to own the result of his or her work
2. **First patent law in France in 1791**: principles of property and land being related to ideas
    - ➔ This set it only in the realm of law and not policy—used as an argument for a registration system with no examination, as if it is a natural right than government should not interfere with it and should simply ensure its enforcement
    - ➔ Patents in this respect serve as rewards for the individual inventor rather than as incentive serving society’s interest
3. **Problems** with the natural approach:
    - ➔ US Judge: 'All useful inventions depend less on any individual than on the progress of society. Inventor is just the **lucky** first one.'
    - ➔ Locke continued to revise his position, noting that apply 'natural' rights to inventions is difficult because the nature of natural rights means one person’s is exactly another person’s **exclusion**
    - ➔ Every invention is based on **accumulated knowledge**, the sum of past inventions made by others. (= the Commons, reffered to by Locke). Locke mentions that granting someone control over the latest invention gives them de facto control of the 'common' previous inventions that the new one is based on and sometimes displaces.
    - ➔ Granting a right on a current invention deprives possible future inventors of that particular right
4. US Judge Arnold in 1941 compares invention to separating a haystack and rewarding the one person who finds the needle. Giving patents for such routine experimentation on a vast scale is to use the patent law to reward capital investment and create monopolies instead of rewarding men of inventive genius.

5. **Opposite views** of natural rights argument is that ideas are naturally free of ownership, as once written by **Jefferson**.

II. ***The Utilitarian Approach***

1. Explanation:
   - ➔ Claims social institutions should be designed to **maximize social welfare**
   - ➔ Argument in relation to patents is that free competition will generate an under-optimal rate of inventions due to the **'public good' characteristic of knowledge**—it is actually in the interest of society to supplement free competition with special institutions, here patents
   - ➔ Utilitarian approach views patents are **rewards for further innovation** rather than past innovation
   - ➔ Utilitarian sees patents as a **policy instrument** tied to circumstances, as the government and market already provide enough incentives for innovation in certain cases
   - ➔ Knowledge is **non-rival** (can be consumed by multiple people). This basically makes it a public good. In a way it is even more public than a road, because there is no such thing as congestion when too many people are using knowledge. Consequences:
     - ▶ Marginal cost of using knowledge is zero. Hence, cost of invention is **sunk**, incurred before the production of a product.
     - ▶ Reinventing an existing piece of knowledge is a **waste of social resources**. As cost of invention is already incurred (sunk), and it generates no further cost, unlimited and free access is socially preferable.
     - ▶ An existing piece of knowledge can be beneficial to those other than the inventor—**'positive spillover'** means social return is usually higher than the private return (social return on an invention is higher than private return for inventor only)
     - ▶ *Certain inventions whose social return would justify the expenditure needed to obtain/invent them will not be made due to **insufficient private return**.* – Shows that competitive marked mechanism might not generate as many inventions as society would be willing to have.
     - ▶ A competitive market may make things worse as an inventor would set a price to recoup his fixed cost in invention while a competitor with access to the idea would only have to recoup his marginal cost to product the product
       - ➔ This would cause companies to keep inventions secret, would lead to need for reinvention mentioned in (2).
     - ▶ Anticipating this, companies will not invest in research in the first place

2. Intervention by government needed according to this approach: **3 Solutions**:
   - ➔ Government sponsorship of inventors or inventions, with free access to inventions to all users = put **inventions in the public domain**
   - ➔ 'Privatize' knowledge, making it an 'excludable good' –*This is Intellectual Property Rights (**IPR**)*
     - ▶ Holder can then retain or allow access under conditions that are economically beneficial to him
     - ▶ This extra reward, beyond the normal competitive profit, makes it worthwhile to invent because cost is recouped
     - ▶ Exclusive rights, however, hamper access to existing inventions and thus **create costs** by reducing positive knowledge spillovers. IPR is a **balance between benefits (incentive to invent) and costs (reduced diffusion).**
   - ➔ European law basically views a patent as a contract granting a transitory monopoly to an inventor in exchange for **disclosure** so society can benefit from the invention. However, disclosure is certainly a part of the objective of the patents system (which is why the patent design is disclosed in the patent document), but the primary goal must remain the provision of incentives to invent.

III. *Are Patents Property Rights?*

1. Interpreting Patents as full protection over tangible property (property rights) gives it plenty of legal backing strict defence, while defining them as something else grants more flexibility
2. **Demsetz** (1968) argues for **full protection** (and thus patents as property rights) on the grounds that assets that are not private are subject to **over-exploitation** (the Tragedy of the Commons—the overfished public pond) and thus **externalities** are internalized with strict patent protection and this creates social welfare.
   (a positive externality means that after a transaction has occurred and as beneficial to all parties involved, further value is created which will accrue either to one of the participants of to a third party)
3. **Marc Lemley** (2004) **rejects** this as he says Demsetz theory speaks to internalizing *negative* externalities, while knowledge is associated with *positive* externalities. Therefore internalization should be weaker for intangibles than for tangible propery => patents not as property rights.
4. **Duffy rejects** Lemley's work as he mentions that what is a positive externality for some (users of the knowledge) is a negative externality for others (producers of the knowledge). No reason to treat intangibles in a different way than tangibles => patents as property rights.
   - ➔ Duffy's argument is wrong cause it ignores the "public good" property of knowledge
   - ➔ Difference between positive and negative externality **is not a matter of distribution of value but a matter of creation versus destruction.**

- ▶ If the invention (transaction) would be diffused anyway, all a patent could do is reduce social welfare (negative externality)

➔ Author argues thus that viewing things as Duffy does puts patents as existing only on distributive grounds and not on efficiency grounds

5. Author argues that property rights are still relevant but in a **dynamic way**

   ➔ Reference to work of **Plant** (1934) that says patents, designed to negate shortage as in overfishing, actually create shortage in not allowing diffusion—owner owns entire supply. **IPR must aim at reducing future scarcity by inducing more investment, property rights on tangibles serve the purpose of managing current scarcity of resources** (f.e. fish pound)

6. **Hart & Moore (1990)**

   ➔ Views property rights as contracts between the inventor and society as with a borrower and a bank—owners(inventors) are residual claimants on income generated by an asset, thus are incentivized to use the invention so as to maximize the value it generates. But patents are not only a way to extract more value (such as property rights) but they have become a way to access others' technology (licensing) or to raise capital (signaling). Patents give a stronger incentive to commercialize a product than property rights and are thus more beneficial to society.

3.2 Patents as Policy Tool

Market do not generate a socially efficient level of innovation. Governments have a range of instruments to encourage innovation, including patents.

I. ***Technology Policy***

1. Policy Instruments
   - **Public Research System**
     1. Types
        1. Universities
        2. Public Laboratories
     2. Funded mainly by tax revenue
     3. Research covers three broad areas
        1. Fundamental Knowledge
           - No direct economic use
        2. Technology fulfilling collective needs of citizens
           - Defence, space, health
        3. Generic, industrial technology
     4. Funding Mechanisms (funding not conditioned on the outcome)
        1. Grants allocated on a competitive basis following a call for tender by governmental agencies
        2. Public Laboratories that receive basic funding and their research agenda

- **Subsidies** (Business-performed research)
    1. Funding Mechanisms
        1. Public Procurement
            - Government purchases research from private party often at 'Cost-Plus' and obtains the intellectual property of the invention.
        2. Research Subsidies
            - Sponsoring of research project (often as a response to a particular government objective, f.e. anti-pollution) without transfer of property to the government.
        3. Prizes
            - Government controlled competitions for well defined innovative projects. Prize goes to the first to submit the requested invention.
        4. Soft Loans
            - Reduced interest rate, guarantee of reimbursement by gov't, clause of reimbursement if success
        5. Tax Breaks
            - Often reduced taxes in proportion to R&D spend decisions that company takes internally
- **Intellectual Property Policies**
    1. Patents
        1. Positive:
            - Like a *targeted tax*: it is a tax that relies on a monopoly granted by the government targeted to only buyers of the protected good. On the contrary, subsidies are funded through the general tax system, contributed by all citizens.
            - Thus, funding that accrues to the inventor is more *closely related* to the value of the invention, not the cost of doing research. Patents system operates farther downstream in the value chain, increasing the value of research output not decreasing the cost of research itself
            - Do not only encourage research but also commercialization of inventions! Reason:
                - ▶ Patent will only generate income when the invention is commercialized. The potential to disseminate the invention, rather than the invention itself, is rewarded
        2. Negative: Has an exclusionary effect (reduced competition) that other instruments don't have
        3. Notable difference from other two instruments

- Patent infringement is punished only when identified by the owner itself, with no monitoring from the government

II. ***What Instrument Should be Used in Which Case?***

Efficiency of an instrument is its ability to generate more innovation at the lowest cost for society. (Utilitarian approach)

1. 1st Issue: Is research **applied versus fundamental**?
    - Fundamental requires public funding
    - However, notion of application is not always clear-cut: f.e. applied research but applications expected only in the long-term so patent might already be expired at the time the market stage is reached
2. 2nd Issue: **Existence of substitutes**?
    - Market power granted by patents is very strong in absence of substitutes
    - Products with no substitute (e.g. certain drugs) become *'essential facilities'* and require close governmental oversight as private monopolies would have detrimental effects on society
3. 3rd Issue: **Exclusion** (Efficiency & Equity)
    - Patents exclude customers which are not ready or able to pay the higher price charged on patented goods
    - Two categories of excluded customers:
        1. Customers that are willing to pay more than marginal cost but not willing to pay full premium that is result of monopoly granted by patent – often excluded by not just subsidizing research, which is socially inefficient as they would gain without imposing any further cost on society. Patents might not be ideal is this case.
        2. People unwilling to pay even marginal cost. This raises an issue of *fairness* outside the realm of patents, applying even to goods such as food!
4. **Additional Issues**
    - To what extent is it fair to make all citizens pay for a good that not all of them will use (by using their tax revenue in subsidies instead of patent-induced monopolistic pricing?)
        - ▶ Depends on industry—seems fair for pharmaceuticals, less so for luxury car improvements because in that case not all citizens will benefit from the results
    - Choice of an instrument is related to the allocation of information. The decision-makers should be those who have the information about the cost and value of the invention.
        - ▶ F.e. Prize system and public procurement should not be used if the government has not idea of value of the requested invention.

▶ Patents are therefore more efficient as the value of the invention is not known by government!
▶ Subsidies are useless if government has no idea of the cost.

3.3 An Economic Incentive

Firm will take a patent if and only if the net gain from taking it is positive: this means that it will consider the expected profit in case the patent is taken (minus the cost of the patent and compare it to the profit is case no patent is taken. Supplementary gain in case of a patent is taken = **patent premium**.
The value of this premium depends on the impact of the patent on the **degree of competition**, **cost of disclosure** and the **price elasticity** of the market. Patenting involves disclosure, which can trigger inventing around and follow-up inventions by competitors, which then limits the control of the market. Too much disclosure can even result in a negative patent premium.

- If an invention is easily to keep secret an inventor is less likely to take a patent because the cost of disclosure will be very high compared against the profit from less competition. If an invention is easily imitated, then the cost of disclosure that comes with patenting will be low and thus the effect of a decrease in competition might be significant. F.e. processes are easier to keep secret that innovative products.
- If demand is highly elastic (f.e. because of substitutable products) than the seller cannot demand a significantly higher price and the his premium from patenting will thus be lower.

So patent if premium is positive and do not patent when premium is negative.

I. Effectiveness of Patents

Empirical studies on the effectiveness of patents not fully conclusive. They can be classified according to the research questions they address:

1. *To what extent and for what purpose do innovative firms use patents?*
   - Firms do not generally view patents the most important issue in maintaining competitive advantage. Complementary manu. and distrib. services were more important for securing market power. Patents are considered as **one option only** in the appropriation strategy of firms, but **not the most important one**
   - Patents deemed effective for securing returns from inventions in **certain industries** only (chemicals, biotech, drugs) and not in others (electronic components, aerospace)
   - More effective for product innovations than **process innovations** (as processes are not easily accessible for competitors, disclosure is costly)
   - More often used for protecting **radical innovations** based on R&D than more marginal inventions
   - Major reasons for use appear to be (in decreasing order): **preventing copying, blocking competitors, and gaining freedom to operate**

(without fear of being sued by others for their own patent rights, etc.). Gaining reputation and obtaining licensing revenues are less important

- Firms tend to **patent more** inventions when they are confronted **with more intense competition**
- Firms which **export** part of their production tend to patent more
- **Large firms** take more patents than small ones

2. *Does patenting add value to innovations (is the patent premium positive)? --Answers based on 1994 Carnegie Mellon Survey*
    - For most innovations, the patent premium is **negative** (due to disclosure costs, etc.), which is why so many innovations are not patented (the average patent premium on non-patented innovations is 50%, meaning the invention would lose half of its value if patented)
    - For **those which are patented**, the **patent premium is very significant** (between 180 and 240%, depending on the industry, meaning that patents basically double the value of the invention)
    - The PP has a skewed distribution (most patents are worth very little with some exceptional high outliers) and **differs largely across industries**: high in biotech/medical/machinery/computers.
    - PP positive in the case of **product innovation** but not in the case of process innovation.
3. *Do patents induce further R&D and innovation?*
    - **Yes**; R&D would decrease by 25-35% overall in the US without patents
    - An increase in the patent premium by 10% in the US would increase business R&D by about 6%
    - Shankerman estimates the value of cash subsidy to R&D provided by patent protection, called equivalent subsidy rate (ESR)
        - ➔ = how much such governments grant to the company to remain its R&D at current level if there was no patent protection.
        - ➔ American data puts ESR at about 30%
    - The Patent Rights Index (PRI) measures strength (coverage, enforcement, requirements etc.) of patent protection across countries, and the PRI was found to have a positive and significant effect on R&D intensity.
    - PRI effects on GDP are positive and strong for low and high income countries, but more transitory for middle income countries
    - IPR is positively and significantly related to innovation (in terms of number of patents)
        - ➔ Poorest countries are negatively affected by stronger IPR in terms of patent filings, but would gain in terms of productivity growth with a strengthening due to a greater access to foreign technology that would come from the strengthening
4. Conclusion: 1) Patents are quite effective in increasing R&D, but depends on industry. 2) Patents are taken for other reasons that protection against imitation and it's to be expected that patents taken with these strategic objectives are much less socially beneficial. 3) Patent regimes contribute to economic growth: through the import of

foreign technology in less developed countries and through domestic inventions for more advanced economies.

3.4 Inventions Disclosure and the Social Cost of Patents

I. Positive: Disclosure

1. Main alternative to patents is **secrecy**. It is shown that most process innovations are not patented and are kept secret (because patenting would require disclosure of a hard for competitors to access innovation) and that most product innovation are patented (because they are harder to keep secret and not patenting would mean that they cannot regenerate the cost of the innovation)
2. **Aim of patents is to make disclosure the preferred option** so that society can benefit from the invention.
    - Facilitates follow-up inventions
        ➔ Major source of new tech is existing knowledge
    - Facilitates invention of substitutes
        ➔ Increases welfare of consumers and reduces market prices
3. However**, limits to research that can be done with patented knowledge without approval from holder**. In some countries universities do not have these limits and can use all patented knowledge without requesting licenses.
4. Laws allowing research on certain goods (drugs) BEFORE patent expires, as otherwise R&D lag would effectively increase the time of the patent
5. **Licensing** is traditional **response to issues regarding use of patented knowledge**. In return for royalty payments, one may use the patented knowledge of the patentee.
    - Has it limits due to contract costs

- **Patenting and secrecy are not necessarily incompatible**: new products/processes are usually made of several inventions, some of which are patented, other kept secret.
    ➔ This limits the effectiveness of a patent system because this half disclosure does not allow the implementation of the whole invention by other as key parts of the technology are kept secret. In this case follow-up inventions cannot be realized and society does not gain from the patent system.

II. Negative: Deadweight Loss

Effects that patents have on customers and on other companies and not on the inventor.

1. Customers benefit from new products but monopolist **markup**'s inflate price of patented goods which results in deadweight loss for society. (**Fairness** debate: is it legimate to deny access to the poorest customers even at the marginal cost of the inventor?)
2. Solution is **price differentiation** (identify willingness to pay for each customer). But in practice this has its limitations:

- Not possible to identify willingness to pay of each customer.
- There is a second-hand market where rich users offer to buy from poor user (f.e. importation of drugs from Canada where they are cheaper = **Parallel imports**)
    - ➔ Europe limits IPR to first sale within EU, not protecting in a second-sale. But when goods are re-sold by first-hand buyers outside the EU, the IPR products stay protected.

III. Strategic Patenting

Defensive Patenting = some companies patent not to get a monopoly but to basically legalize their presence and participation in the market, or to protect them from competitors' patents.
This way they can preserve their **freedom to operate**, (this is another important reason for patenting, third most important behind preventing copy and blocking competitors).
This is a prisoners' dilemma because patents are costly and when none of your competitors take patents, you don't have to preserve your freedom to operate either and you won't take patents either. But when competitors do, you must do it as well in order to preserve your own survival. Equilibrium will be that all firms will pay for patents, however, its Pareto-optimal that no-one patents. = **Patent wars**

IV. Distortions in Profit and Investment

Since the patent system affects the distribution of profits across industries and probably affects the allocation of investment accordingly, an economy with a stronger patent system tends to invest more in drugs, while a company with a weaker patent system would specialize in textiles

6. Does the European Paradox Still Hold? Did it Ever? - *Dosi G., Llerena P. & Labini M. (2008)*

Abstract

- This paper assesses the "science-technology-industry" link in Europe
- The traditional argument has been that Europe is a leader in scientific research, but is unable to convert it into wealth-generating innovations and competitive advantages (this is the **European Paradox**)
- The paper is broken into sections
    1. European strengths and weaknesses in science production
        - ➔ main comparison will be to United States
        - ➔ the primary place for scientific development is higher education systems, and research shows American universities have greater performance level than European universities (this is partly due to low investment levels in European universities)
    2. European performance in technological innovation
        - ➔ Several R&D indicators that pinpoint the European lag
        - ➔ Intensity of higher education expenditures on R&D are positively related to private investment in R&D. Europe invests not enough in this.
    3. Policy implications suggested to stimulate private R&D
        - ➔ more emphasis should be placed on strengthening frontier research and the quality of research universities
        - ➔ increase mission oriented public R&D
        - ➔ explicit industrial policies

1. Introduction

- Since the 2nd half of the 1990s, economic performance/growth in Europe has been less than that in the US (measured by annual growth of per capital GDP)
- European institutions and policies have not been as suited as those in the US to adapt to the "Information Technology Revolution".
- We know that Europe does not invest enough in R&D and its knowledge economy is weak – but these are CONSEQUENCES of something else, not the cause
- European policymakers have proposed the **European Paradox** (see above), however, **evidence does not support this theory**
- Instead, evidence shows that Europe is **weak both in scientific research and in the new technology-based industry**

2. The Myth that Europe is a Leader in Science

- The main support for this European paradox myth stems from the 1995 EU Green Paper on Innovation, which measured the strength of European science using the number of publications per Euro spent in R&D
    1. this number was higher than the US, only because the total number of publications is higher in Europe than the US
    2. this measurement does not take into account the effect that these publications have on the advancement of science
    3. one way to gage this is through articles' citations, and these European articles barely have any (in fact, measured with number of citations, outstanding EU scientific output is less than half than the US one)
    4. while European universities have more researchers in number, the quality of the actual research in the US is stronger
    5. Highly Cited Researchers (HCRs), which are researchers whose works have received the most number of citations (and can therefore be considered the researchers who have made most significant contributions to advancement of science and technology)
        - ➔ 66% are from American institutions
        - ➔ only 22% are from European institute
- In summary, if we replace this measure of number of publications with more demanding indicators, the European leadership in science becomes a myth. There is a structural lag in top level research output and the number of top researchers per capital is lower in Europe than US. One the causes of the dismal performance of science, technology and innovation systems is precisely the weak European scientific impact.

<u>3. EU universities, Comparatively Speaking</u>

- The first place to explain Europe's weakness in scientific research is European universities
- Data comparing these universities to others worldwide can be found using HCR database and Shanghai Academic Ranking of World Universities
    1. the US outperforms European countries in the Top 50 Universities
    2. European Universities do better as the "pool" gets larger, i.e., in the Top 100 and Top 500 Universities – this is because you are no longer looking at the select elite, but rather are including a lot of average universities as well
- So why is there poor scientific performance in European Universities? 2 Reasons:
    1. Amount of **money** spent in higher education
        - ➔ US spends more than Europe on higher education
        - ➔ Every year, Europe spends almost 2% of GDP less than the US (1.3% v 2.9% of GDP)
        - ➔ Otherwise put, EU spends approx $7,000 per student in contrast to US spending $20,000 per student – Shanghai ranking shows strong correlation between expenditure per student and country performance
    2. **Institutional differences**

- ➔ Universities seem to occupy a less significant position among research producer institutions in Europe – a relevant portion of top scientific research is NOT performed by university institutions (CNRS in France)
  - vs. in the US, research universities are top place to carry out scientific research (Harvard and Stanford are top 2)
- ➔ University systems in Europe have centralized control and are largely under the authority of national governments
  - unlike the US, there are not distinct liberal arts colleges, technical institutes, etc… in Europe each university is a **blend** of these
  - centralized control is likely to prevent US-style of competition for research funds, faculty and students
  - Data shows that a university's autonomy in budgeting, hiring, and remuneration increases the efficiency of both public and private spending. This is not the case in Europe, in US it is.
  - In summary, European universities should not be over-regulated and there should be competitions across institutions for research funds, faculties and students.

<u>4. Europe's Poor Technological Performance (and R&D investments)</u>

- The **Lisbon Agenda** of the European Commission aims at making the EU "the most dynamic and competitive knowledge based economy in the world" through **2 targets**
  1. EU R&D expenditures on GDP is supposed to reach 3% by 2010
  2. The share of this spending funded by business should rise to 2/3
- However, the EU under-invests, compared to the US and to Japan, and is not going to reach the 3% goal by 2010 ; also, the share of R&D spending funded by business is rising too slowly to hit 2/3. **Europe will miss the two targets**.
- To understand the European weaknesses and to put forward corrective measures, it is useful to explore the direct and indirect channels through which the government might be able to increase R&D investment:
  1. **Public spending** for R&D (direct)
     - ➔ US government spends more than EU governments in R&D carried out both by firms and by institutions
     - ➔ Governments can increase business R&D by 1) **reducing its costs** through grants, loans and fiscal measures; 2) financing the R&D as part of **procurement** programs (esp, for defense or space objectives); and 3) providing **public support to research institutions**, such as universities
     - ➔ In the US, federal support of industrial technology is paid almost entirely to firms, not public institutions (mission-oriented R&D and procurement). Similar in UK and France but Netherlands and Germany f.e. funds are distributed evenly across the 3 categories.
  2. **Stimulate R&D financed by private sector** (indirect)

- ➔ Private investment in R&D and the localization of private R&D laboratories are likely to be stimulated by the quality and the financial efforts in academic research. So Europe should increase its HERD (higher education expenditures on R&D) to attract more financing from the private sector.
    - The most important factor behind academic research is the supply of a qualified and skilled labor force (public conferences, dissemination of scientific information, and consulting is also important)
- ➔ Data shows that industry-financed R&D is positively correlated with the per capita number of HCRs and the expenditures on higher education R&D

- In summary, **EU policy should aim to increase mission-oriented public R&D and stimulate private R&D investment (it can do this through strengthening top research universities)**

<u>5. Wrong diagnoses and misguided policies: Modest Alternative Proposals</u>

- We have seen that Europe's system of scientific research lags behind that of the US
- The need is for strong science and higher education policies, but because of the incorrect "European Paradox", EU policies do not provide support for basic research or to research universities
    1. The "Frame Programmes" (especially the "Networks of Excellence Programme"), currently in place, not only don't support research but they explicitly prohibit the use of EU money for that purpose
    2. Firms and academics try to extract community money so that they do not have to invest their own funds for R&D
    3. There are more people "networking" and administering the research processes in Europe than actually undertaking research (both at national and EU level)
- Solutions
    1. Increase support to high quality basic science through **research institutions**. In that prospect, the European Science Council is a good development (like American National Science Foundation NSF in the US)
    2. Make **distinctions within the higher education system** between research universities and the other kinds (like liberal arts and technical schools)
        - ➔ currently, higher education European institutions offer a blend of these types that is neither good for research nor for mass-level training
    3. Build ambitious, **technological missions** which may have great **future value** (esp. in energy conservation, health care, environmental protection)
        - ➔ EU countries should be able to undertake high quality research without massive defense and health expenditures

7. Is the Internet a US invention? An economic and technological history of computer networking

1. Introduction

The Internet was created through a series of inventions and innovations in fields ranging from computing and communications to regulatory policy, business and finance. Although its development and deployment occurred largely within the US, the inventions embodied in the Internet originated in a more diverse set of industrial economies. This paper addresses the question of *why other nations, including several that made important inventive contributions to the Internet, did not play a larger role in its development*. Our explanation relies on a comparison of the **US** "**national innovation system**" with those of other industrial economies.

2. A brief history of the Internet

2.1. 1960–1985: early computer networks

2.1.1. Packet switching

Research on computer networking began in the early 1960s.

- ➔ Most of the US research in this field during the 1960s was funded by the **Department of Defence** (DoD) in order to develop technologies to support shared use of computing resources located at a few research centers. (the agency supported also research in academia and useful industries)
- ➔ During the early 1960s **several researchers** (including Davies) developed various aspects of the theory of **packet switching** (>< circuit switching of telephone calls. Packet switching = information is broken up into a series of packages that are sent individually and reassembled on the receiving end. 1 circuit may contain packets from different connections and a single communication may take different routes)
- ➔ By the late 1960s, the theoretical work and early experiments of the researchers led the Defence Advanced Research Projects Agency (DARPA) of the US Department of Defence granted a contract to built the first packet switch network. The switch was called an Interface Message Processor (IMP), and linked computers at several major computing facilities over what is now called a wide-area network. A computer with a dedicated connection to this network was referred to as a "host." The **ARPANET network** is widely recognized as the earliest forerunner of the Internet.
- ➔ The first "killer application" developed for ARPANET was electronic mail (**e-mail**), released in 1972.
- ➔ By 1975, as universities and other major defence research sites were linked to the network, ARPANET had **grown** to more than 100 nodes.
- ➔ ARPANET was not the only prototype packet-switched network deployed during the late 1960s and early 1970s. Donald Davies completed the construction of a data

network at the National Physical Laboratories (NPL) in the **UK** before the deployment of ARPANET, and a **French** network, CYCLADES, was built in 1972.

- ➔ CYCLADES and the construction of Davies ran **out of funding**, while the ARPANET, by contrast, benefited from sustained and substantial development funding and from its large-scale deployment.
- ➔ Also the **US** network connected three **universities** (UCLA, UCSB and Utah), a consulting firm (BBN), and a research institute (Stanford Research Institute). ↔ British and French

2.1.2. TCP/IP

- ➔ In 1973, two engineers, Robert **Kahn** and Vinton **Cerf**, developed an improved data-networking communications protocol that simplified routing, eliminated the need for an IMP, and allowed physically distinct networks to interconnect with one another as 'peers' in order to exchange packets through special hardware, called a gateway. Kahn and Cerf published their specification for the "**transmission control protocol (TCP)**" in 1974. These researchers made a critical contribution to the future structure of the Internet. The TCP protocol subsequently was split into two pieces and renamed **TCP/IP** (Transmission Control Protocol/Internet Protocol).
- ➔ During the 1980s, a number of protocols were introduced, the **TCP/IP** protocol ultimately **won** out for several reasons:
  - o TCP/IP ran on a variety of network hardware configurations
  - o It was more reliable than first-generation network protocols
  - o TCP/IP is an open standard—a complete description of TCP/IP and the rights to use it were freely available to the networking community along with several different implementations.
- ➔ TCP/IP also benefited from **good timing**, since it was developed just as the computing research community began to standardize on a common platform. Finally, a 1985 decision by the National Science Foundation (NSF) to adopt TCP/IP as the standard on its university research computing network helped create a large installed base.

2.1.3. Early coordination efforts

- ➔ The diffusion of the Internet relied also on the creation of a set of flexible and responsive **governance institutions.** Most of these institutions trace their origins to an informal correspondence process called request for comments (**RFC**), RFCs were distributed over the nascent computer network and quickly became the standard forum where ARPANET's growing technical user community gathered to propose and debate new ideas.
- ➔ The Internet's first **formal governance organizations** began to appear in the US during the early 1980s. Efforts to rationalize the resources of several US networking initiatives operated by NASA, the Department of Energy, and the NSF led to the creation of a set of organizations. The **Internet Configuration Control Board**

(ICCB) was established in 1979 by Vinton Cerf. In 1983, when ARPANET switched over to TCP/IP, the ICCB was reorganized as the **Internet Activities Board** (IAB), which managed the Internet's architecture and technical standard-setting processes, along with several other sub-committees.

- ➔ The IAB and its progeny coordinated the infrastructure and connectivity boom, but by the early 1990s, **the costs** of managing the Internet infrastructure began to **exceed the available federal funding**. In 1992 the **Internet Society (ISOC)** was founded with funding from a variety of private and public sector sources.
- ➔ These informal organizations made a number of decisions that contributed to the remarkable growth in scale and technical performance of the overall network. These Internet self-governance organizations were also a **credible alternative** to the standard-setting committees of the global telecommunications industry.

2.1.4. European efforts

- ➔ Although early research efforts in Europe (e.g. Cyclades) failed to develop a network comparable in scale to the ARPANET, the early 1980s saw a number of **efforts at intra-European and US-European collaboration**. (e.g. the first international ARPANET nodes were established at University College in London)
- ➔ Although European research networks could offer the European research community the same basic services as ARPANET, such as e-mail and file transfer, the alternative standards did not achieve the widespread success of the TCP/IP protocol suite, and the European networks grew more slowly than the ARPANET

2.2. 1985–1995: infrastructure development and growth

During the next 15 years, however, the Internet infrastructure was tested by a dramatic expansion in the number of new networks and users. Growth was accompanied by consolidation and privatization of the network infrastructure, as well as by expanded commercial use.

2.2.1. Infrastructure evolution

- ➔ The first steps toward **privatization** of the US network infrastructure were taken in 1983, when DARPA **split** the ARPANET into two parallel networks—**ARPANET** and **MILNET**. The latter network was used exclusively for military applications, while ARPANET remained a network primarily linking research computers in industry, academia, and government research facilities.
- ➔ In 1985, the **NSF** (National science foundation) mandated that any university receiving NSF funding for an Internet connection must use **TCP/IP** on its network, **NSFNET**, and must provide access to all 'qualified users'. The NSF requirement strengthened the position of TCP/IP as the dominant network protocol

- ➔ In the same year, all of the federal agencies then operating networks—DARPA, NSF, DOE and NASA—established the **federal Internet exchange (FIX)**, a common connection point that allowed them to share their backbone infrastructure.
- ➔ In 1990, the NSF maintained an **acceptable use policy (AUP)** that prohibited the use of NSFNET for **commercial purposes**. The growing population of commercial Internet users was allowed to access NSFNET as a research tool, but commercial users were prohibited from using it to conduct business.
- ➔ In 1991 the **NSF abandoned the AUP**. The transition of the core network infrastructure into private hands was completed in 1995, when the NSF transferred control of its four major Network Access Points to Sprint, Ameritech, MFS, and Pacific Bell.
- ➔ Data from the US Department of Commerce indicate that expenditures on software and information technology accounted for 24% of total US private fixed investment in 1970, US$ 8.31 billion. ITs share of annual private sector investment flows grew during the next thirty years, reaching US$ 542.2 billion by 1999. This **large privately financed IT investment** created a huge domestic 'platform' in the US for the rapid adoption of the Internet and for user-led innovation in Internet services and technologies.
- ➔ Western Europe also developed a data-networking infrastructure during the late 1980s, **Reseaux IP European (RIPE)**, but its scale and standardization lagged US efforts. The large scale and open standards of the **NSFNET** made it **an attractive alternative to the European networks**, and many networks from industrial economies outside the US chose to connect with the NSFNET infrastructure.

2.2.2. Technical advances

- ➔ Growth in regional networks and the NSFNET backbone in the late 1980s induced a series of **incremental improvements** and innovations that cumulatively improved the performance of the Internet:
    - o The speed of the NSFNET backbone was upgraded
    - o The domain name server (DNS): it maps Internet domain names to the numerical network address scheme utilized by TCP/IP.
    - o The creation of a hierarchical classification scheme for sub-networks.
- ➔ The advances in domain name servers and classification schemes were the work of computer scientists in US **universities**.
- ➔ The firms that eventually came to dominate the market of **innovations** in the networking hardware and software products were **not large incumbents** (such as IBM). Instead, a **group of smaller firms** from the late 1980s, rose to prominence by selling multi-protocol products that were tailored towards the open platform represented by TCP/IP and Ethernet.

2.2.3. Origins of the consumer Internet

- ➔ Simultaneously with the rapid growth and consolidation of the NSFNET infrastructure, another type of networking appeared. The introduction of the "**personal computer**" in the late 1970s and early 1980s made networking available to individual as well as institutional users.
- ➔ Compuserve launched the first commercial "bulletin board" or BBN service in 1979. The three largest **online service providers** (Prodigy, Compuserve and America Online) rapidly gained thousands of subscribers.
- ➔ With the notable exception of France's Minitel, there is **little evidence of the contemporaneous emergence of a European online service provider** industry.

2.2.4. World Wide Web

- ➔ In May 1991 two physicists working at the CERN laboratory in Switzerland, released a new document format called **HTML** and an accompanying document retrieval protocol called **http.** (HTML incorporated multimedia capabilities that allowed authors to include pictures and graphics into the text of their documents). Together, HTML and HTTP turned the Internet into a vast cross-referenced collection of multimedia documents. The collaborators named their invention the "**WWW**".
- ➔ By 1996, HTTP traffic was generating **more Internet traffic** than any other application!
- ➔ Although HTML and HTTP were not invented in the US, 20 years of federal and private-sector investments in R&D and infrastructure supported their **rapid domestic adoption** and development. (The US researchers and entrepreneurs played a pioneering role in developing commercial applications of the Web)

2.3. 1995–present: creating commercial content and applications

2.3.1. Commercialization of the Internet

- ➔ The invention of the **WWW** catalyzed the development of commercial content and applications by simplifying the Internet and providing a set of standard protocols for delivering a wide variety of content to almost any desktop.
- ➔ Commercialization was leaded by a booming US economy and overheated equities market.
- ➔ In 1996, the commercial ".com" and ".net" top-level domains became much more important hosts as the educational ".edu" domain. By 2000, the term "**dot com**" had become a popular expression.
- ➔ In 1998 the **US** was the most intensive user of secure web servers on a per-capita basis.
- ➔ A wide variety of **hardware and software businesses** related to Internet commercialization flourished during the late 1990s. (e.g. Cisco/Dell). Also **Consumer-oriented e-commerce markets** (e.g. Yahoo!, Amazon.com, eBay) grew very fast.

- ➔ **US financial markets** played a role in the commercialization of the Internet during the 1990s by ensuring a robust supply of **equity** and **Venture Capital financing** for new IT firms. (> healthcare!)
- ➔ Venture capital funding for Internet ventures was not entirely lacking in **Europe**, but it was much less abundant, consistent with the **more modest level of overall development of VC** in Europe and other industrial economies

Time Period	Critical Developments
1960-1985	Invention of digital packet-switching and associated standards/protocols Birth of Internet self-governance institutions
1985-1995	Growth of NSFNET and parallel private infrastructure Growth in installed base of PC's and LAN's
1995-Present	Diffusion of the World Wide Web Privatization of Internet infrastructure and commercialization of Internet content

Figuur 1 Evolution of the Internet

3. The US national innovation system and the Internet

The Internet resembles many post-war innovations in information technology in that it was invented and commercialized primarily in the US. The US was the first country to deploy a large national research-computing network, the first country to standardize on TCP/IP, and the first to develop a large, competitive market for individual access. The US' role in invention, diffusion and commercialization of computer networking technology reflects the unusual **mix of institutions and policies** that characterize the post-1945 **US national innovation system**, while also exploiting **long-established characteristics of the US economy** that were important to economic growth and innovation in the first half of the 20th century. Even as the international uniqueness of many characteristics of the US national innovation system has diminished somewhat in the face of globalization, several remaining and internationally unique characteristics of the US system have had a major impact on its performance, especially in information technologies.

3.1. The role of government-sponsored research

- ➔ Federal R&D spending, much of which was defence-related, played an important role in the creation of a diverse array of information technology industries in the post-war **US.** (Internet-related projects funded through the Department of Defence and other Federal R&D investments were used to develop many of the early inventions that fuelled the development of the Internet in the US.)

- ➔ The large scale of the US **defence-related programs** in computer science research and **networking distinguished them from those in the UK and France**. (A great deal of US defence-related R&D consisted of long-term research that was conducted in universities ↔ UK where a lack between military and civilian researchers and engineers weakened the early British computer industry)
- ➔ Beside this 'military aspect' was there also **a lack of Federal funding** in **Europe.** (See Donald Davies' national computer network and Louis Pouzin's CYCLADES packet network research program)
- ➔ **Contracts** were often awarded in the US **to small firms**. This policy helped foster entry by new firms in emerging industries, supporting competition and innovation.
- ➔ Another factor in the success of US R&D programs was their **neutrality with respect to specific commercial applications.** (These US programs generally avoided the promotion of specific products, in contrast to efforts in other industrial economies, such as the French Minitel program or Britain's national champion policies in the computer industry)
- ➔ The diversity of the federal Internet R&D portfolio reflected the fact that federal R&D investments were **not coordinated by any central agency** (even within DoD).
- ➔ Our emphasis on the role of public policies and public R&D funding should not be construed as suggesting that **private R&D** and related investments were unimportant to the development and diffusion of the Internet in the US. Private R&D **complemented** and responded to the incentives created by public policies and larger market forces

3.2. Other government policies

- ➔ In addition to supporting Internet-related R&D, the US government influenced the development and diffusion of the Internet through regulatory, antitrust, and intellectual property rights policies.
- ➔ US antitrust policy influenced the evolution of the Internet by **limiting the activities of two of the leading sources** of technological innovation (**antitrust policy**) in the information technology sector during the post-war period, AT&T and IBM. (e.g. there were significant restrictions on AT&T's activities outside of telecommunications services and major information technology innovations of IBM were licensed on liberal terms and diffused extensively)
- ➔ **Federal telecommunications policy**, particularly the introduction of competition in local markets, also affected the evolution of the Internet in the US (The 1984 Modified Final Judgment stipulated that the Regional Bell Operating Companies (RBOCs) could not offer long distance services until they established competitive local markets) => widespread diffusion.
- ➔ **State and federal regulation of telecommunications prices** aided the domestic diffusion of the Internet by lowering the price of Internet access (↔Other industrial economies have been slower to institute deregulatory and other structural changes in telecommunications)

- ➔ US **intellectual property rights** (IPR) policies also influenced the evolution of the Internet. Many of the key technical advances embodied in the Internet, such as TCP/IP and HTTP/HTML, were placed in the public domain from their inception.
- ➔ Even the expanded role of **US venture capital** in Internet and related investments during the 1980s and 1990s was affected by changes in federal policy. These regulatory changes helped US venture capitalists raise money from large institutional investors and grow their industry more quickly than European counterparts during the 1990s.

3.3. Internet commercialization and the changing US national innovation system

- ➔ Although antitrust and deregulatory telecommunications policies remained influential, defence R&D spending was overshadowed by private sector R&D investment by the 1990s. And one of the most important mechanisms for Internet commercialization was the US VC industry, which assumed a larger role in the commercial exploitation of the Internet than had been true during the formative years of other postwar US high-technology industries.
- ➔ The Internet explosion of the 1990s in the US relied on close university-industry links, an abundant supply of VC, an active antitrust policy, and a deregulatory posture in telecommunications. (Defence-related procurement, which played a prominent role during earlier stages of the Internet’s development, was not an important factor during the 1990s).
- ➔ Finally, the relatively open IPR regime that typified the development of Internet infrastructure during the 1970s and early 1980s shifted during the late 1980s and 1990s towards a 'pro-patent' posture.

4. Conclusion

Although it drew on important technical advances from foreign sources, the development of the Internet was primarily a US-based phenomenon. Moreover, the creation of the Internet drew on many of the same institutions and policies of the post-war US “national innovation system” that were influential in other post-war high-technology industries.
Nevertheless, the ultimate effects of early US leadership in commercial Internet applications are far from clear. In 2001, a slowing US economy and slumping equity market have been accompanied by declining investment in information technology and the Internet. The rapid growth of the Internet outside the US may allow other industrial economies to catch up in the development of commercial applications.

8. The Role of Entrepreneurial Universities within Innovation Systems: an Overview and Assessment

Abstract

The role of entrepreneurial universities within national innovation systems gains increasing interest. Special attention goes to the unintended side effects on the level of scientific activities and role of legislative framework conditions that might foster a more active role of universities in terms of technology development. Combining technological and scientific activity is not only feasible, but also desirable, especially for Europe within the current global, knowledge economy.

1. Introduction: the phenomenon of entrepreneurial universities

The **collaboration between science and industry** or **entrepreneurial universities** have been studied extensively over the last decades because of the acknowledgement of their fundamental role in stimulating technological performance, international competitiveness and economic growth. Science in general and knowledge generating institutions stimulate innovative capacity and consequently economical performance.

Innovation system concept[4] is the new guiding framework to understand innovation dynamics. In these models knowledge generation institutions such as universities, research labs, industrial research centers en government institutions are acknowledged, besides firms and enterprises as important players in innovation. Furthermore, the **interactions** among firms and these knowledge creation institutes is important!

Reasons why universities are relevant actors in within an innovation system:

1. They provide information and ideas for the basic development of a product, process or service.
2. Research institutions can work on certain research for a longer period of time
   - ➔ Therefore they a well placed to tackle **market failures** that arise in relation to basic research: private investors refrain from investing in **basic research** because of its uncertain outcome and its long time frame to bear fruits (often decades)
   - ➔ Therefore, in order to avoid loss of social welfare and **technological lock-in phenomena**, national innovation systems invest considerably in basic research performed at universities and public institutes.
3. In order to continuously stimulate economic growth, the **technology portfolio** of country should contain both **routine technological activities** (such as process and incremental development) and non-**routine technological activities** (such as new technology creation and radical developments). Universities play a significant part is this respect: They contribute to the **generation of new knowledge** and the continued

[4] See figure p. 63

diffusion of this knowledge among regional actors (= double dynamic of knowledge centers/universities)

➔ If a region fails to include this dual task of routine and non-routine research, there is a risk of regression and stagnation in the long run.

4. Finally, the non-routine activities lead to international knowledge exchange. Niosi and Bas (2001) showed that the presence of knowledge centers is a factor for companies choosing a location. Recent research confirms this relation: Explicit research focus coincides with a larger number of enterprising activities.

Contributing effectively to the innovative capacity of the innovation system, requires a willingness of universities to become more entrepreneurial. An **entrepreneurial universities** can be described as:

1. more intense commercialization of research results
2. patent and license activities
3. spin-off activities
4. collaboration projects with the industry
5. greater involvement in economic and social development

This is called the **second academic revolution**: education and research become complemented with service and valorisation activities aimed at transferring scientific knowledge to economical activity.

Factors that have contributed to this phenomenon of entrepreneurial enterprises:

➔ In the **US**: In the 40s, 50s and 60s, universities were involved successfully in space industry, defense and energy. Moreover, shifts in the federal financing policy and taxation charges for R&D expenditures have contributed to more entrepreneurship at US universities. In 80s policy priorities shifted to R&d activities that contribute to productivity and worldwide competitiveness of the American industry

➔ In the **EU**: Major factor was the fact that Europe's competitiveness in today's knowledge economy had to be increased and the transfer of knowledge had to improve. This led to the Lisbon targets which implied an increased role of universities in the European Research Area.

2. Entrepreneurial Universities: Concerns

Scientific and entrepreneurial activities at the level of the professor: complementary of contradictory?

Unintended side effects may occur concerning entrepreneurial universities:

1. Impact of university-industry cooperation on the **research agenda's of professors**: duties of teaching, research, time with students and service obligations to the university are affected by the involvement in company cooperation such as consulting activities state that they are continuously busy with research leading to conflicts of

commitment and interest. However, universities often have policies regarding these conflicts of interest issues.

2. **Conflicting publication incentives**. Whereas universities are in favour of direct publication to create an open discussion, companies want to delay any publication in order to protect their investments until a patent is arranged. Florida and Cohen (1999) referred to this phenomenon as the **secrecy problem** in research universities. Empirical research has shown that in many cases publications were delayed in order to allow sufficient time for the sponsoring company to file a patent application.
3. **Corporate manipulation bias**: university research should characterized by independence and should be curiosity driven only. Corporations interfere with the normal pursuit of science and seek to control relevant university research for their own ends. This invokes a **shift from basic to applied research** = **the skewing problem** on the research agenda

Several studies react to these arguments:

1. (to argument 3) Performing more applied research does not necessarily imply a trade-off with basic research: studies have shown that however the number of university-industry research centres almost doubled in the 1980s and university patenting sharply increased, the percentage of basic research remained quite stable.

- Contract research and scientific activities do not hamper each other: contract research coincided with increased publication outputs, without affecting the nature of the publication involved.

2. (to argument 2) Academic inventors systematically publish more than their colleagues who are not engaged in patenting activities: positive relationship between inventive activity (measured by involvement in patent activity) and scientific activity (measured by publication).

- Universities have found a way to reconcile both activities.

Role of Legislative Framework Conditions

The increase of entrepreneurial universities is partly associated with several policy measures. In the **US**, the Bayh-Dole Act (1980) and the Steverson-Wydler Act (1980) secured more **transparency** concerning the rights of ownership of intellectual property (IP rights) from publicly funded research. Whether performed by universities or companies, the involved institutions obtain in principle the right of ownership and this which resulted in a patenting increase. (f.e. strong performance of American universities in patenting activities nowadays).

Similar legislation might be a very interesting option for European countries in order to further stimulate innovation. This will reduce the incentive issues: if scientific inventors are not acknowledged as 'owners', incentives to engage in further development efforts are absent, resulting in technologies of embryonic nature that require additional investments to arrive at market applications. Empirical research has shown that a legislative framework has a significant and considerable impact on the amount of technological activity, a **net gain** in amount of technological activity

But who should acquire the IP rights: the inventor or the university?

If the **individual** inventors obtain the ownership, underinvestment might occur due to risk averseness. Often, no further investment is dedicated to the development of the product because of lack of financial capabilities of the inventor. Finally, there rise conflicts of commitment between the individual inventor and the university: inventors pursuing technological development and universities education and research.

If the principal, meaning the **university**, obtains the ownership, multiple academic missions are present, avoiding conflicts of secrecy and skewing. There is more transparency towards the industry and a reduction of the transaction costs. The majority of European countries recently changed their inventor's ownership policy towards the university's ownership regulation, resulting in higher levels of technological activity. Plessis et al. (2006) indicated that this impact of ownership concerning IP rights can be expressed as a net gain.

3. Conclusion

Reconciling scientific and technological activities is feasible (they are not contradictory) and more technological activity is being observed when installing university specific legislative patent framework conditions. More technological activity within universities is desirable in Europe.

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9. Perspectives on Innovation Processes - *Garud, Tuertscher & Van de Ven*

Abstract

This paper:

- covers the existing literature pertaining to innovation processes, the sequence of events that unfold as ideas emerge, are developed and are implemented within firms, across multi-play networks and within communities.
- explores the complexities associated with innovation processes that arrive because innovation processes are evolutionary, relational, inter-temporal and cultural.

1. A review of the literature on innovation processes

1980s: research on innovation focuses on identifying links between independent and the innovation dependent variable. This way they tried to find the antecedents and consequences of innovation and to establish causal links between them.

This paper adopts a **process perspective**. It wants to observe the sequence of events that unfold over time and then infer generative causality. Innovation is more than the **emergence of novel ideas**: ideas must be **developed**, manufacturing and supply chains must be put in place, marketing and servicing must established and **implementation** of the innovation must follow.

- 3 steps in the innovation process
    1. *Invention* (emergence of ideas): a long period of gestation precedes this emergence and when the novel ideas emerge the shock the system and set planning in motion
    2. *Development* (elaboration of the idea): this is not a straightforward step, it's characterized by a proliferation of paths and many **setbacks**.
    3. *Implementation* (widespread acceptance of the innovation): more than simple diffusion! It's more integrating the innovation with what already exists.
- Innovation processes do not unfold in orderly steps, they are characterized by repeated cycles of divergent and convergent phases.

Punctuated equilibrium model of change (Tushman):

1. Era of **ferment**: products and services with different functionalities vie for market dominance.
2. Emergence of a **dominant design**.
3. Era of **incremental** change

This model is consistent with the **evolutionary perspective** on innovation which builds on variation (emergence of novelty), selection (weeding out of those that are unfit) and retention (the elaboration of those that remain).

Besides the evolutionary perspective, there is the Science and Technology Studies (Freeman) and the **Social Construction of Technological Systems** (Bijker) that consider the social contexts that determine the dimensions of innovation. Both have in common that they draw attention to the difficulties associated with the development and implementation of novel ideas.

The literature can also be organized by the different levels at which these innovation processes unfold:

1. **Firms**
2. **Multi-play networks**: constellations of firms that interact with one another to invent, develop and implement innovations
3. **Communities**: public and private actors who have diverse interests and roles in creating an infrastructure for the innovation.

Invention

Mechanisms underlying invention

- **Demand-pull**: 'necessity is the mother of invention', people invent to solve an existing problem
- **Technology-push**: 'invention is the mother of necessity'
- Mowery and Rosenberg have shown that **both** demand and supply factors are crucial.

The major mechanism underlying invention is **recombination of ideas** and artifacts across different domains of knowledge and practice.

Invention within firms

- Firms are vibrant forums for the flow ideas and are repositories of knowledge. This sets the stage for the invention of new ideas through recombination of ideas in different domains.
- Problems: **Complexity** (large firms) and **Hierarchy** dampen the emergence of novelty. Ideas become locked in their departments and some ideas are just stamped out by management who are unable to fully appreciate the value of these new ideas.
- Solutions:
    1. Foster a **culture of play** and creativity (f.e. 15% of time must be dedicated to free exploration)
    2. **Rotation** of people
    3. **Skunk works**: groups of employees that are separated from the organizational structure so that they can escape innovation killers. The goal is to **separate exploration efforts from exploitation**. Tushman and O'Reilly call this the **ambidextrous organization**.

Invention across multi-party networks

- Networks are important because they generate a flow of knowledge

- **Absorptive capacity** is important: a firm's ability to absorb domain-specific knowledge from the network based on its prior knowledge.
- Problems that hamper recombination of knowledge:
    1. To the extent that firms within a network lack this capacity, the **recombination** of knowledge is hampered.
    2. Intellectual property protection: the protection of ideas by firms hampers the flow of ideas across the network.
- Solutions to IP protection:
    1. Contractual relationships to share, transfer and license intellectual property
    2. Establish trust
    3. Even if firms try to protect their intellectual property, knowledge will eventually leak out anyway.
- Competitive learning races: the **relative absorptive capacity** of firms makes that some learn faster that others and eventually gain competitive advantage.
- **Location** in the network is important. Central positioned firms are better positioned to identify and exploit opportunities.

Invention within communities

- **Pooling of resources** across multiple parties within a community is an approach being used to address complex problems. These communities are often the venues for ideas for which a market not yet emerged.
- The users of the community are the contributors.
- Problem: **Tragedy of the commons**: individual members are not incented to contribute to the collective knowledge of the community.
- Solutions:
    1. Offer privileges of being a community member and institute incentives to contribute to the collective by sharing ideas
    2. Commit norms for the sharing of ideas
- Sometimes solutions are not even necessary: f.e. a user benefits from sharing his idea because his idea gets evaluated by the community. Or f.e. he gains respect for his ideas, etc.

Development

Mechanisms underlying development

- Development is challenging, it takes time and effort for an idea to develop before it can offer value.
- All novel ideas must be critically revised.
- At some stage, proof of concept must be demonstrated (f.e. prototypes)
- The initial idea must snowball into a collection of assets, resources, capabilities which make it possible for the innovation to be manufactured, serviced and sustained.
- Feedback by different social groups is important.
- There are often false-starts and dead-ends.

Development within firms

- Firms are fertile ground for the development of novel ideas, as they are rich with resources and capital.
- Management selects and nurtures initiatives that emerge from all around the firm.
- Traps arise when management is unable to recognize the need for change: this way the core competencies of a company become core rigidities.
- **Projects** are a way to overcome the traps. Projects are forums for action and interaction among a diverse set of organizational actors to facilitate the emergence, formation and transformation of beliefs, routines and practices.
- Different projects, however, compete for top management attention to gain corporate resources.

Development across multi-party networks

- No firm has all the assets required to develop an innovation, but assets lie distributed across a multi-party network of firms.
- **Technological platforms**: 'an evolving system made of interdependent pieces that each can be innovated upon'.
    - Platforms are especially important in industries where the value of an innovation depends on the complementary assets that a network partner offers (f.e. value of new innovation in computer depends complementary products: on the internet connections of clients, the processors that make it able to run the new innovation on a computer, etc.)
    - One must architect its platforms in such a way that actors offering complementary products can join.
    - = **Open innovation**: firms can build upon the strength of others, establish an industry-wide standard, create a bandwagon.
    - Continuous war among firms for dominance on the platform.

Development within communities

- Innovation requires a **macro infrastructure**:
    1. Private entrepreneurial firms: R&D, manufacturing, marketing, distribution, ...
    2. Collective resources: intellectual, financial and technological endowments
    3. Institutional standards and legitimacy
    4. Educated consumers
- The creation of this infrastructure is beyond the reach of any individual firm. It requires involvement of many public- and private-sector organizations such as universities and financial institutions.
- An innovation thus requires support of all this constituents. The paradox here is that the radical innovation requires support of the very constituents it disrupts.
- The first-mover must set the scene. It needs to expend considerable resources to create of transform this macro structure.

- Benefits of being a first mover might therefore be overstated: the first mover sets the scene for fast followers to reap the benefits.

Implementation

Mechanism underlying implementation

1. Invention is just the beginning, it just represents a hopeful debutant. Many additional steps must unfold before innovations take root.

➔ f.e. electrical cars: have been invented for many years, but implementation not complete yet.

2. **Diffusion** is the key mechanism driving implementation. 3 steps:
    1. Critical mass has not yet emerged for social movement to take hold
    2. Once a social movement begins, widespread adoption of the innovation occurs
    3. Saturation of the market
3. Diffusion involves reinvention: adopters modify an innovation to fit local circumstances.
4. **Generative imitation**: linking and integrating the new with the old. Completely substituting the old is often not practical of possible. People are reluctant to replace the old because of the commitments they have made to it. Implementation proceeds more smoothly when new integrating the new with the existing arrangements.

Implementation within firms

- Once dominant design has emerged, firms shift their attention to making non-trivial and more certain investments. Abernathy and Utterback call this the **specific phase** and Tushman calls this the **era of incremental change**.
- Design is rationalized so that it can be mass-produced
- Parts, that come from the overall technological **platform** of the network, are **standardized**

Implementation across multi-play networks

- Even if an innovation offers benefits, implementation across a multi-play network with actors who are cooperating and competing is difficult.
- **Breakthrough innovation disrupts the constituencies in the industry.**
- Innovations will encounter resistance from the network partners.
- Over time network partners adopt their technologies to the new innovation. The new innovation has emerged in and through adoption!
- **Trials of strength** on the technological **platform**: firms try to convince industry members of adopting their innovations and adapting products to their technologies.
- In the end, institutionalization of innovation in the multi-party network: allocation of responsibilities and rights.

Implementation within communities

Industry standards for implementation in the industry. Also user and regulators have implement the new innovation after they have evaluated it.

Summary

		Levels		
	Mechanism	**Firms**	**MP networks**	**Communities**
Invention	Recombination	Creativity	Knowledge networks	Inverse commons
Development	Transformation	Internal venturing	Platform leadership	Industry infrastructure
Implementation	Institutionalization	Adoption	Diffusion	Stabilization

2. Complexities Associated with Innovation Processes

Innovation and Complexities

Evolutionary Complexity

Punctuated equilibrium model (Tushman) and the evolutionary approach: selection pressures will result in a dominant model. This process/evolution is determined by chance and by the sequence of certain events. Once locked in, once the dominant model has been chosen, the system can escape only when it encounters exogenous shocks.

Relational complexity

Innovation process occurred only through ongoing interactions between the innovators, the technology, users, networks, etc. Social elements play a role.

Temporal complexity

Innovation processes are characterized by multiple temporal rhythms and events. Momentum plays a role. One can encounter unanticipated roadblocks requiring changes in plans. What is considered a bad idea in one point in time can easily turn out to be valuable at a later point. F.e. due to a lack of complementary assets in the network/platform an innovation might not be valuable. When these complementary assets appear later, the idea might become valuable.

Cultural Complexity

Different cultural contexts have their own practices, values and discourses that drive innovation. What is useful and novel is culturally defined. Cultural contexts harness different kinds of innovation processes and generate different kinds of outcomes.

Innovations are never diffused unaltered across cultures. For different groups, the innovation must be reinvented and redesigned.

10. Creating Project Plans to Focus Product Development - *Wheelwright & Clark*

1. Introduction

Long-term competitiveness depends on the success of **new product development**. Few development projects, however, fully deliver on their promises. Furthermore, some projects are never completed and some projects in the pipeline do no longer reflect the needs of the market. This can be due to poor leadership, absence of essential skill but most of all due to the lack of an **Aggregate Project Plan**.

Aggregate Project Plan:

- Goal is to manage the **set** of projects: no single projects defines the company's future, the set of projects does.
- It focuses on how resources are allocated between projects.
- Plans how set of projects should change over time: which projects should be added?
- Steps in creating an APP:
    1. **Mapping** of projects: categorize projects based on the amount of resources they consume on how they will contribute to the company's product line.
    2. See where gaps exist in the development strategy.
    3. Sequence projects carefully.
- The plan enables management to create a set of projects that is **consistent with** the company's development strategy and **business strategy**, rather than just selecting projects from a long list.
- It's not appropriate to give one department (f.e. engineering, marketing) the sole responsibility because a department is usually not in a position to determine every project's strategic worth.

2. How to Map Projects

Define and map the projects on two dimensions[5]:

1. Degree of change in the product
2. Degree of change in the manufacturing process

We can divide projects into 5 types, first 3 are **commercial development projects**, the other are **R&D** and **alliances projects**.

1. Derivative projects:
    - ➔ Cost-reducing projects, add-ons or enhancements of existing products and processes
    - ➔ 3 categories:

[5] See figure p.74

i. Incremental product changes (new package, new feature, ...) but no process changes
ii. Incremental process changes (lower cost manufacturing process, less materials used, improved reliability of process, ...)and no product changes
iii. Incremental product and process changes

➔ Require fewer development resources
➔ Are completed faster

2. Breakthrough projects
   ➔ Significant changes to existing products or processes
   ➔ Breakthrough products often automatically require new manufacturing processes
   ➔ New core products or processes that differ from previous ones
   ➔ Require a lot of development resources
3. Platform projects
   ➔ In the middle of two previous projects
   ➔ More product and process change than derivatives but do not introduce untried and fundamentally new technologies like breakthroughs.
   ➔ f.e. New iPhone version: is not fundamentally different from previous iPhone version but requires more change than just cost-reducing derivative projects
   ➔ **Fundamental incremental improvements**
   ➔ Provide smooth migration between several breakthrough projects
   ➔ They offer considerable competitive advantage but companies systematically underinvest in them, because managers lack the awareness of their strategic value
4. R&D projects
   ➔ creation of know-how of new-materials and technologies
   ➔ precursor of commercial development projects
   ➔ compete with commercial development projects for resources
   ➔ Greater risk
   ➔ Relationship between R&D and commercial development projects is necessary
5. Alliances & partner projects
   ➔ Like R&D outside the commercial development map
   ➔ Amount of resources varies
   ➔ Many companies fail to include them in their Aggregate Project Plan.
   ➔ Even when partner takes full responsibility for a project, the company must devote in-house resources to adopt the technology (=**adsorptive capacity**)

Each of the types requires a unique combination of development resources and management attention. All 5 are vital for creating a development organization that is responsive to the market, so all five must be adopted in the set of projects/ project mix (but not too many breakthrough projects at the same time, more platform projects is better)

Mapping of projects and the allocation of resources and rethinking the mix of projects, however, is not easy! It takes a lot of time and involves conceptualization of the product lines and processes, close management and customer involvement.

3. Focus on platforms

- **The more mature the industry, the more important it is to focus on platforms.**
- Typical industry life-cycle:
  1. Early stages: growth, innovative and dynamic companies that gain market position.
     - ➔ **Breakthrough-platform strategy**
  2. Industry develops and opportunities for breakthroughs decrease.
     - ➔ Making incremental improvements, **derivative-based strategy**
     - ➔ The key lies in developing a few well-designed platform products, on each of which a generation of products can be built
- **Exception**: for companies that must react on constant changes in fashion and consumer tastes, a different relationship between platform and derivative projects exists:
  - ➔ **High-variety strategy**: a broad range of extensions that offer something tailored to every niche (f.e. Sony Walkman had 200 different model based on just three platforms)
- **No one ideal mix:** every companies must pursue the projects that match its opportunities (depends on industry life-cycle), business strategy and available resources. The mix changes over time as well .

4. Steady Stream Sequencing

- Periodically evaluating the product mix keeps the development activities on the right track.
- **Sequencing = planning the time line of the projects**.[6]
- To smooth transition from one platform or breakthrough to another, a company can release different derivatives first.
- **Example of steady stream sequencing strategy**: Releasing a platform *every year*, and in between you release derivatives. When a team finishes work on a platform it can be assigned to another project or go work on the derivative.
- The mode of planning/sequencing to be used depends on industry and the time in the industry life-cycle.

5. An alternative: Secondary Wave Planning

The strategy works like this:

1. Development team begins to work on a next-generation platform
2. The company completes the project and the people start to work on another platform.

[6] See figure p. 79

3. As the introduced platform starts to age and is challenged by competitors, the company refocuses development resources on a set of **derivatives in order to strengthen and extend the platform's life**.
4. This gives the company feedback for the next generation platform. Key people bring this information together and use is to launch a new platform product.
5. The cycle begins again.

Sometimes in some industries however, companies**, by speeding their rate at which they introduced new platforms, increased their market share**.

6. Long-term Goal: Building critical capabilities

Possibly greatest value of the APP is its **ability to shape and build development capabilities**, both individual and organizational. F.e. it gives insight in which people to assign on what projects. Experienced employee better assigned to lead platform and breakthrough projects than inexperienced one. An less experienced engineer can learn and develop capabilities on derivative projects. The APP can also make gaps in people skills visible. F.e. more experienced people necessary to fulfill the projects and to be able to meet the business strategy.

11. New Problems, New Solutions: Making Portfolio management more efficient - *Cooper, Edgett & Kleinschmidt*

Portfolio management is about resource allocation, selection of development projects and about aligning these project with the business strategy. It has gained prominence for a number of reasons:

1. Maximizing return on R&D an technology spending
2. Staying competitive
3. Properly allocate resources
4. Forging a link between project selection and business strategy
5. Stronger focus
6. Communicate project priorities within the organization
7. Providing greater objectivity in project selection

However, in **previous studies**, managers have rated the **effectiveness of portfolio management** and the results are provocative:

- Portfolio management **succeeds** in:
    1. aligning R&D spending with business' strategy
    2. Selecting high value projects
- Portfolio management **fails** in:
    1. Making sure to have the right number of projects
    2. Promoting timely completion of projects
    3. Making sure to have the right balance of projects (balance between derivatives, platforms and breakthroughs)

<u>**4 Main challenges of Portfolio Management**</u>:

1. **Resource Balancing**: demand usually exceeds the supply of resources
    - Too many projects and not enough resources
    - Go decisions are made, but resource implications are often not factored in the NPV analysis
    - Consequences:
        1. Time to market of projects starts to suffer
        2. People are spread thinly across projects: they have to save time and quality starts to suffer.
        3. People are spread thinly across projects: increased stress and moral suffers
        4. Higher failure rates of projects.
2. **Prioritizing** projects against one another: difficulty discriminating, all projects look good.
    - Project selection tools (like NPV) only imply a minimum acceptable value.

- Firms forget to **rank** all positive NPV project and only take the best ones.
- Instead all positive NPV projects get a Go.

3. **Making Go/Kill decisions** in the absence of solid information
   - Early investigation and gathering information is costly but it pays off
   - Able to select only the winning project and remove the bad dogs.
   - The quality of this early work is an excellent foundation for subsequent activities.
   - Result: higher success rates
4. **Too many minor projects** in the portfolio: absence of major revenue generators (breakthroughs)
   - **Reasons** for this problem:
     1. preoccupation with short-term financial results: fast projects over long-term projects
     2. Lack of discipline: urgent things always take precedence over important things.
     3. Difficulty of predicting the long-term. Easier to assess short-term projects
     4. Difficulty of finding major revenue generators because of maturing market.

➔ These 4 challenges are highly interlinked (f.e. inability to discriminate leads to difficulties in resource balancing, ...)

Improving Quality of information generated in projects

Stage-Gate processes[7]: New product/process developments have different stages (from invention to preliminary investigation to development to testing and validation to product launch). All stages in the model define the best practices at that stage. All stages are preceded by a gate. The gates defines visible and concrete criteria for Go/Kill decisions. When a product/process does not meet the criteria it has to go through the previous stage again (or it is killed).

Introduce Resource Capacity Analysis

Analysis of the projects' **demand for resources versus the availability of resources**. For each project in place, the firm must note the number of person-days of work and which group/department will do the work. If there is extra resource capacity left, the firm can look if the resource demand of the new project does not exceed this available supply.

Develop a PITS for your Business

Product Innovation and Technology Strategy (PITS) is used to improve the balance of projects in the portfolio. It must ensure a reasonable balance between short-term, quick, small, incremental projects and long-term breakthrough projects.

[7] See Figure p. 25

The PITS should:

1. Define the goals for your new product and development effort. F.e. what percentage of business sales will come from new products?
2. Define areas for focus: key markets, technologies, etc.
3. Define deployment of resources across projects
4. Define attack plan: **Innovator/First Mover vs. Fast follower**

Integrating Portfolio Management

Stage-gate processes allow to kill poor projects and improve information about projects but they are only a partial solution. They only focus on individual projects. By contrast, **portfolio management** considers all projects together.

3 goals of portfolio management and their **different tools**:

1. **Value Maximization**: to allocate resources so as to maximize the value of the portfolio
   - ➔ Tools: NPV, Option Pricing theory, Check lists (Yes/No questions to rate the projects), Scoring models (rate project on a number of questions and scales, this leads to a Project Attractiveness Score which must clear a minimum value)
   - ➔ Projects are ranked according to their value resulting from the different tools.
2. **Balance**: achieve balance of projects in terms of long-term/short-term projects, across various markets and product types.
   - ➔ Tools: Visual graphs, Bubble diagrams[8], Pie charts
3. **Strategic Decision**: ensure that portfolio reflects business strategy
   - ➔ Strategic Buckets approach: management pre-allocates funds to various buckets (f.e. platform projects, new products and minor projects), projects are categorized by bucket and then rank-ordered within a bucket.

How are these **portfolio tools used in conjunction with a Stage-Gating Process**?

2 Approaches:

1. **The Gates Dominate[9]:** 'When the Stage-Gate process is working well, the portfolio will take care of itself'
   1) Projects are scored individually following the Stage-Gate procedure.
   2) However, to introduce portfolio management, gates become two-part decisions
      - First: Pass-versus-Kill decision (based on financial, checklists and scoring model valuations)

[8] See Figure p.24
[9] See figure p.29

- Second: Prioritization against other projects. All projects are ranked but the ones that received a go but are low in the ranking and there are not enough resources for the anymore are placed on hold.

3) To make sure portfolio of projects is still ok, management meets twice a year. But normally, good procedures at the gates will make sure portfolio is ok too.

2. **Portfolio Review Dominates:** 'Every project must compete against the others'. A single decision on all projects replaces one of the gates in the gating process.

    1) Go/Kill and prioritization decisions at the Portfolio Reviews where all projects are considered together.
    2) This review occurs 2-4 times a year
    3) The Stage-Gate serves merely as checks on projects, ensuring that projects remain financially sound and are proceeding on schedule
    4) Method:
        - The project enters the portfolio typically after the first stage (at Gate 2, after the invention, and the initial screen and investigation) when data are available.
        - A combined Gate 2 and Portfolio meeting takes place: all new Gate two projects together with all projects past Gate are reviewed and prioritized against one another. All active projects can be killed or reprioritized according to confidence in the project team, revenues, match with strategic plan, profitability, availability of resources, ...
        - The gates after Gate 2 are merely checkpoints or review points for the individual projects, the kill/prioritization decisions are taken at the portfolio meetings
    5) Advantage:
        - Easier to prioritize when looking at all projects, rather than one at a time in Gates Dominate approach.
    6) Disadvantage:
        - Requires time commitment from management for extra portfolio meetings
        - Gates reviews are more in depth than ever is possible when all projects are considered together.

12. Intellectual Property Policies and Strategies

I. ADVANTAGES AND DISADVANTAGES OF PATENTING

1. Advantages of patenting

External advantages

a) For protection

1. Protecting proprietary product technology
2. Protecting proprietary process technology
3. Creating **retaliatory power** against competitors: an Arms Race
   - ➔ Each process or product linked to several patents, each patent linked to several processes or products
   - ➔ Companies interdependent on each other's patent portfolio.
   - ➔ **Second-order deterrence** may occur: a result of an imitator or potential infringer holding patent rights relevant to some business area critical to the innovator or original patent right holder.
   - ➔ Thus, retaliatory power through a broad patent portfolio held by a competitor (innovator) may weaken the protective advantage of single patents held by an innovator (competitor).
   - ➔ At the same time, however, the vulnerability of companies to infringement accusations increases with their diversity of businesses and technology.

b) For bargaining

4. Giving better possibilities of selling **licenses**: Companies become more and more dependent upon each other. This makes patents into bargaining chips through licensing. Companies have increasingly taken out patents outside their immediate product areas and used them for licensing business. Due to more exploratory R&D, more active patenting and more technology intelligence, opportunities for more "stand-alone" licensing businesses has increased.
5. Giving better possibilities of accessing technology through **cross-licensing**
6. Facilitating **R&D cooperation** with others: another type of bargaining situation in which patents are advantageous, both for identifying, attracting, negotiating with R&D partners.
7. Giving a better bargaining position in **standard-setting** (making sure that your product becomes that standard on the platform). More and more standard-settings involves patents, but far from all patents involve standard-setting.

c) For image

8. Improving the **corporate image**: public image of the company as being technologically progressive; attracting graduate engineering students

Internal advantages (not of major importance relative to other advantages)

9. Providing motivation for employees to invent
10. Providing a measure of R&D productivity

2. Disadvantages of patenting

The disadvantages are ranked significantly lower than any of the advantages, although there are differences across industries.

1. Disclosing of technical information: (less of a disadvantage than direct costs but difference is not significant)
2. Incurring direct costs of patenting

3. Defensive and offensive patenting

Other ways to formulate and classify advantages of patents. It could be said that the most important motive behind patenting is to block competitors in both senses (defensive and offensive).

➔ To block competitors from using a technology and in so doing increase their cost and time for imitation and/or inventing around the patent, in order to increase their willingness to pay for a license or to stay away from the market = **offensive patenting** = using patents as a competitive weapon

➔ To block competitors from blocking oneself, and thereby ensure 'design freedom' = **defensive patenting**.

II. IP POLICIES

Policy is a set of statements to be used as a general guideline for operations in an area. A policy simplifies decision-making and action taken by narrowing down options and focusing attention and efforts in the organization. Such a policy is typically long-lived and not specified in terms of time. A policy pertains to a certain area of operations. With many interdependent policy areas, a need for policy coordination arises. Policies also evolve over time in stages corresponding to the increasing importance and attention attached to IPRs in companies (see table).

Stage	Characteristics of IP policies
1	Ip ignored
2	rewards for patents
	intellectual property issues left to legal department
3	selective patenting based on evaluation of pros and cons
	licensing in if needed and licensing out if requested
	trade secrets defended in court
	review of patent positions
4	intellectual property opportunities are part of business strategy,
	project selection and project management critereria
	In-licensing to maintian focus, speed, external point of

	comparison and learning opportunities technical staff rotate through intellectual property department out-licensing based on businesses and technical assessments comprehensive trade secret policies

As IP policies become increasingly elaborated in companies, more policy issues come to the forefront: demand for policies exceeds the supply from policy-makers. Useful to have a 'living policy': there is always one set of policy issues pending, awaiting a policy decision, and another set of policies already in place. There are many policy areas and policy issues pertaining to patenting and IP (such as coordination of patenting across business divisions, coordination of patenting with R&D department, licensing policies, infringement policies, how to file patent applications, …)

Many Western companies fail to reach a stage with clearly formulated IP Policies. The book gives an example of a clearly formulated policy[10].

III. PATENT STRATEGIES

1. Patent strategies in general

Where, why and how to patent? Different strategies will be discussed at the level of the patent portfolio (one could also consider strategies for patents individually)

Patenting in technology space

In order to illustrate various patent strategies it is useful to think of a general technology space in terms of a technological terrain or technology landscape, which is explored by R&D processes. Parts of this terrain with similar R&D difficulties in terms of costs could be delineated by R&D isocost curves. Various maps of this landscape can be constructed, improved when R&D proceeds. A patent could be represented by a circle enclosing the technical solutions in the claims of the patent. Size of the circle indicates scope of the patent. With this type of map a number of patent strategies can be illustrated[11]. The actual strategies have also to take in account actual qualities of the individual patents as well as the company situation in general.

1. **Ad hoc blocking and 'inventing around'**: one or a few patents are used to protect an innovation in a special application. The possibilities to invent around are many, R&D costs and time for inventing around are low.
2. **Strategic patent searching**: strategic patent is a patent with a **large blocking power**. Strategic patents have high invent-around costs and are therefore necessary for doing business within a specific product area.
3. **'Blanketing' and 'flooding'**: area becomes a **minefield** of patents. Used as a strategy in emerging technologies when uncertainty is high regarding R&D directions or in situations with uncertainty about the economic importance of the scope of a patent.

[10] See p.217

[11] See p. 220

Blanketing and flooding take out patents on minor inventions from a technical point of view. Minor patents may be useful in building bargaining power of a patent portfolio and to slow down competitors.

4. **Fencing**: a series of patents (ordered) block certain lines or directions of R&D.
5. **Surrounding**: an important central patent can be surrounded by other patents. These patents are individually less important, but collectively block the use of the central patent, even after its expiration. For competitors surrounding patents (for different application of the basic invention) can be used to access the surrounded technology.
6. **Combination into patent networks**: building a patent portfolio in which patents of various kinds are used to strengthen overall protection and bargaining power.

Patenting over time

Two principal types of diagrams can be used: one showing the development over time (in the PLC, product life cycle) of some economic variable (FCF's f.e.) and one showing some technology-related variable (Performance f.e.). Illustration of economic variable diagram with cash-flow as variable[12]: 2 alternative patent strategies can used:

1. **Sporadic patenting**: a few patents at key steps in the R&D process.
2. **Continuous or follow-up patenting**: build-up of a patent portfolio, patents are applied for more or less continuously in the R&D process. More costly and discloses more information, but a broader and more long-lasting protection. (~kaizen or continuous improvement)

The book also gives an example of patenting over time with **2 competing product generation**s where 2 or 3 companies are illustrated on the same graph[13].

When and how to enter the new technology and when and how to exit the old technology are thus crucial timing decisions for technological management. It is easy to fall behind because of a failure to build up patents positions in the new emerging technology. There is never a single race for patens on 1 technology, there are several competing products and technologies for which there is a separate **patent race**. R&D investment strategies: patenting strategies are linked to R&D strategies of the competing companies. Patenting is a reflection of R&D strategies (to some extent), **patent information is useful to outsiders in tracking down these R&D strategies**. Patent flooding can however disguise the R&D strategy of a firm

2. Patent strategies in Japan

Several of the patenting behaviors and strategies described above were found in the Japanese corporations.

Evolution of strategy

Japanese companies have emphasized the **quantity** of patents, although well aware that the technological and economic importance of individual patents differs widely. The strategy of

[12] See p.222
[13] See p.224

extensive patenting of minor improvements in Japanese companies evolved in connection with the catch-up process in the post-war era. There was an urge to improve technology of others and to invent around the patents. A patent was perceived as a sign of world technical leadership. Historical conditions, a long process of catching up and competing with the West and a strong domestic competition at the same time give a rise to different patenting behaviors (flooding, blanketing, fencing). The IP management capabilities that Japanese industry built up during its catch-up phase also paid off in the subsequent phase of industrial development, giving Japan a competitive advantage over Western companies.

Strategic Patents

The importance of achieving a **high quality** of patents has increased in recent years in Japan. This is due to **(1)** Japan reaching and advancing technological frontiers in 80s **(2)** lawsuits from the USA **(3)** the increased direct cost of patenting **(4)** the adoption of a multiclaim system in Japan. This way Japan focused on obtaining '**strategic patents**' (= a patent decisive important for someone wanting to commercialize a technology in a product area). Such patents can be acquired through one's own R&D or through external acquisition (licensing in). Early 90s: open licensing policy; mid 90s: open licensing policy modified to a more selective licensing. The search for strategic patents in a new technology creates a race among companies. There is also a second race for the surrounding patents in order to fence the strategic patent. The outcome of this second race determines the distribution of bargaining power among the competitors. An old patent may become one of the surrounding patents to a strategic patent over time. Surrounding patents can be used by competitors when bargaining about the original strategic patent, because in some cases a strategic patent cannot be used when infringing a surrounding one. So the strategic patent holder is compelled to search for surrounding patents. However, there is a belief that a single good patent is sufficient to protect a new business. Firms may also lack resources and management concerning patenting. Circumstances like these result in ignoring follow-up patenting and failure to build up patent portfolios over time.

3. General response strategies when confronting a blocking or strategic patent

Patent clearance procedure: When planning a new products, one must do a relevant patent search in which it evaluates the existing patents. One should ask himself if his new product is an infringement against these existing patents. Yes, then R&D/manufacturing can be stopped on time.

4. Litigation strategies

= **Detection of infringement against own patents**. Infringement monitoring can be very difficult in a large international cooperation (ex. Typical patent enforcement procedure for Toshiba[14]). Infringement monitoring costs must not exceed expected benefits from patent enforcement. If infringement occurs, various strategies for legal enforcement of patent rights can be employed. One can first send warning letters, come to an agreement of if that does not work out, file a lawsuit.

[14] See p.235

5. *Summary of Technology and Patent Strategies*[15]

IV. SECRECY STRATEGIES

1. *General Secrecy Strategies*

Company's technology can temporarily be protected by secrecy rather than by patents. Secrecy protection is effective, but very much up to the company itself (weak legal protection).There exist technology scanning strategies and secrecy strategies:

SECRECY MEASURES	TECHNOLOGY SCANNING ACTIVITIES
Control of publishing by researchers & employees	Licensing the technology
Controlled access to facilities	Learning details provided by patent disclosures
Monitoring of visitors and temporary employees	Learning details through publications, ope meetings
Avoidance of patenting	Details through informal conversations
Implementation of internal secrecy policy	Hiring R&D employees with experience fro comp
Efforts to prevent competitors hiring over key R&D pers.	Acquiring the product and reverse-engineering it
Fragmentation of tech info among manangers & empl	Espionage
Counterintelligence	

Secrecy barriers are often erected by individuals or small groups for personal reasons such as fame, prestige, power and rewards. This counteract the purpose to stimulate innovativeness. Finally the total costs and benefits of an extensive secrecy or information security system have to be considered.

2. *Secrecy and prophylaxis as alternatives to patents*

- Common to file a **patent application** as early as possible in the R&D process and to built up patent power. This is certainly important in fast moving areas
- Counterargument: "technology moves so fast that it renders patents useless".
- Only **rarely** did a company resort to secrecy as an alternative to patent protection. Cases were secrecy policy was considered are:
    1. Having a substantial **technological lead** and long time for competitors to catch up
    2. Competitor's cost and time for overcoming the **secrecy barrier** are substantial
    3. **Infringement monitoring is difficult**
    4. Possibilities to **invent around** are numerous and cheap, while costly to block efficiently with patents.

[15] See p. 236

- Sometimes, but fairly seldom, **prophylactic publishing** is used in Japan, whereby technical information is disclosed to prevent competitors from fulfilling the novelty requirement for obtaining patent rights.

V. TRADEMARK STRATEGIES

1. Trademarks in general

- Trademarks have increased in general importance because trademark protection can be perpetuated **permanently** and thereby accumulates value if managed properly through advertising and so on. There are 4 general approaches to **valuation of trademarks**:
    1. Cost-based (f.e. accumulation of advertising costs),
    2. Income-based (f.e. costs of recruiting graduates)
    3. Based on market valuations (f.e. comparison with other trademarks)
    4. Indirect valuation methods (f.e. based on indices that are assumed to be correlated with trademark value such as brand awareness and loyalty)
- Trademark values are **vulnerable to bad publicity and customer dissatisfaction**, but they are resilient in the long run once they have gained strength.
- A special threat is **dilution**: this happens when a trademark becomes so successful that it is **incorporated into everyday language** and loses the distinctiveness that is required for legal protection.
- Trademarks offer **economies of scale** (expanding sales in an area for which trademark protection already exists), of **scope** (one trademark is combined with others, **co-branding**) and **speed** (well-reputed trademark speeds up the market penetration for a new product).
- One can note **similarities between trademark and patent strategies:**
    1. A trademark gives a broad coverage or scope (just like a patent)
    2. Trademarks and patents can be made strategic so that they are unavoidable to customers and to the public. But be aware of **overadvertising**: customers start to react negatively to being bombarded with messages.
    3. Certain areas are crowded with trademarks → flooding or blanketing attractive areas
    4. Surrounding one's strategic patent with own patents is similar to having a corporate brand (Sony) and being surrounded by business brands (Walkman, Discman, Handycam)

2. Trademark strategies in Japan

Some types of branding behaviour or strategies found in Japan:

1. General upgrading in the building of trademarks
2. Long-term upgrading of the national image (vs. earlier downplaying with 'made in Japan)

3. Conscious building of corporate image and business image (**joint CI/BI**). F.e. Toyota-Corolla together not just Toyota and Corolla separately. or Sony Walkman
4. Strategic branding (customers cannot avoid being exposed to them)
5. Mixing Original Equipment Manufacturing (OEM) with branded sales (OEM occurs when a new unknown company lets a well-known company market its products)
6. Use of technology for prestige
7. Combining patents, trademarks, designs, copyrights and so into '**multiprotection**'

VI. MULTIPROTECTION AND TOTAL IP STRATEGIES

There are many types of intellectual property or assets in a company and many ways to create these assets jointly with a particular business. Therefore it is important to create multiprotection systems and total IP strategies. Nevertheless patent matters dominate when dealing with IP. Easy to place too much emphasis on patent and too little on trademarks, trade secrets, copyrights and designs and to neglect complementarities among different IP elements. → How much more comprehensively should IP matters be treated?

Selecting and securing property rights for various elements constituting a business is **not enough** for multiprotection. The rights **have to be enforced** and infringers have to be deterred.

A business can be broken down into various constituent elements and product technologies that could be covered by various IPR, resulting in a multiprotection system for the business[16]. Different IP types sometimes substitute for each other at the business component level (for a particular invention patent and secrecy protection can be substitutes). The different IP types can also be used to complement or reinforce on another. The different business elements form a business system in a product area. At the level of a business system the various IPRs should be complementary, forming effective multiprotection. For multibusiness corporation there is a need to coordinate IP protection across businesses.

[16] For an example see p. 249

13. Disruptive technologies, Catching the Wave - *Joseph L. Bower & Clayton M. Christensen (1995)*

Question : Why is it that established companies invest in the technologies necessary to retain their current customers but fail to make the technological investments that customers of the future will demand?

- ➔ Firms succumb to one of the most popular management dogmas: **they stay close to their customers**.

Customers wield extraordinary power in directing a company's investments. Before managers decide to launch a technology, develop a product, build a plant or establish new channels of distribution, they first listen to their customers. *Do their customers want it? How big will the market be? Will the investments be profitable?* The more intensely managers ask and answer these questions, the more completely their investments will be aligned with the needs of their customers.

Most leading, well-managed companies are consistently **ahead** of their industries in developing and commercializing new technologies (incremental improvements & radical innovations) **as longs as those technologies address the next-generation performance needs of their customers** but have rarely a front position in commercializing new technologies that initially don't meet the needs of their current customers. Companies gave the product performance they are looking for but, in the end, they are hurt by the technologies their customers led them to ignore.

The processes and incentives (forecast technological trends, assess profitability, allocate resources across competing proposals for investment, take new products to the market) that companies use to keep focused on their main customers work so well that they blind these companies to important new technologies in emerging markets.

The technological changes that damage established companies are usually not radically new or different from technological point of view but they have 2 characteristics:

1. They have a different package of performance attributes that are not valued by existing customers.
2. The performance attributes that existing customers do value improve so rapidly that the new technology can later invade those established markets. Only at this point, mainstream customers want the technology. But by then it is often too late for the established suppliers: the pioneers of new technology dominate the market.

- ➔ **To develop the new technologies**, managers must protect them from the processes and incentives that serve established customers by creating organizations that are **independent from the mainstream business**.

The performance trajectories: the rate at which the performance of a product has improved and is expected to improve, over time.

➔ F.e.: For disk drive: the performance in storing capacity for a given size of drive. For photocopiers improvement in number of copies per minute

This concept is helpful to understand the impact of a certain technological innovation on a given industry. Different types of technological innovations affect performance trajectories in different ways:

1. **Sustaining technology:** tend to maintain a rate of improvement. They improve something that the consumer already values. *Ex: more capacity on one hard drive*.
2. **Disruptive technology:** introduces a very different package of attributes and they often perform far worse one or two dimensions that the customer values. Mainstream customers are unwilling to use a disruptive product in application they know. Therefore a disruptive technology is usually only valued and used in new markets or new applications. In fact, they generally make possible the emergence of new markets. *Ex: Sony's early transistor radios created a market for portable radios.*

Current market leaders often do not invest in disruptive technologies. New market entrants first capture the new markets that the disruptive technology opens and then dethrone the leading companies in the mainstream market. Leading companies that finally launch the disruptive technology already lag behind when they do.

Question: How could technologies that were initially inferior and useful only to new markets eventually threaten leading companies in established markets?

A company's revenue and cost structures play a critical role in the way it evaluates proposed technological innovations. Generally, disruptive technologies look financially unattractive to established firms: the potential revenues are small and the market over the long term is difficult to estimate. In addition, established firms have often installed higher cost structures to serve sustaining technologies than those required by disruptive technologies. Managers typically have two choices when deciding whether to pursue disruptive technologies:

1. Go **downmarket** with disruptive technologies and accept the lower profit margins
2. Go **upmarket** with sustaining technologies and enter market segments whose profit margins are high.

Any **rational resource-allocation process** will choose going upmarket rather than going down and this has consequences.

The managers should pay attention to potentially disruptive technologies that do not meet current customers' need (management myopia or lack of foresight). The processes that companies have developed to allocate resources among investments are incapable of funnelling resources into programs that current customers don't want and with unattractive profit margins.

Managing the development of new technology is tightly linked to a company's investment processes. Most strategic proposals which add capacity or develop new products/processes take shape at the lower levels of organizations in engineering groups or project teams. Companies use analytical planning and budgeting systems to select proposals. Managers are evaluated on their ability to place the right bets so mid- and top-level managers back projects in which the market seems assured (⇔ new businesses: unreliable estimates of market size).

Method to spotting and cultivating disruptive technology:

1. **Determine whether the technology is disruptive or sustaining**:
    - Examine **internal disagreements** over the development of new product or technology.
        - ➔ Marketing and financial managers will not approve because of their managerial and financial incentives rarely support disruptive technology.
        - ➔ Technical personnel will often support disruptive technology.
    - Disagreement between those two groups often signals a disruptive technology that top-level management should explore
2. **Define the strategic significance of the DT:**
    - Ask the right questions to the right people.
        - ➔ **Mainstream customers** are reliably accurate when it comes to assessing the potential of **sustaining technology** but are reliably inaccurate when it comes to assessing the potential of disruptive technologies.
    - Compare the anticipated rate of performance of the new technology with that of the established technology[17]. Current performance of the new technology will usually be much lower than the current technology when it is a disruptive technology. It's the slope of trajectory of the disruptive technology compared with that of the market that is important. This slope indicates the rate at which the performance of a product will improve (usually higher with disruptive technologies). The greater the slope of the new technology, the higher the risk the technology implies for the current technology

3. **Locate the initial market for the disruptive technology:**
    - If the manager has found that the technology is disruptive and strategically critical, he has to locate the market.
    - Market research is not a good tool to locate the market.
    - Because disruptive technologies signal the emergence of new markets, the manager must create information about such market: *who the customers will be, which dimensions of product performance will matter most to which customers, what the right price points will be.*
    - They can create this information by experimenting with the product and the market. For established companies undertaking such experiments is very

[17] See figure p. 165

difficult. By letting start-ups (funded by the company or without connection to the company) conduct the experiments established companies can probe a market for disruptive technologies. They are good to rolling with the punches, changing product and market strategies in response to feedback from the market. (ex: IBM let Apple, Commodore ad Tandy define the laptop and then, aggressively entered the market).

➔ **Strategy of being second to invent**: let a small firm lead the way to the market for you.

4. **Place responsibility for building a disruptive-technology business in an independent organization (small teams, skunk works, etc.):**
   - It is necessary to create a separate organization only when the disruptive technology has a lower profit margin than the mainstream business. It must serve the unique needs of a new set of customers.
   - If this is not the case, creating a separate organization is not necessary because there is no finance problem then: the resources of the new technology can provide the company with enough new resources to deal with the lower profits from the old technology.

5. **Keep the disruptive organization independent:**
   - The managers assume that once a spin-off has become commercially viable in a new market, it should be integrated into the mainstream organization.
   - This can be disastrous. Companies must give managers of disruptive innovation free rein to realize the technology's full potential (**even if it means ultimately killing the mainstream business**).
   - For the corporation to live, it must be willing to see business units die. If the corporation doesn't kill them off itself, competitors will.

14. The ambidextrous organization - *Charles A. O'Reilly and Muchael L. Tushman (2004)*

Firms must constantly **look backward** at the products and processes of the past but also **gaze forward** to prepare the innovations that will define the future. Most successful enterprises are adept at refining their current offerings, but they falter when it comes to pioneering radically new products and services. Some companies, however, have actually been quite successful at both exploiting the present and exploring the future. The authors of found that these companies share important characteristics:

1. They separate their new, exploratory units from their traditional, exploitative ones, allowing for different processes, structures and cultures at the same time
2. They maintain, however, tight links across these units at the senior executive level

➔ Authors call these **Ambidextrous Organizations**, which allows forward-looking executives with a model to pioneer radical, disruptive innovations, while pursuing incremental gains on their existing products as well.

Exploiting and Exploring

Companies need to maintain a variety of innovation efforts:

1. **Incremental innovation**: small improvements in their existing products and processes that offer greater value to customers
2. **Architectural Innovation**: applying technological or process advance to fundamentally change some component or element of the business. (ex: move the call centre of a bank to a low-labour-cost country like India)
3. **Discontinuous innovation**: radical advances that profoundly alter the basis for competition in an industry, often rendering old products or ways of working obsolete. (ex : digital photography)

All these types of innovation can have different targets:

- Aimed at firm's current customers
- Aiming at existing market that currently lies beyond the scope of the company
- Serving an entirely new market
    - ➔ **A Map of Innovation**[18]: types of innovation and targeted markets plotted in a matrix

Companies have tended to structure their breakthrough projects in one of four basic ways:

1. **Functional design** : integrate project teams into the existing organisational and management structure.
2. **Cross-functional design**: groups operate within the established organization, but outside the existing management hierarchy.
3. **Unsupported teams**: are set up outside the established organization and management hierarchy
4. **Ambidextrous organisation**: project teams are structurally independent units, each having its own processes, structures and cultures, but are **integrated into the existing management hierarchy**.

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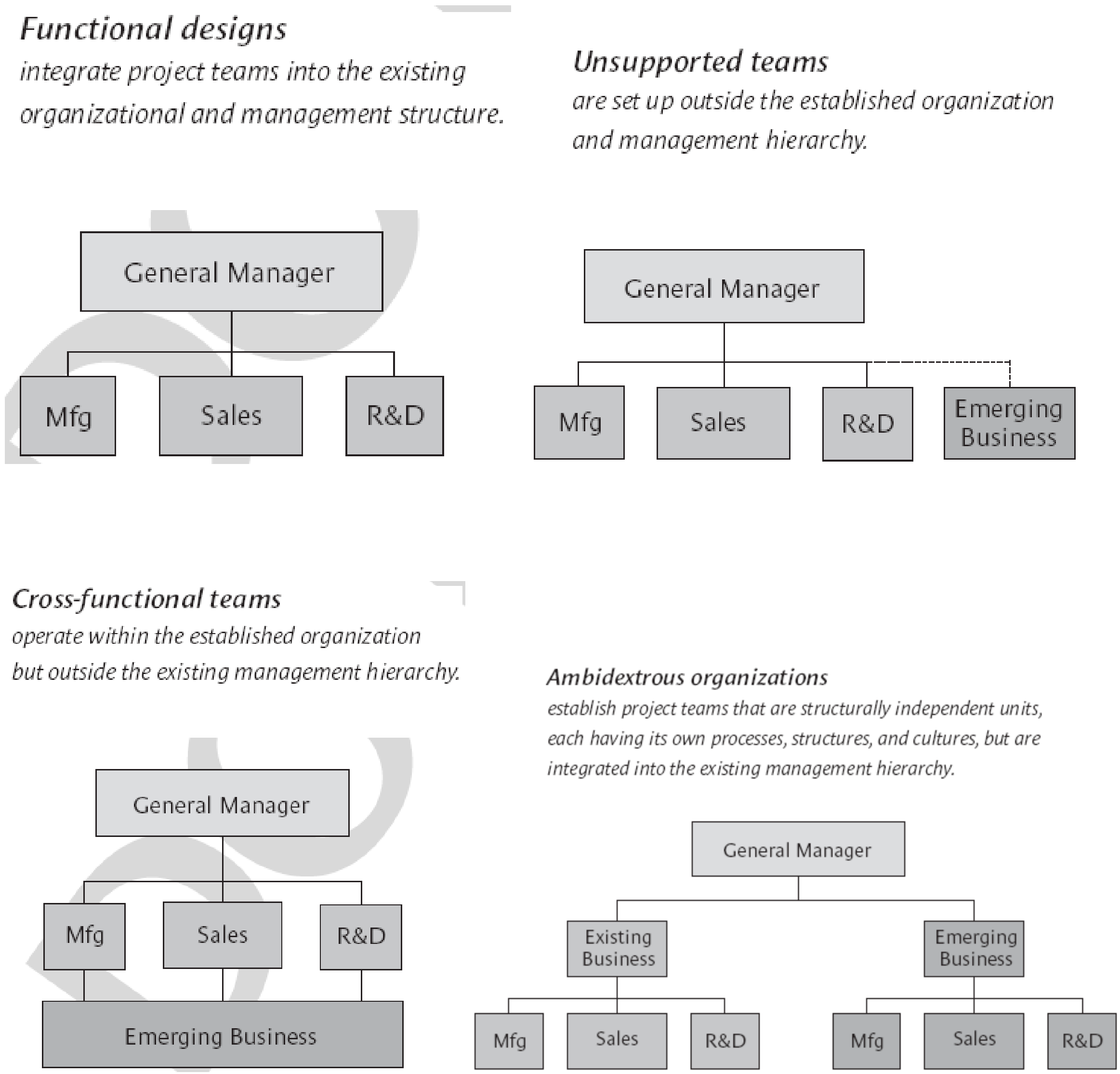
[18] See figure p.77



According to the author's research, when it comes to launching breakthrough products or services, ambidextrous organizations have proven to be significantly more successful! (90% of ambidextrous organizations reached their goals). The superiority of the ambidextrous organizations became even more apparent when organizations changed its structure from functional designs, cross-functional teams or unsupported teams to an ambidextrous one.

Reasons for superiority of the ambidextrous structure:

1. **Allows cross-fertilization** among units: tight coordination at the managerial level enables the fledgling units to share important resources from the traditional units (cash, expertise, talent, customers, ...)
2. **Prevents cross-contamination**: organizational separation ensures that the new distinctive processes and cultures are not overwhelmed by the forces of 'business as usual'. At the same time the established units are not distracted with the launch of new products, so they can focus better.

But how do ambidextrous organizations work?

A Newspaper invents itself

The authors use two organizations, ***USA Today*** (Newspaper business) and **Ciba Vision** (contact lenses and eye-care products), as examples of how companies can renew themselves with breakthrough products without harming its existing business. Both companies were struggling to compete in their respective markets until they became ambidextrous organizations. USA Today for example, was exhibiting more and more competition from other media like television and internet. It launched the online service USAToday.com as a skunk work. Financial results were disappointing at first but this was because this new unit was entirely isolated from the print operations. It could not capitalize on the newspaper's vast resources (use synergies). Therefore more integration between the units must follow and they set-up an ambidextrous organization.

The following are a few managerial and organizational **characteristics** of ambidextrous organizations (in addition, see Exhibit 3 below):

1. Senior managers must agree with and be committed to the network strategy involved in an ambidextrous organization. Project leaders must be willing to challenge the status quo.
2. Senior leadership of different units must be tightly integrated and should keep each other informed of necessary information.
3. Executive incentive programs involving the entire company are used as opposed to bonus programs tied to individual units.
4. The company's research and development budget may be allotted almost entirely to producing breakthroughs while existing business pursues only incremental innovations.
5. A clear vision is crucial in transforming a company into an ambidextrous organization.

Summary

The Scope of the Ambidextrous Organization*		
Alignment of:	**Exploitative Business**	**Exploratory Business**
Strategic intent	Cost, profit	Innovation, growth
Critical tasks	Operations, efficiency, incremental innovation	Adaptability, new products, breakthrough innovation
Competencies	Operational	Entrepreneurial
Structure	Formal, mechanistic	Adaptive, loose
Controls, rewards	Margins, productivity	Milestones, growth
Culture	Efficiency, low risk, quality, customers	Risk taking, speed, flexibility, experimentation
Leadership role	Authoritative, top down	Visionary, involved

15. Organizing for continuous innovation: on the sustainability of ambidextrous organizations - *Bart Van looy, Thierry Martens and Koenraad Debackere (2005)*

Setting the Stage

Innovation activities display paradoxical requirements pertaining to the social dynamics in which exploitation (incremental development) and exploration (disruptive development) unfold. Therefore, within incumbent firms who have multiple resources and capabilities aimed at exploitation, exploration might be hampered.

Exploitation ⇔ Exploration
Incremental innovations ⇔ Radical innovations
flexibility ⇔ commitment
divergent behaviour ⇔ convergent behaviour
Path creation ⇔ path dependence

organizations trying to achieve both types of activities are confronted with the challenge of reconciling conflicting requirements: $\neq$ in technology and $\neq$ in market maturation

Being both explorative and exploitative requires both flexibility and commitment. To achieve both, a firm must set up **hybrid structures/semi- or quasi-structures/ambidextrous organizations**. However at the same time separate units in those organizations must have a clear common vision as well in the form of a shared senior management.

Financial returns will inevitably reflect such a diversified resource allocation. Compared to organizations that focus on the most profitable part of the portfolio, ambidextrous organizations (encountering additional organizational costs) tend to be - ceteris paribus - inferior in terms of financial returns, at least in the short run. In addition, the **higher levels of managerial and organizational complexity** introduce additional costs for ambidextrous organizations

Under which conditions ambidextrous organizations are able to outperform focused firms and by doing so ensure their sustainability?

Methodological approach

They compare an ambidextrous or diversified firm with a firm that focuses on only one type of activity. These findings obtained by analysing this simplified representation are highly informative for understanding the financial dynamics of ambidextrous organizations. The different premises relate to:

1. The technology life-cycle affecting the amount of value created in a given time period. Four Stages:
   - ➔ Seed
   - ➔ Growth

- ➔ Mature
- ➔ Decline

2. The resources needed to organize and manage the diversity entailed within ambidextrous organizations.
3. The resources needed to enact the diversity present within ambidextrous organizational forms.

(In my opinion the methodological part of this paper it is not very relevant for the course, the results and conclusions are)

Conclusion

Under certain conditions, **AO** takes on a **sustainable form** whereby sustainability is defined as resulting in overall value creation equal or superior to focused mature firm.

To have a **strong performance**, different elements play a role:

1. Adopting longer timeframes: AO have mature and emerging activities so they can compensate the decline of a mature activity (in term of financial returns) by the growth of emerging activities. Such **portfolio effects** require longer timeframes. At the same time ambidextrous firms are not outperforming focused firms but they are able to compensate over time the inferior performance of the first phases.
2. Synergies: When synergies are being introduces in the ambidextrous organization, a higher impact on financial results is observed. Synergies manifest themselves threefold:
    a. Flexibility in terms of resource allocation across activities
        - ➔ Benefits: if an organization is able to shift resources from declining parts of the business portfolio to growing parts, financial returns tend to increase rather than decrease. Stated otherwise, reallocation presupposes relatedness or synergy on the level of technology
    b. **Cross-fertilization** affecting market growth: the more one is able to affect the growth rates, both of emerging and declining activities, the more beneficial effects in terms of financial returns become outspoken.
    c. Cross fertilization affecting he overall size of the market: combining resources within two different activities might result in the development of new products and/or market applications affecting the overall size of the attainable market . When AO are able to influence the size of the market, sustainability becomes a non-issue.

Given these observations, tight coupling seems to be as relevant as loose coupling.

- ⇨ It's **crucial** to **assess** the potential **cross-fertilization effects** when defining and developing the **portfolio** of activities of the AO. This implies an important role for management of assessing and enacting the potential cross-fertilization effects.

⇨ Synergetic potential of technologies are necessary for AO to become sustainable.

16. Unravelling the process of creative destruction: complementary assets and incumbent survival in the typesetter industry

When radical technological change transforms an industry, established firms sometimes fail drastically and are displaced by new entrants, yet other times survive and prosper.

1. Literature

There are three factors that influence the commercial performance of incumbents and new entrants:

1. **Investment** in developing the new technology
2. **Technical capabilities**
3. The **ability to appropriate the benefits of technological innovation** through specialized **complementary assets**.

The balance and interaction among these three factors determine whether incumbents or new entrants are more successful in the face of competence-destroying technological change.

(1) Investment

When innovation is radical (it replaces rather than competes with the old technology), then incumbent monopolists have less incentive to invest in the new technology than new entrants. In contrast, when innovation is incremental (it competes with the existing technology), then incumbents have greater incentives than new entrants to invest.

Alternatively, established firms fail to invest in developing radically new technology as a result firms' resource allocation mechanisms that is guided by the needs of existing customers. When new technology targets new markets and does not address the needs of the firm's existing customers, firms focus their efforts away from the new technology. Similarly, when new technology is sustaining in that is meets the needs of the existing customers, then incumbent firms invest in the technology.

(2) Technical capabilities

Different stages of the technology life cycle have major implications for the technical capabilities (development skills in the R&D team) of incumbents and new entrants. During an incremental period, when technological innovation builds upon the capabilities of established firms, they have an advantage over new entrants. When faced with a radical, competence-destroying technological shift (f.e. from a mechanical to an electric model that requires totally different capabilities of employees), established firms are often at a disadvantage because of the difficulty to adapt. They have effective organizational structures, routines and procedures for the existing technology that is hard to adapt.

However, others found that (f.e. in the disk drive industry) established firms did not have difficulty developing new technology, even when innovation was radical. This indicates that sometimes incumbents possess dynamic capability to renew, augment and adapt their core competencies over time and not let those core competencies become core rigidities.

➔ No clear prediction as to whether established firms will have inferior technological performance in competence-destroying technological generations.

(3) Appropriability through complementary assets

Large established firms with capital and market power are in a stronger position to exploit innovation. **Complementary assets** are described as factors such as **specialized manufacturing capabilities**, **access to distribution channels**, **service networks** and **complementary technologies**. We can distinguish between generic, specialized and co-specialized complementary assets. Generic assets have multiple applications, specialized are useful only in the context of a give innovation.

When competence-destroying innovations have low transilience in that they do not substantially change the market/customer linkages, then incumbents perform well in the market. The **sales/service relationships** of the incumbents serve as a specialized complementary asset that new entrants find hard to contract for or imitate. Some introduced the term '**value network**', i.e. the system of producers and markets serving the ultimate user of the products or services to which a given innovation contributes. This network can serve as a specialized complementary asset that provides incumbents with a buffer to new entrants.

However, technological innovation can sometimes destroy these specialized complementary assets:

- ➔ When an incumbent in electromechanical calculators has a specialized sales and service team as complementary asset and new entrants enter the market with new electronic calculators that are far more reliable so that service becomes far less important, the value of this complementary asset is completely undone.

Note that new entrants can also possess these assets.

(4) Synthesis

These three elements drive incumbent vs. new entrant performance. This paper argues that the expected outcome depends upon the balance and interaction among these three elements. Examples of outcomes:

1. If incumbents choose not invest in the new technology, then new entrants that make the investment will dominate the market for the new technology.

2. If incumbents do invest, but their technological performance is inferior to that of new entrants, then, assuming a weak regime of intellectual property protection, their commercial performance will depend upon whether the technological shift also devaluated the relevant specialized complementary assets.
    - ➔ If incumbents possess these assets, and due to their specialized nature they cannot be acquired by entrants, then incumbents are likely to dominate the market, even if their products are technological inferior.
    - ➔ If the technological shift also decreased the value of these complementary assets, then incumbent have no buffer and new entrants dominate
3. If incumbents invest in the competence-destroying radical technology and their technological performance is on par or superior to that of new entrants, the commercial result is still dependent upon who possesses the necessary complementary assets. If neither of both possesses the assets, it is unclear what will happen.

2. Data and research setting

The issues discussed in the literature study are examined through a study of the technological and competitive history of the typesetter industry for a period over 100 years. From its inception in 1886 through 1990, the industry has undergone three waves of creative destruction where competence-destroying, architectural technological change transformed the industry. In total 42 different firms participated in the industry, with a maximum of 25 competitors and a minimum of three in the industry at any point in time. There have been three generations of radical technological change since the initial invention of mechanical, ‘hot metal’ typesetter technology in 1886: analog phototypesetting (1949), digital CRT phototypesetting (1965) and laser imagesetting (1976). The effects of each generation on the three elements:

(1) Effect on investment

Each of the generations was incremental in the economic sense in that the old generation of technology continued to compete with the new generation. There was very little investment by new entrants in hot metal typesetter technology during the many years of incremental hot metal innovation. However, almost every firm that established even a moderate presence in a given typesetter generation invested in developing a machine for the following generation. Moreover, incumbents invested in second-generation machines much earlier than new entrants. Incumbents and new entrants did not differ significantly in their investment timing for third and fourth generations.

(2) Effect on technical capabilities

Established firms are handicapped by their prior experience in their approach to new product developments was shaped by that experience. The initial products developed by established firms were consistently inferior to those of new entrants. The need for both new technical skills and new architectural knowledge proved difficult for incumbents to manage.

The development of skills of a team were compared for each generation, as well as the product components, interfaces and overall machine logic to better understand the architectural change. If a large percentage of the required skills in a generation were new, then the relative value of an incumbent's existing skill base decreased. A generation was classified as competence-destroying from the standpoint of skill base if 50% or more of the skills in a generation were new. The three generations were all competence-destroying. All three generations were also competence-destroying from the standpoint of their effect on architectural knowledge.

(3) Effect on complementary assets

Incumbents do not necessarily suffer commercial consequences as a result of their inferior technological position. We identify 3 salient complementary assets in the typesetter industry: (1) **specialized manufacturing capability**, (2) a **sales and service network**, (3) and a **font library**. New entrants perceived an opportunity due to the changing technology, but the ownership of specialized complementary assets by incumbents, a sales/service network and for libraries in particular, appear to have protected the incumbents from competition.

(1) Manufacturing capability is a generic complementary asset that could be easily contracted for in the three generations. However, production of hot metal machines required very strong specialized manufacturing capabilities.

(2) The primary typesetter buyer segments were newspapers/magazines, commercial printers and typographers/advertisers. The second generation of technology (analog phototypesetters) resulted in a new market segment, i.e. the in-house publisher. The third and fourth generation (CRT and laser machines) had the same set of buyers to be served through the same set of salespeople. As a result, the sales and services networks built up during the second generation remained valuable specialized complementary assets during the third and fourth generation.

(3) For 3 customer segments (typographers/advertisers, commercial printers and in-house publishers) the font library was one of the most critical purchase criteria. In contrast, newspapers required a smaller variety of fonts, but they looked for a specific font that was important to the 'look and feel' of the paper. A proprietary font library retained its value throughout the three subsequent generations of technology.

3. Conclusion

While lack of investment is sometimes responsible for incumbent failure, other times incumbents do invest and still lose the market. This suggest that performance does not only depends on investment. This paper shows that is also depends on technical capabilities and specialized complementary assets. When specialized complementary assets are devalued in addition to competence being destroyed, the effect of being an incumbent is significant and negative. When specialized complementary assets retain their value, the effect of being an incumbent no longer hurts performance significantly. In conclusion, **incumbents only suffered in the market when both competence was destroyed and the value of specialized complementary assets was diminished.**

17. Organizing Innovation within Incumbent firms: Structure Enabling Strategic Autonomy - *Van Looy & Visscher*

Theoretical Background

1. In order to stay sustainable over longer time periods, firms need to divide their attention between exploitation (leverage of existing capabilities by means of activities such as standardization, scaling and refinement) and exploration (creation of new capabilities by engaging in fundamental research, experimentation and search activities).
2. This is not a straightforward exercise because of the multitude of objectives such a double strategy implies.
3. How to reconcile exploitation and exploration? Two approaches have been reviewed by the literature with the attention to:
    1. The **scope of technological activities**: relatedness and complementarities are crucial to reconcile exploration and exploitation
    2. The **organizational design** arrangements in which both become embedded.

Scope: The importance of a Diversified Knowledge Base and the Presence of Related and Complementary Capabilities for Combining Exploitation and Exploration

- **Technology diversification**:
    - ➔ Firms that can rely on knowledge in a variety of fields have the potential to cross-fertilize, yielding new inventions and functionalities and/or increased product and process performance.
    - ➔ Combination of knowledge from different technology fields allows firms to create complete new products (exploration)
    - ➔ Cross-fertilization and synergies result from the diversified technology portfolio
- **Specialized Complementary Assets:**
    - ➔ (See text 16: *Unravelling the process of creative destruction: complementary assets and incumbent survival in the typesetter industry*)

Incorporating Different Objectives into Organizational Design

- Exploration and exploitation activities should be organized in **separate**, entrepreneurial units: ventures, spin-outs, ambidextrous organizations and semi- or quasi-structures
- Reason:
    - ➔ Exploitation requires homogeneity and consensus
    - ➔ Exploration benefits from heterogeneity and episodes of conflict.
- Different organizational structures allow executives to pioneer radical or disruptive innovations while also pursuing incremental gains. However, there always must be an clear, encompassing vision at senior management level.
- However, other scholars are in favour of integrating both activities more explicitly. They argue that a **behavioural context** can be created that fosters both current and innovative activities:
    - ➔ clear standards
    - ➔ ambitious goals
    - ➔ rapid feedback systems
    - ➔ good access to resources

- ➔ freedom to initiative and mutual trust
- ➔ commitment

- (F.e. environments in which employees divide their time between exploitation and exploration)
- This integration approach requires less coordination costs.

This study analyzes the effectiveness of innovation strategies while considering both technological diversification/complementary assets and organizational designs, by looking at the case of Alcatel.

The Development of ADSL at Alcatel

1. 1980: Alcatel were not concentrating on ADSL but on **ISDN**. Alcatel believed that ISDN would remain the technology of the coming years and decennia.
2. 1990: Alcatel believed that the **maximum speed capacity** over copper wire had been reached by their Broadband ISDN. However, in the US, Belcore researchers demonstrated that higher transmissions over copper wire were possible through ADSL.
3. Martin de Prycker proposed to senior management to start a **small research program** on these new possibilities of ADSL, within Alcatel's central research unit.
4. At that time, there were several **competing technological alternatives** to copper wire: COAX and optical fiber.
5. 1993: the foreseen killer application for ADSL, COAX and optical fiber was **Video On Demand** (VOD). Therefore, Alcatel started the development of VOD with **ADSL and optical fiber**.
6. 1995: the great expectations for VOD collapsed: the **market was not ready**, tariffs for consumers would have been too expensive.
7. Because of this collapse, another potential application for ADSL gained attention: **Internet**
8. Martin De Prycker advocates to focus on this new application and initiated a minor research program focusing on internet technology.
9. Given the competition of cable networks(f.e. Telenet) using the faster COAX cable, ADSL was the most viable solution for telecom operators (f.e. Belgacom) to compete.
10. To further develop ADSL technology for internet usage, Alcatel set up a semi-autonomous unit (**Virtual Company** or VC) for Martin De Prycker which had an autonomous position and was able to determine its own purchase and HR policies. The **support from management** for this unit was not evident, since demand for ADSL was not there yet and since the previous VOD dead-end.
11. 1996: Alcatel wins the huge **JPC contract** in the US against competitors like Erickson and Westell. JPC was a consortium that aimed to purchase ADSL equipment to offer internet services in the US. This gave the company the most prominent position in the ADSL market.
12. Factors that lead to this success:
    - ➔ **Technological capabilities and diversification**: in contrast to its competitors (f.e. Erikson relied on Motorola chips for its ADSL technology), Alcatel had its own chip division (= technological diversifaction) . Also Alcatel had adopted a **broad technological portfolio** (**portfolio approach**) by investing in research in ADSL, Fibre and COAX)
    - ➔ **Organizational factors**: entrepreneurial actions by Martin De Prycker (**entrepreneurial champion**), support from management and the effective Virtual

Company design that was flexible, could make fast decisions and could use corporate resources (financial buffers and technological expertise = knowledge spillovers)

So in the first phase, when the market was still very uncertain, Alcatel adopted the portfolio approach and the integration approach (no separate unit but research teams sitting literally next to each other but with teams limited to 5-7 people to boost creativity). In the second phase, when there was a clear innovative target (the internet), development took place in a specific VC.

As such, this paper highlights the **interactivity between organizational design and the presence of complementary resources** when engaging in innovation processes.

18. The era of open Innovation - *Chesbrough H.*

1. Closed innovation model[19]

- **Company generates, develops, commercializes its own ideas**
- Strict boundary between the firm and its surrounding environment.
- Philosophy of 'self-reliance = 'if you want something done right, you have got to do it yourself'
- This model worked for most of the 20th century
- "Successful innovation requires control"
- **Virtuous cycle**: leading industrial corporations/powerhouses (IBM, AT&T) invested more heavily in internal R&D than their competitors → discovered the best ideas → entered the market first + **controlled its Intellectual Property** → ↑profits → reinvested in R&D

2. Open innovation model[20]

- **Company commercializes both its own ideas as well as innovations from other firms**
- Boundary between a firm and its surrounding environment is **porous**.
- Toward the end of the 20th century a number of factors started to eroded the underpinnings of closed innovation:
  - ➔ Rise in the number and mobility of knowledge workers, making it increasingly difficult to control their proprietary ideas and expertise
  - ➔ Availability of venture capital which helped to finance new firms
- Therefore, the **virtuous cycle that sustained closed innovation was shattered:** Company that originally funds a breakthrough does not profit from the investment and the firm that did reap the benefits did not reinvest its proceeds to finance the next generation of discoveries
- **Means** for accomplishing open innovation:
  - ➔ Start-up companies financed and staffed with some of the company's own personnel
  - ➔ Licensing agreements
  - ➔ Joint ventures
- Company should no longer lock up its IP, but should find ways to profit from other's use of that technology licensing, joint ventures, etc.

Both closed and open innovation models weed out **false positive** investment possibilities, bad ideas that initially look promising. But open innovation allows to rescue **false negatives**, ideas that initially look to lack promise but turn out surprisingly valuable. Closed innovation

[19] See figure p.36
[20] See figure p. 37

companies cannot recover these false negatives and may discover that some of the projects that were abandoned had tremendous commercial value.

Many industries (telecommunication, pharmaceuticals, biotechnology, ...) are transitioning from closed to open innovation, but not all (nuclear reactor industry). At the moment, there is a continuum industries going from closed to open. (f.e. Hollywood film industry is completely open). The locus of innovation migrates from central R&D laboratories of large companies to start-ups, universities, research consortia and other outside organizations.

Contrasting principles of Closed and Open innovation	
Closed	**Open**
The smart people in our field work for us	Not all smart people work for us so we must find and into the knowledge of individuals outside our company
To profit from R&D, we must discover, develop and ship it ourselves	External R&D can create significant value, internal R&D is needed to claim to portion of that value
If we discover it ourselves, we will get it to the market first	We don't have to originate the research in order to profit from it
If we are the first to commercialize an innovation, we will win	Building a better business model is better than getting to the market first
If we create the most and best ideas in the industry, we will win	If we make the best use of internal and external ideas, we will win
We should Control our intellectual property (IP) so that our competitors don't profit from our ideas	We should profit from others' use of our IP, and we should buy others' IP whenever it advances our own business model

Different Modes of Innovation

Companies have different strategies for exploiting the principles of open innovation. They focus their activities on:

1. ***Funding innovation*** (supplying the innovation fire)
    1. **Innovation investors**: Venture Capital Firms, Corporate Venture Capital entities, angel investors, private equity firms, Small Business Investment Companies (SBIC) that provide capital to small businesses. In addition to financing they also advice. They help move ideas out of universities/corporations into the market.
    2. **Innovation benefactors**: Focus on the early stage of research discovery (**basic research**). Fe. National Science Foundation (NSF): through its rewards and grants programs, the NSF provides about 20% of federal support for academic

institutions to conduct basic research. But also companies, not only government agencies.

2. Generating innovation

1. **Innovation explorers**: Tend to innovate **for innovation's sake**. Specialize in performing the discovery research function that previously took place within corporate R&D laboratories. Most of them are spinoffs of laboratories that used to be part of larger organizations. Also, in the aftermath of the Cold War, major government labs refocused their mission and now focus on finding applications for their basic research.
2. **Innovation merchants**: Innovate with **commercial goals**. Also explore, but their activities are focused on a narrow set of technologies that are codified into intellectual property and aggressively sold to others. They seek financial profits from their work in terms of **royalties from their IP**.
3. **Innovation architects**: Coordinate complex technologies, develop architectures (that partition this complexity) enabling companies to provide other pieces of the system in order to create value for its customers. They ensure that all parts fit together (Fe. Boeing engineers overall architectural design of an aircraft after which other companies develop the jet engines, etc).
   - ➔ In fast moving and complex industries
   - ➔ But success depends on how they can persuade others of the platform to use their technology as basis.
4. **Innovation missionaries**: Do not seek financial profits from their work. Their mission is what motivates them **(**non-profits, religious groups, professional programmers, hobbyists, user groups help define how a particular software program will evolve)

3. Commercializing innovation(ability to market ideas)

1. **Innovation marketers**: focus on understanding the markets' needs and this helps them to identify which outside ideas to bring in-house. Close interactions with customers and good in identifying and adapting outside technologies to satisfy those needs. They profit from innovation they did not discover themselves.
2. **Innovation one-stop centres**: provide comprehensive products/services and deliver the best ideas to their customers at competitive prices. Like marketer they thrive by selling other's ideas but are different in that they typically form unshakeable connections to end users, managing a customer's resources to his/her specifications (F.e. Yahoo! enables people to shop, send e-mail, manage their finance.

4. Fully integrated innovators

- Some companies are continuing to do **all three innovations**
- They stay close to the **closed innovation system** with the credo 'innovation through total control'

Summary

Firms that can harness outside ideas to advance their own businesses while leveraging their internal ideas outside their current operations will likely thrive in this new era of open innovation.

19. Toward an integrative perspective on alliance governance: connecting contract design, trust dynamics, and contract application - *Faems D., Janssens M. Madhook A. & Van Looy B.*

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1. Introduction

Alliances have become a very popular strategy organizations use to complement and supplement their internal activities. Nevertheless, failure rates of alliances are high. Scholars have investigated two different theoretical perspectives that try to explain alliance performance:

1. Focus on **structural** design and the importance of agreements in writing and **legally binding contracts**.
2. Focus on **relational** processes within the interfirm relationships and the importance of **trust** for safeguarding and coordinating alliances.

This paper provides a more integrative understanding of alliance governance: How design and application of structural elements (contracts) are related to relational processes (thrust) at both operational and managerial levels. The authors conducted a case study in which they investigated two sequential exploratory R&D alliances between the same pair of firms.

2. Theoretical Background

Structural and Relational Perspectives on Alliance Governance

Characteristic	Structural Perspective	Relational Perspective
Focus of analysis	Single transaction	Interfirm relationship
Theoretical basis	Transaction cost theory	Social exchange theory
Main assumptions	- Partners tend to act opportunistically - Alliance performance is driven by the quality of the initial structural design	- Partners tend to act in a trustworthy fashion - Alliance performance is driven by the quality of the ongoing relational processes
Governance mechanism	Complex contracts: Specified contracts with large number of clauses, precisely written division of labour and coordination between the companies.	Trust: knowledge and information will not be misused, partners are also more likely to engage in extensive communication and info sharing in an atmosphere of thrust.
Criticism	Undersocialized view of human action (neglecting the social context in which alliance transactions take place)	Oversocialized view of human action (having a too rosy view on human nature, men always acts trustworthy)

Connecting Structural and Relational Perspectives

Both perspectives need to be integrated. Some empirical research has already explored connections between structural and relational governance perspectives but the results are inconsistent and ambiguous, due to three important reasons:

1. They only focus on the **degree** of contractual formalization (number of clauses) and ignore the **nature** of formalization (the content of the clauses).
2. Attention only on the **initial design** of contract and not on how they are applied during the alliance. Enforcement is sometimes strict, sometimes more flexible and contract application and trust are also likely to coevolve over time.
3. They only focus on relational processes at **managerial level** and ignore the processes at operational level (among employees).

This leads to the following **Research Questions** in this paper:

1. *How does the content of contracts influence trust dynamics at both operational and managerial levels in alliances?*
2. *How does the application of contracts coevolve with trust dynamics at both operational and managerial levels in alliances.*

3. <u>Methodology</u>

Research Design and Setting

Case study of two **sequential R&D alliances**, labeled the **'side shooter head alliance'** (SSH) and the **'end shooter head alliance**' (ESH) between the same two firms **Graph** (world leading imaging company of more than 20 000 people) and **Jet** (stock quoted inkjet technology company of 185 people).

For each alliance both Graph and Jet created engineering teams of 5 engineers that were responsible for the execution of the project. The reported back to two senior managers.

Data Collection and Analysis

Data collected in a retrospective way (after the alliances were completed) through interviews with manager and engineers of both companies. After the collection of the data, the authors made a case study report that reconstructed the history of the two alliances. These reports were send to the companies' managers for comments, which made it possible to check whether the authors made correct interpretations of the data.

Each author made a individual analysis of the data to make predictions about contract design, trust dynamics and contract application. Afterwards they integrated their views in one final analysis. To fine-tune their insights, the first draft of the article was sent to the managers of the companies for last feedback and to test the validity of the findings.

4. <u>The Side Shooter Head and End Shooter Head Alliances</u>

The Side Shooter Head Alliance [21]

- 1990: Jet invented Side Shooter Head Technology (= sort of inkjet technology)
- Jet had limited financial resources for this revolutionary innovation project and also lacked technological expertise in digital printing systems. Therefore it looked for partners and found this partnership with Graph.
- 1998: Alliance contract was negotiated. The **contact** stipulated:
    1. Graph would pay contributions in the development costs and in exchange they would become one of at most three preferential partners to which Jet would sell the SSH printhead.
    2. Clauses about the partners' behaviour outside of the alliance:
        - Legal action was permitted
        - Forbidding to pass exchanged information to outside parties
        - alliance did not imply an agency relationship between the partners
        - Rules for allocation IP
    3. Clauses about the execution of the collaborative agreement (**task division**):
        - Jet would design and develop the prototype printheads and Graph would develop a prototype printing system afterwards.
        - No information exchange but only monitoring of the partner's' outputs.
- The reason for this strict task division was Jet's **fear for knowledge spillovers** that would increase the potential of opportunistic behaviour by Graph. They avoided profound technological involvement and interaction of the Graph engineers.
- Later **unanticipated technological problems** (UTP) showed up. And because of the task division Graph engineers had to watch from the sideline. Jet did not ask for support.
    - ➔ Result: Graph started questioning the good intentions of Jet. It seemed that Jet only wanted their financial help. Jet on the other had feared opportunistic behaviour of Graph when giving them to much access to their technological knowledge.
- 2000: **Delay's** in the development process caused Graph to increase the contractual pressure on Jet to deliver SSH printheads. Instead of focusing on sustainable solutions for the UTP's, Jet engineers started to look for technological shortcuts. Jet remained unwilling to deviate from the mode of collaboration (limited exchange of information with the Graph engineers).
- The quality of the printheads was not in accordance with the performance standards of Graph and the company started to doubt the feasibility of the SSH project.
- 2001: Graph terminated to SSH alliance.

The End Shooter Head Alliance [22]

- Second alliance, now to explore Jet's ESH technology. It might seem odd of Graph to start another alliance after the SSH project but two explanations for this:
    1. Graph was highly dependent on Jet for access to inkjet technology

[21] See figure 1 p. 1062
[22] See figure 2 p.1066

2. ESH team at Jet was completely different form the SSH engineers and they had already successfully commercialized inkjet printheads in the past.

- **Contract**:
    1. Graph dominated the negotiations (in SSH project is was Jet who put forward the main conditions of the contract) because Jet had financial problems and needed the funding of Graph.
    2. Graph funds exploratory efforts of Jet to design and develop ESH prototype printheads
    3. Jet granted Graph a **royalty-free license** to use the ESH printhead manufactured by Jet in any Graph application.
    4. Clauses about the partners' behaviour outside of the alliance: same as in SSH project
    5. Clauses about the execution of the collaborative agreement and task division:
        - Contractual statements regulating the activities that Jet was **obliged** to conduct
        - Graph could monitor and follow up on the activities of Jet to arrive at outputs
        - Task division with overlap: engineering teams would **work together**.
        - Clauses to exchange information on specific technological activities
    6. Jet: Enthusiasm about this new more cooperative contract was still limited because concern about potential opportunistic actions by Graph was still high, but it had no other option than to accept.
- 2000, again **UTP's**, problems with developing prototype head, would be more difficult than expected. However, now Jet engineers were obliged to provide information about ongoing technological activities and because of overlapping task division joint brainstorming sessions took place. Both companies jointly searched for solutions.
- Efforts quickly started to pay off.
    - Jet: engineers able to successfully address a number of technological issues.
    - Graph: engineers much better informed about UTPs and could closely monitor Jet.
- As a result, the **relationship between the managers of both partners started to change**. The focus was on technology instead of financial interests (2 reasons):
    - Good collaboration at operational level triggered relational turnaround at managerial level
    - Appointment of new CEO at Jet further accelerated positive dynamics at managerial level
- October 2001: First ESH prototype built by Jet. However, the fundamental problems with electronics remained unresolved.
- This time however, Graph didn’t increase contractual pressure on Jet as in SSH but the original time schedule was just adapted
- Jet continued to search for high-quality solutions and information exchange from Jet to Graph further increased. Jet’s management even instructed its own engineers to start providing detailed information to Graph on core of Jet’s ESH technology, even though

there were not contractually obliged to do so. This additional information led to better understanding by Graph. **So contract was applied in a different way than with SSH!**

- Technological successes at the **operational level** followed: both were convinced that the alliance brought added value to the development process.
- At the **managerial level**: further improvement of quality of the relationship and trust: Less suspicion of both firm's management towards each other's intentions. The focus was now on technology and not on financial interests.
- March 2002: Delivery of fully functional ESH prototype printheads, allowing both partners to jointly move to the downstream stages of this technological innovation trajectory.

5. Multilevel Process Models[23]

Out of the findings, the authors developed two models, separating out governance, operational and managerial levels. This section discusses the models and links them to the two research questions.

Contract Content and its Impact on Trust Dynamics (First RQ)

What is *similar* between the two contracts?

➔ The degree of formalization (same number of clauses)

What is *different* between the two contracts?

➔ **Nature**/content of both contracts:

1. **Monitoring**:
   - SSH: performance-monitoring (definition of milestones, target dates and performance standard)
   - ESH: performance-monitoring + behaviour-monitoring (contract specified the specific technological activities that Jet had to do)
2. **Formalization of task division and information flows**
   - SSH: mutually exclusive task division and no information sharing
   - ESH: overlapping task division, collaboration and specific statements in the contract about the exchange of information

Given these observations, the authors suggest a distinction between two concepts of **contractual interface structures**:

1. Narrow (SSH):
   - Mutually exclusive task division
   - Absence of obligations to exchange information
   - Monitoring mechanisms that are mainly performance-oriented
2. Broad (ESH):

[23] See figure p. 1068

- Overlapping task division
- Presence of obligations to exchange information
- Mechanisms that provide opportunities for performance + behaviour monitoring

These contractual interface structures have an impact on **operational joint sense making**: The narrow approach limits information change on UTP's. This paves the way for an 'Impoverished problem definition and solution space'. The broad approach enhanced the opportunities for problem definition and problem solving. This operational joint sense making in its turn influences **managerial trust dynamics**. Presence of joint problem solving contribute to a more positive assessment of the other's intentions and to more positive trust dynamics at the managerial level. This leads to the following proposition:

Proposition 1:
In an exploratory R&D alliance, a broad (narrow) contractual interface structure facilitates (hampers) joint sense making on unanticipated technological problems at the operational level, which in turn positively (negatively) influences goodwill trust dynamics at the managerial level.

Coevolution of Contract Application and Trust Dynamics (Second RQ)

Results showed a clear impact of trust dynamics on mode of application.
- SSH: **Rigid mode**: Graph unwilling to adjust milestones, target dates, ... Jet unwilling to adjust the task division and information flows. This coincided with negative goodwill trust dynamics at the managerial level.
- ESH: **Flexible mode**: Graph adjusted the target dates and milestones and Jet management was willing to further increase information flows and overlap in task activities. This coincided with positive goodwill trust dynamics at the managerial level

This leads to the following proposition:

Proposition 2
In an exploratory R&D alliance, positive (negative) goodwill trust dynamics at the managerial level increase the probability of flexible (rigid) contract application.

However, the results show that even after positive trust dynamics emerged, the contact remains an important safeguarding and coordination device. To in contrast to what other studies found, in positive trust environments, formal contracts are not necessarily pushed to the background. Constant checking whether the partner is in line with the contractual arrangements is important.

There is a risk of negative reinforcing cycles between contract application and trust dynamics, but it can also result in positive reinforcing cycles.

➔ Example negative reinforcing cycle: Rigid application in SSH reduced the opportunities for joint sense making, which in turn increased suspicion of Graph's management about the intentions of Jet management and they pressed the contractual target dates even harder. Jet started to deliver low quality, which in turn led to lower expectations of Graph about the feasibility of the project.

➔ Example positive reinforcing cycle = ESH alliance.

This leads to the following propositio,:

Proposition 3

In an exploratory R&D alliance, a rigid (flexible) application of the contract is likely to trigger negative (positive) trust dynamics at both operational and managerial levels, which in turn leads to increasing rigidity (flexibility) regarding contract application.

6. Toward an integrative perspective on alliance governance

(Discussion of the theoretical implications of the findings)

Connections between Structural Design and Relational Dynamics within Transactions

- This study points to relational processes at the operational level as important intermediary processes between contract design at the governance level and goodwill trust dynamics at the managerial level instead of treating the operational levels as a black box
- This study provides a different perspective on the role of goodwill trust in governing alliance transactions:
- This study does not find evidence that positive goodwill trust dynamics substantially reduced the importance of contracts.
- They found strong indications that positive goodwill trust dynamics allowed for a flexible approach to contract application.
- The data of this study suggest that in the case of negative goodwill trust dynamics, a rigid mode of contract application is likely to emerge.

Therefore, this study does not want to refer to goodwill trust as an alternative governance mechanism for contracts, but rather as a condition that determines how contracts are applied.

Connections between Relational Dynamics and Structural Design between Transactions

- **Learning experiences** in previous transactions trigger a need to change contract content in subsequent transactions. The partner with a greater distribution of power is able to affect structural design more than the partner with less power.
- In the case of asymmetric learning experiences (e.g. only one partner perceives a need to change the content of a contract), a partner will primarily be able to effect such a shift if it has the necessary relative **bargaining power** to do so.

- This study questions the role of goodwill trust as a necessary condition for continuing interfirm relationships over different alliance transactions because this case study provides an example in which, despite the negative goodwill trust dynamics in previous transaction, the managers of both partners negotiated a new contractual transactions. **Mutual interdependence** and **competence trust** might be more important conditions.

7. Conclusion

This study clearly shows that structural and relational aspects are inherently linked and mutually influence each other, both within and between transactions.

1. It provides a process-oriented view of the relationship between contracts and trust.
2. It conceptualises goodwill trust as a condition that determines how contracts are applied.
3. It defines the contracting process as an incremental learning process that is sensitive to changes in relative bargaining power.
4. It points to mutual interdependence and competence trust as crucial conditions for subsequent transactions.

20. Lead Users : An important source of novel product concepts - *von Hippel E.*

1. Marketing research constrained by user experience

Problem

Users selected for consumer and industrial market analyses have an important limitation: their insights into new product needs and potential solutions are constrained by their own real-world experience. Subjects who use an object or see it used in a familiar way are strongly blocked from using that object in a novel way. Consequently, they are poorly situated with regard to the difficult problem-solving tasks associated with assessing unfamiliar product and processes.

Example:

When making a switch from oven to microwave cooking this is likely to cause new patterns like food recipes and kitchen practices. In the market analyses users must evaluate the new product's potential contribution to new usage patterns and this is clearly very difficult, particularly oven-users, whose familiarity with the oven interferes with their ability to evaluate the microwave.

Marketing research techniques

Even in sophisticated consumer marketing research techniques like multi-attribute mapping the constraint of users to the familiar (the problem) pertains.

Example of multi-attribute marketing research methods:

A list of attributes is given for a specific product category and users can be asked to give a grade from 0-10 for each attribute.

These methods do not offer a means of going beyond the experience of the users interviewed because of three reasons:

1. Users are not well positioned to evaluate novel product attributes which lie outside the range of their real-world experience.
2. There is no mechanism to induce users to identify all product attributes potentially relevant to a product category, especially when these are currently not present in any existant category member. To illustrate this point, consider two types of such methods:
   - ➔ **Similarity-dissimilarity**: In this method, consumers needs to specify the ways in which two products are similar or different. This heavily depends on an analyst's qualitative ability to interpret the data and only attributes which exist are being explored
     - *Example:* If a set of cameras is being compared and none has the particular feature of 'instant developing', this feature would not be incorporated and the method would have been blind to the possible value of a 'Polaroid camera'.

- ➔ **Focus group methods**: involves a qualitative discussion which is recorded and reviewed by an analyst. It is unlikely that consumers will identify any novel attribute and this method also heavily depends on an analyst's qualitative ability to interpret the data.
  - *Example:* When a consumer mentions its satisfaction with the time lag between picture taking and the finished photograph, how likely is it that an analyst will take this creative step?

3. This method focuses on a familiar product category. In other words, the analysis is constrained to narrow to a specific product category or topic, which is another restriction.

In **sum**: marketing researchers face serious difficulties when determining new product needs falling outside of the real-world experiences of the users they analyze.

<u>2. Lead users' experience is needed for marketing research in fast-moving fields.</u>

For fast-moving industries, 'lead users', who have real-life experience with novel product of processes, are proposed.

Lead users display two characteristics:

1. Lead users **face needs** that will be general in a market place, but face them months or years **before the bulk of that marketplace** encounters them
2. Lead users are positioned to **benefit significantly by obtaining a solution** to those needs.

Example
A semiconductor producer with a current strong need for a process innovation which many semiconductor producers will need in two years, is a lead user with respect to that process.

The greater a benefit a given user obtain from a needed novel product or process, the greater his effort to obtain a solution, and the greater his need to share his knowledge with inquiring market researchers.

<u>3. Utilizing lead users in marketing research</u>

A **4 step process** makes it possible to incorporate 'lead users' into marketing research.

1. ***Identifying an important trend***

Several methods are used to identify important trends affecting promising markets (f.e. judgment of experts), but it still remains something of an art. Analysts must judge which of many important trends in a market they will focus on.

- ➔ In the case of **industrial goods**, this identification can often be accurate because potential buyers measure the value of new proposed products in economic terms (profit and costs)

- *Example* : Microprocessor chips are getting more capable and less expensive for a given capability every year and this trend is also likely to continue for a number of years.

➔ In the case of **consumer goods**, accurate trend identification is often more difficult because there is often no underlying stable basis for comparison such as that played by economic value for industrial goods.

2. ***Identifying lead users***

Once a firm has identified one or more significant trends which appear associated with promising new product opportunities, the market research can begin to search for lead users:

➔ **Industrial goods**: very straightforward because a firm's position on a range of trends in usually very well known to the industry. Furthermore, industrial good manufacturers only have a few major potential customers.

- *Example:* Semiconductor process equipment makers could seek for (1) those few VLSI memory manufacturers (equipment users) who are actively developing processes for manufacture of denser chips. A user conducting such R&D is probably a lead user because innovation is expansive and (2) the user engaged in it surely expects to reap high net benefit from a problem solution.
- One also must identify the subset of those firms who are not positioned at the forefront of the trend but who are also able to obtain high net benefits from adopting a solution.
- An additional, very practical method is to identify innovators as leading users.

➔ **Consumer goods**: use appropriately designed surveys

- *Example*: Health foods: lead users can be identified by questions concerning the value they place on improvements in the healthfulness of food.

Three important complexities:

1. Lead users should not necessarily be sought within the usual consumer base, they may be consumers of a competitor or totally outside of the industry.
2. It is not required that lead users illumine the entire novel product, process or service which one wishes to develop, only a few, or one attribute can be interesting too.
3. Users driven by expectations of high net benefit to develop a solution to a need, might well have solved their problem already, and no longer feel that need.

3. ***Analyzing lead user data***

Data derived from lead users can be incorporated in market research analyses, using standard market research methods. All need statements, like 'I am unhappy' or 'about this or that', contain information. Moreover, when **users themselves have developed useful solutions** to their needs, this information can be extremely useful (f.e. when I mixed my powdered detergent into a paste and apply it the stain before washing, it helps get things clean).

4. ***Projecting lead user data onto the general market of interest***

The early adopters of a novel product differ in significant ways from the bulk of the users who follow them. Thus, analysts will need to assess how lead user data apply to the more typical user in a target market rather than simply assume such data straightforwardly transferable. In the case of **industrial goods**, the lead users calculate the relative costs and benefits. All users, not just lead users, will make these similar calculations and thus provide a common basis for market projections. On the other hand, market projections of **consumer goods** aren't that simple. One approach involves prototyping the novel product and asking a sample of typical users to use it. Accurate product evaluation occurs when (1) conditions for the user must be similar to the conditions a future user would face, and (2) when the user were given enough time to fully explore the new product and fully adapt his usage patterns to it.

21. Product development: past research, present findings, and future directions - *Shona L. Brown and Kathleen M. Eisenhardt*

Product development (=PD) is critical because new products are becoming the nexus of competition for many firms, PD is a potential source of **competitive advantage**. Because of the fast changing markets proactive PD can influence the competitive success, adaptation, and renewal of organizations. The purpose of this article is to understand the **past literature** about PD, developing a **model of current thinking** and to generate some **future directions**.

Literature review

The article begins by organizing the empirical literature on PD into three research streams[24]: rational plan, communication web and disciplined problem solving. Research within each stream centres on particular aspects of PD

1. The **rational plan** research focuses on a very broad range of determinants of financial performance of the product.
2. The **communication web** work concerns the effects of communication on project performance.
3. **Disciplined problem solving** centres on the effects of product development process.

These three streams complement and somewhat overlap one another, that is why we will blend them into an integrative model of PD.

1) PD as rational plan: this perspective emphasizes that a successful product is the result of careful planning of a superior product for an attractive market and the execution of that plan by a competent and well-coordinated cross-functional team that operates with the blessings of senior management.

- ➔ A product that is well planned, implemented, and appropriately supported will be a success!

A lot of studies did research on this topic and discovered some facts which are important to the success of the products:

- Excellent internal organization
- Market pull
- Products need to be well planned and implemented
- Products need top management commitment
- Products which are built on existing corporate strengths are successful.
- Also product factors such as superior customer value, low cost, reliability, quality, and uniqueness influence the success of a product.
- Finally market factors also influence product success. More recently authors discovered that predevelopment planning and a focus on marketing and R&D are important.

[24] See table1 p.347

➔ Overall, according to this stream of research, successful PD is the result of rational planning and execution. That is, successful products are more likely when the product has **marketplace advantages**, is targeted at an **attractive market**, and is well executed through excellent **internal organization**.

2) PD as communication web: this second stream of PD research centres on **communication**. The better members are connected with each other and with key outsiders, the more successful the development process will be. This stream focuses on 1 independent variable: communication. Two sorts of communication are important for successful PD:

- **External communication**: successful PD teams include **gatekeepers** who encourage team communication outside of their groups, and powerful project managers, who communicate externally to ensure resources for the group. These teams also engage in political (increases resources of the team) and task-oriented (increases the amount and variety of information) external communication.
- **Internal communication** improves development-team performance. Cross-functional teams that structure their internal communication around concrete tasks, novel routines, and fluid job descriptions have been associated with improved internal communication and successful products. So, high internal communication increases the amount and variety of internal information flow, and improves PD performance.

The principal shortcoming of this perspective is that it is so focused on communication by project team members that other factors are neglected.

3) PD as disciplined problem solving: in this third stream of research, successful PD is seen as balancing act between relatively autonomous problem solving by the project team and the discipline of a **heavyweight leader**, **strong top management**, and an **overarching product vision**. The result is a fast, productive development process and a high-quality product concept.

Successful PD involves relatively autonomous problem solving by cross-functional teams with high communication and the organization of work according to the demands of the development task. This perspective also highlights the role of **project leaders** and **senior management** in giving problem solving a discipline – a product vision. This stream portrays product development as a balancing act between product vision developed at the executive level and problem solving at the project level.

➔ In contrast to the rational plan stream, this stream is more specific about the effective organization of work and is more focused on the **development process** and **product concept** than on the financial success of the product.

➔ In contrast to the communication web perspective, this stream has a broader scope and considers the role of suppliers and senior management in addition to project leaders and teams.

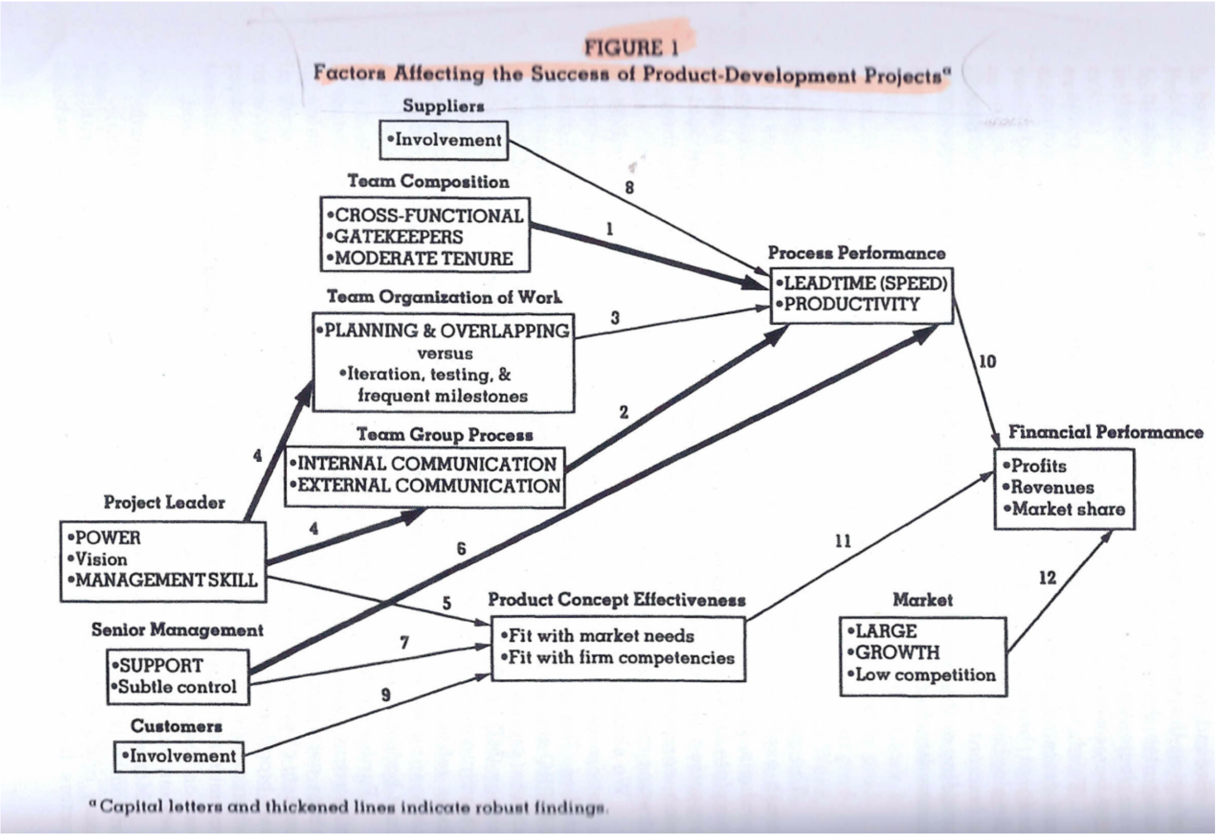
Toward an integrative model of product development

In the previous section, we described three streams of PD research. In this section, we rely on these insights to provide the basis of an integrative model. First we need to understand that the three streams focus on both overlapping and complementary sets of constructs.

Reminder: the **rational plan perspective** (atheoretical) contributes a view of PD, including team, senior management, market, and product characteristics to predict financial success. In contrast, the **problem solving perspective** (cognitive theoretical orientation) has a more deeply focused view on the actual development process. The **communication web perspective** (consistent theoretical view) focuses on a very specific, although important, aspect of PD, namely on internal and external communication by project team leaders.

➔ These streams are ready for a synthesis into an integrative model!

Model Overview: (figure 1!): The idea is that there are multiple players whose actions influence product performance. We argue that the project team, leader, senior management, and suppliers affect **process performance.** The project leader, customers, and senior management affect **product effectiveness.** And the combination of an efficient process, effective product, and munificent market shapes affect the **financial success.**



1. *Project team*: Project team members are who transform vague ideas, concepts, and product specifications into the design of new products. The project team is central to our model of PD.
   ➔ **Cross-functional teams** are critical to process performance, and we define them as those project groups with members from more than one functional area

(engineering, manufacturing,…). The functional diversity increases the amount and variety of information available to design products.

- ➔ **Gatekeepers** are individuals who frequently obtain information external to the group and then share it within the project team. They affect process performance by increasing the amount and variety of information available in the design process.
- ➔ **Team tenure** is also important because teams with a short history together tend to lack effective patterns of information sharing and working together. Teams with a long tenure together tend to become inward focused and neglect external communication. That is why process performance is highest when team tenure is at moderate levels.

2. *Group process:* effective group processes, particularly those related to communication, increase information and so are essential for high-performing development processes.
    - ➔ In the case of **internal communication** frequent communication increases the amount of information and also builds team cohesion. It cuts misunderstandings and barriers to interchange.
    - ➔ In the case of **external communication** frequent communication opens the project team up to new information.

    Internal and external communication both increase the amount and variety of information and the resources available to the project team. These, in turn, improve process performance.
3. *Team organization of work:* for stable and mature products, PD is a complex task for which tactics such as **extensive planning** and **overlapped development** stages are appropriate. In contrast, when there is more uncertainty in the design process, such as in rapidly changing industries, more experiential tactics, including frequent iterations of product designs, **extensive testing** of those designs, and **short milestones** improve process performance. Under conditions of uncertainty it is not helpful to plan.
4. *Project leader* is the key person in the development process. He is the bridge between the project team and senior management.
    - ➔ One central characteristic is **power**. By powerful leaders we mean those project leaders with significant decision-making responsibility, organization wide authority, and high hierarchical level. Such leaders improve process performance.
    - ➔ Another characteristic is **vision**. This involves the cognitive ability to mesh a variety of factors together to create an effective, holistic view and to communicate it to others.
    - ➔ Project team leaders also are **small-group managers** of their project teams.
5. *Senior Management* is important as well.
    - ➔ Senior management **support** is critical to successful product-development processes. By support we mean the provision of resources to the project team, including both financial and political resources.

- ➔ **Subtle control** is also important to superior process performance and effective products; it involves having the vision necessary to develop and communicate a distinctive, coherent product concept.

6. *Suppliers and customers:* Extensive **supplier/customer involvement** in product design can cut the complexity of the design project, which in turn creates a faster and more productive product-development process.
7. *Financial success:* The previous discussion linked the key players in PD to process performance and product effectiveness. In this section we will predict the **financial performance** of the product.
   - ➔ A **productive process** means lower costs and thus, lower prices, which leads to greater product success. Second, a faster process creates strategic flexibility and less time to product launch, both of which may lead to financially successful products.
   - ➔ The second predictor of the financial success is **product effectiveness.** Product characteristics such as low-cost and unique benefits and fit-with-firm competencies create financially successful products.
   - ➔ The third link ties a **munificent market** (large and growing market with low competition) to financial success.

Agenda for future research

Although many of the concepts presented in Figure 1 have been well studied, some concepts have been less sharply defined; these shortcomings present research opportunities.

- ➔ One research opportunity is to examine the **primary links of the model** (links among process performance, effective product, market factors, and financial performance). These links have been primarily examined in the rational plan research stream. However, the validity of these links is tenuous. Thus, a test of thee fundamental theoretical links would be useful. Another related opportunity is to examine whether process performance, product effectiveness, and munificent markets are actually **independent variables.**
- ➔ A second area of research is the **organization of work.** Two models have emerged to describe alternative organizations of work. One is the well-studied model that includes extensive planning and overlapped development stages. A more recent model, related to improvisional thinking, emphasizes experiential product development such as frequent iterations, testing, and milestones, yet this second model has received only limited empirical examination.
- ➔ Third, our understanding of how senior managers affect development is incomplete. They are consistently found to be important contributors to project success. However, the management-related concepts in Figure 1 such as vision, subtle control, and even support are vague.

Conclusion

Product Development is the nexus of competition for many firms as well as the central organizational process for adaption and renewal. The article has 3 conclusions:

1. PD literature can be organized into three streams of research: PD as rational plan, communication web, and disciplined problem solving.
2. We conclude that these streams can be synthesized into a model of factors affecting PD success.
3. We conclude that there are research implications for the future based on the mixture of support for various findings in the model.

22. Communication Networks in R&D Laboratories - *Allen T.J.*

1. Introduction

Automated transmission of scientific and technologic information in R&D laboratories have been notable for their failure. The reason is not the lack of attention to the problem, but more the nature and complexity of the information itself. Additionally, every user in the lab has its own needs of information. Therefore, the use of colleagues for information is strongly related to scientific and technological performance.

2. The study

8 pairs of individuals from different organizations, but working on identical problems were compared to which of them consulted with colleagues. They made a difference between "low" and "high" performers, making a comparison possible for behaviour leading to low or high performance.

Results show that **high performers make increased use of technical information consulted by colleagues**. Not only the frequency of consultation is greater, also the time in discussion with colleagues is significantly larger. In addition, through the wide range of contact within his specialty the performer is less likely to miss an important development, which might have some impact on the problem to which he is assigned.

3. Support from outside the project: the paradox.

Given the benefits of internal consultation, we would expect that project members rely heavily on technical staff for information. A study done by Allen contradicted this. Project members obtain more outside firms than inside, although they mark poor performance.

We might expect that a person returns more frequently to those channels that reward him most consistently. Regarding the data, often the opposite is true. This **paradox** can be resolved if we add another parameter. A person will repeat a behaviour that is rewarded more frequently than one that is unrewarded, only if the **cost** to him is less than the cost of the unrewarded behaviour. This high cost associated with colleague consultation can be the fact that it is hard to admit that one needs help.

4. Technological 'gatekeepers'

Studies indicated that technologists do not read very much. Literature is not a very effective vehicle for bringing new information into the organization. Although outside contact is very heavily used among technologists, it's not more instrumental than literature. This is because a technologist cannot communicate effectively with outsiders. How then does information enter the organization? The first clue is that, of all information sources, only one appears to satisfactorily meet the needs of R& D project members. And that one **source is the colleague**. A lot of studies show this.

The **process by which organizations most effectively import information is an indirect one**; there are a small number of key people whom others rely very heavily for information. We call these people the "**technological gatekeepers**". They differ from their colleagues in their orientation toward outside information sources. He reads more and has broader-ranging and longer-term relationships with technologist outside of their organization. The technological gateway keeper mediates between his organizational colleagues and the world outside. And he effectively couples the organization to scientific and technological activity in the world at large.

5. **Networks of gatekeepers**

A communication network can be characterized according to the connectivity among the nodes[25]. And there are different degrees of connectivity. In a strong communication network, a potential exists for the transmission of information between any two members of a strong component. Studies have found that:

1. The formation of strong components is not aligned with formal organizational groups.
2. Nearly all of the gatekeepers can be found together as members of the strong component.

The gatekeepers maintain close communication among themselves, increasing their effectiveness in coupling the organization to the outside world. **New information is brought into the organization through the gatekeeper and can be communicated to other gatekeepers and then towards other members of the organization.** The most interesting aspect of this functioning of the organizational network is that it has developed spontaneously, without managerial intervention.

6. **The influence of nonorganizational factors on the structure of communication networks**

The **organization's structure** is a very important determinant of communication patterns. But it's not the sole determinant; there are **2 others** that promote communication:

1. The extension of **informal friendship type relations** within the organization. People are more willing to ask questions of others whom they know, than of strangers. To increase the proportion of people who can be approached for information, management would be well advised to increase the number of acquaintanceships among its technical personnel.
   - ➔ There are a number of ways through which technical people can come to meet one another:
     - i. Interdepartmental projects
     - ii. Transfers within the organization (the most important contribution of the transferred person lies in his ability to make referrals)

[25] See figure p. 324

2. The effects of **geographical location**: The physical configuration of the facilities in which an organization is placed can influence the structure of organizational communication networks. Studies show that probability of communication decays with the distance separating people, which is not too surprising. What is surprising is the sensitivity of probability of communication to distance. The function already reaches its asymptote **within 25 yards** (23m) Furthermore, the amount of difficulty, by way of corners to be turned, indirect paths to be followed, etc. intensify the effect of separation on communication probability.

7. Organizational structure

To encourage communication between project teams and technical staff, separation distances must be kept to a minimum. Effective coordination of all elements of project activity may require that all or most of the team members be located together in a specially assigned place. On the other hand, to maintain the specialists assigned to the project demand that they be kept in contact with the specialist colleagues. This favours them locating within their specialist groups. By consequence, there has to be a **trade-off**:

➔ The longevity of the project may be the key to the trade-off. **Long projects demand functional organization; short-duration projects may be organized on a project basis with all team members located together.**

Functional organization has the undesirable consequence of making intra-project coordination difficult. A possible solution is the matrix organization. It achieves the desired goals of the functional organization without the loss in project coordination. But project and matrix organization have the disadvantage of making communication between functional departments difficult. Transfers and interdepartmental projects can counter that.

In addition, the configuration of the laboratory should be structured in a way that it eases inter-functional communication. What matters is that interaction facilities must be positioned in a way that they promote **interaction among groups that would not otherwise interact, while at the same time they are not so far removed from any of the groups that they lose their effectiveness**.

8. Conclusion

The importance of technical support to R&D projects is very high. The project must obtain much of its required information from sources beyond its own membership. The best source for this support lies in the technical staff of the laboratory itself (internally). **Direct outside information has been proved ineffective**.

Outside developments are best included by making proper use of existing information systems. This includes the use of **technological gatekeepers** for project support. Outside information can then be delivered to the project quite effectively albeit an **indirect** route. The indirect approach has been proven to be far more effective than the direct approach.

To improve the communication and coordination between projects and their supporting staff, different techniques can be used. A number of formal organizational mechanisms have been described, next to the informal relationships for people to come in contact to one another. Physical location is also an important determinant for interaction.

Finally, all these factors must be properly arranged in order to effectively couple the R&D project to its supporting information system.

23. Organizing for product development - *Thomas Allen*

Introduction

Organizations are always looking for new ways to group activities together to achieve greater efficiency or effectiveness. With few exceptions, management school academics have completely ignored this activity and have failed to come to grips with the need for guidance in organizational form. This study will analyze organizational structure in research, development and engineering functions. Reasons for focusing on product development:

- R&D managers have been most creative in developing new organizational forms (matrix forms, skunk works, ...) and R&D was the first business function to employ large numbers of highly educated, highly specialized personnel.
- Most organisations are structured by grouping people by task, specialty or geography. Corporations for example can be structured by function or product, with either taking the dominant position:
  - Functions dominate[26]: product line groupings under each function
  - Product lines dominate[27]: functional groupings in each product organization

Some background on product development

On level of product development we will look at the history of different organizational forms. We will discuss the underlying rationale and the advantages of certain forms. Finally we will propose **four parameters that determine the optimum form of organization for research, development and engineering**. Positioning an organizational situation along these four parameters will prescribe the organizational structure most suitable for that situation.

A simple model of the innovation process

Innovation is a process that mediates between two streams of activity:

1. The development of technological knowledge
2. The developing set of market needs

Innovation has to match the drawn information from both streams. (problems without solutions, and a found solution for which you have to search a problem are both unprofitable)

Departmental or functional organization

Organizations can be structured to function well with either of the streams, difficulty occurs when we try to structure to serve both simultaneously. Requirement to align the organization with technology is incompatible with the requirement for a market alignment.

Historically we find product development organizations first aligned themselves with the structure of the technology stream. Technology or technological knowledge is grouped into disciplines or specialties, these are hierarchically structured into sub-specialties (**departmental organization**). This enables the staff to communicate with colleagues in their area of specialization outside the organizations and most important to keep one another

[26] See figure 1 p.3
[27] See figure 2 p.3

informed. (Allen discovered that engineers and even scientists obtain a major portion of their technical information through colleague contact). The system works very well, primarily because until very recently universities have not been called upon to do very much cross-disciplinary research. In industry you do not have this luxury, because it normally requires a blending or integration of knowledge from different specialties to develop even relatively simple products.

This form of organization very soon encountered difficulty in relating effectively to the market. Market needs are defined in the form of products and services, these do not necessarily align with technological specialties or disciplines.

- ➔ *Combining or integrating* knowledge from different specialties to develop a new product requires coordination among the specialists. Difficult to coordinate work of separate specialties that are often required for the development of a new product or service. **Interface problems** (incompatibilities in the relationships or interfaces between different parts of the product.)

Project organization

Here specialists are, at least temporarily, removed from their departments and grouped together in a team under a common boss. They work together in this new organizational form as long as their talents are needed in development of new product or service. This form makes coordination easier. The price comes in the form of separation of the specialists from their knowledge base. Less contact with colleagues from same specialization. Too heavy use of project team organization will lead to a gradual erosion of the organization's technology base.

The matrix organization

Project teams and departments are supposed to interact in a way that accomplishes the necessary coordination, while maintaining current knowledge in the relevant technologies. This is not easy to implement, often tension between project teams and departments. Question how much emphasis to place on project teams and how much need there is to retain departmental structure.

The basic trade-off between departmental organization and project organization

Departmental organization	Project team
Knowledge base	Coordination
Coordination	Knowledge base

(green is good, red is bad)

The need for knowledge

If a technology is not developing very rapidly staying, current is not so difficult. Those working with mature, stable technologies are not as impelled to communicate with colleagues and stay current. The rate at which knowledge advances is a very important parameter determining organizational structure. Rapidly changing technologies on the other hand, makes that old knowledge becomes quickly outdated and there is a strong need to keep up.

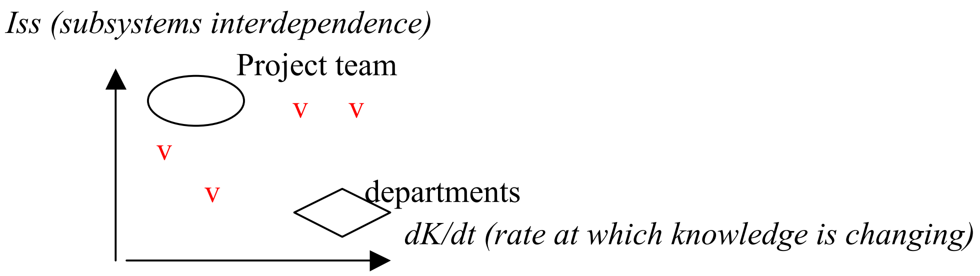
➔ **Rate at which knowledge advances (dK/dt)** is a very important parameter determining organizational structure.

The need for coordination

Need for coordination varies as well. When the work of several specialists on a project is highly interdependent, coordination becomes critical. This is reflected in the product. Parts vary in their degree of interdependence with other parts. So coordination required is not necessarily distributed evenly over the project team. So parts require more coordination than others.

➔ **Interdependence** is a second parameter when deciding an organization's structure.

The organizational structure space



Most organizations will have a mix of product developments underway at any time, some of these will employ primarily mature stable technologies, others will use dynamic technologies. **Interdependence** will also vary across product developments. Every point on the graph represents an individual engineer or scientist. Its position is determined by the average degree of interdependence between that person's work and the work of others engaged in the development, and by the rate at which the individual's knowledge base is changing. The round and the rectangular show two extreme cases: one with mature stable technologies and high interdependencies, the other with dynamic technologies and low interdependencies. These two developments should be organized differently. As discussed earlier **high interdependence and low knowledge change calls for project teams and the opposite for departments because of coordination and knowledge requirements**. Obviously there is always need for some point of overall responsibility, always some coordination necessary, so need for project manager, with the individuals in separate departments receiving some degree of direction or at least guidance from that project manager (**weak matrix organization**)

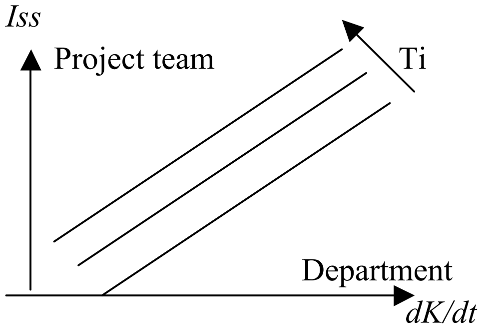
The individuals (v) are not in some extreme space, but spread all around, they would be working together on a development that combined a variety of technologies with different levels among them of interdependence and rate of change of knowledge. This certainly seems to require a combination of organizational structures. Some people could be organized in a project team, while others were left in departments, depending upon their location in space.

➔ Some **boundary** must divide the space into two regions. Individuals positioned in one region would be organized in a project team. Those in the other region would be kept in their specialist department.

Project duration

Where does the boundary lie and what determines its position? The answer to this question introduces the third parameter of organizational structure. This is time to market, project duration or more precisely the length of time that any engineer or scientist is assigned to work on the project. For exceptionally long project team assignment an engineer may fall behind in even a moderately dynamic technology, in very short project team assignments even those dealing with the most dynamic technologies will not fall behind in their state of knowledge.
So the longer the project the larger the region in which departmental organization produces higher performance and the greater the number of people who should be retained in their departments. **For shorter projects the same applies to project teams**.

➔ **Time to market** is the third parameter.



Measuring the parameters

We cannot provide precise scales for the three parameters, but we will give some guidance toward developing scales.

- ***Rate of technology change***

A good indicator of the rate at which knowledge is developing is the half-life citations or references in the articles contained in journals treating this specialty.

➔ For example: If half the citations in a given journal are to articles published within the previous two years, the knowledge contained in the articles of that journal would be developing at a rate faster than that in a journal whose citation half-life is ten years. Now the manager has the ability to compare different specialties along this dimension.

- ***Interdependence***

While partitioning the overall problem and making task assignments, the wise project manager attempts to partition at points of minimum interdependence. The measurement of interdependence has been formalized in what is called the **Design structure Matrix**. Here interdependence is measured in terms of **expected and required information flows**. A project is first partitioned into subsystems or subproblems and a matrix is laid out, relating tasks to one another. When one task requires information from the output of another task, this is indicated in the cell connecting the two in the matrix. The marginal values from the matrix can be used to measure the degree of interdependence of any task with al the other tasks in a given project.

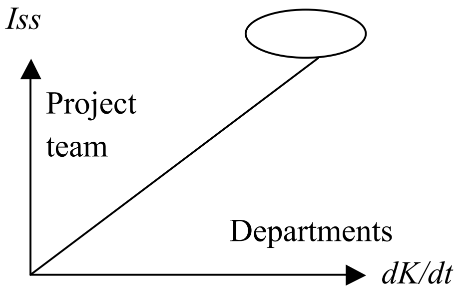
- ***Project duration***: easily determined.

Normal industrial practice

These rules are not normally followed. Normal industrial practice ignores rate at which technologies are evolving and project interdependencies. Organizing is based entirely on project duration. Short term developments, projects of three to six months, people are left in departments. It is considered too disruptive to form project teams. For long term projects from 5 to 6 years project teams are formed.

Project teams are formed for long direction projects and departmental organization is used for short projects. This is completely opposite of the recommendations from theory. It fails to take into account the relation between project duration and the loss of specialized knowledge. It thus results in the decision going the in a direction opposite to what the previous theory would dictate.

High interdependence AND rapid technology change



There is no clear way to classify on the basis of project duration for cases in the balloon with both high interdependence and rapid technology change. Two ways to deal with this:

1. Try to re-partition the basic problem to reduce interdependencies
2. Cycle staff between project team and departments for short periods of time to prevent them from being away from either their project team of departmental colleagues. This enables them to keep up with their disciplines while still being able to coordinate reasonably with other team members.

➔ Price for this is considerable disruption of the project.

The market

Customers' and society's need change in many different ways and at different rates. Markets vary in their dynamism, just as technologies do. This has implications for organizational structure. The project team form is better able to cope with rapidly changing market, as it has a single, well-defined interface with the market. The more rapidly markets are changing, the more one will want to use project teams.

➔ **Speed at which markets change** (**dM/dt**) is the fourth parameter.

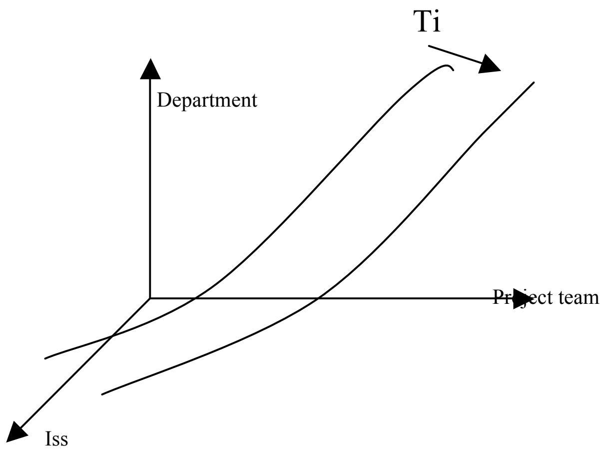
It is more difficult

Shift in technology and shift in market influence each other, new technology gives opportunity for new market or stimulate existing ones, and market changes stimulate technology change (**Market pull vs. technology push**). In the past, the market has provided stimuli for commercially successful innovations but technology push has contributed several important products that have completely changed markets.

Fast market change induces that project has to be completed faster, so affects project duration.

<u>The relationship between market change and technology change</u>

Assume orthogonality. High rate of technology change will make it more important for the project members to remain in their departments. And a dynamic market will be better served by project team organization.



<u>Summary</u>

We now have a rational scheme for defining the appropriate structure for a product development organization. The structure must provide for good communication with both the sources of technical knowledge and of market intelligence. The organization must also enable very complex tasks to be coordinated effectively. These are often conflicting goals.

24. Informal Leadership Roles in the Innovation Process : Human side of managing technological innovation - *Roberts E.B. & Fusfeld A.R.*

Critical Functions: Needed Roles in the Innovation Process

This article examines the main elements of the technology-based innovation process in terms of certain usually informal but critical people functions that can be the key to an effective organizational base for innovation. This approach to the innovation process is similar to that taken by industrial theorists (Taylor) who focused on the production process (e.g. chain of command, division of labour and span of control). Today, these principles of the production process still govern the operation of the modern organization. It has been proved that many corporations' attempts to innovate consequently suffer from ineffective management and inadequately staffed organizations due to an absence of comparable theory. The following sections will characterize how people should perform to innovate effectively.

1. **The Innovation Process**

Six major steps are involved in the technology-based process. Each stage and its activities require a different mix of people skills and behaviours to be carried out effectively.

1. **Pre-project:** The technical work that provides a basis for later innovation efforts. Scientists, engineers, and marketing people find themselves involved in discussions internal and external to the organization (R&D). Technical personnel work on problem-solving efforts in their area of specialization.
2. **Project possibilities:** Arising from the pre-project activities, specific ideas are generated for possible projects, ideas that are considered to be feasible and have success of ideas that are perceptions of possible customer interest in product of process changes. These ideas are originated by technical of marketing personnel of may result from direct contact with customers.
3. **Project initiation:** The innovation process moves into a more formal project initiation stage. Technical ideas are matched with a need in the market. And inevitably, a specific project proposal has to be written up and budgets have to be planned.
4. **Project execution:** One person is responsible to manage the project and execute the activities. Engineers and scientists solve technical problems that arise during the project. Technical people track outside activities and market interest related to project area and keeping project staff up to date. Senior people preserve the project team from unnecessary organizational constraints providing guidance and experience.
5. **Project outcome evaluation:** Intense evaluation to see how the results stack up against prior expectations and current market perceptions.
6. **Project Transfer:** If the project results survive this evaluation, transfer efforts take place and new projects can be undertaken. Key technical people may be shifted to the downstream unit to transfer their expertise. The stages are then repeated until the successful innovation is achieved or until project termination occurs.

2. <u>Needed roles</u>

For an effective execution through all six steps of an innovative effort, five basic critical work roles must be carried out by one or more individuals.

1. **Idea generating**: analyzing and/or synthesizing information about markets, technologies, approaches and procedures.
2. **Entrepreneuring or championing**: recognizing, proposing, pushing and demonstrating a new technical idea.
3. **Project leading**: planning and coordinating the diverse sets of activities and people
4. **Gate keeping**: collecting and channelling information about important changes in the internal and external environments
5. **Sponsoring or coaching**: behind-the-scene support generating function of the protector and advocate and sometimes the 'bootlegger' of funds

Critical functions

These five critical functions represent the various roles in an organization that must be carried out for successful innovation to occur. They are critical from two points of view:

1. Each role is different or unique, demanding different skills
2. Each role tends to be carried out primarily by relatively few individuals thereby making even more unique the critical role players.

Generally, the critical functions are not specified within job descriptions but they do represent necessary activities for R&D, such as problem definition, idea nurturing, information transfer, information integration, and program pushing. Consequently, these role behaviours are the underlying informal functions that an organization carries out as part of the innovation process. It is desirable for an organization to have a balanced set of abilities to carry out these roles.

Impact of role deficiencies

Many organizations suffer because one of the roles is missing. Certain characteristic signs can provide evidence that a critical function is missing.

Idea generating is deficient if the organization is not thinking of new and different ways of doing things. Project leading is suspect if schedules are not met, activities fall through cracks, people do not have a sense for the overall goal of their work or units that are needed to support the work back out of their commitments. Gate keeping is inadequate if people within the organization are not getting the information that they need because it has not been passed on to them. Inadequate sponsoring or coaching often explains projects that get pushed into application too soon or project managers who have to spend too much time defending their work.

The importance of each function varies with the development stage of the project. Initially in pre-project idea generation is crucial, later entrepreneurial skill and once the project is established, leading is needed.

3. Characteristics of the role players[28]

Patterns in the characteristics of the people who perform each innovation function indicate which persons are predisposed to be interested in one type of activity more than another and to perform certain types of activity well.

A significant point here is that the staffing needed to cause effective innovation in a technical organization is far broader than the typical research and development director has usually assumed. Studies indicate that many ineffective technical organizations have failed to be innovative solely because one or more of these five quite different critical functions has been absent.

Multiple Roles

Some individuals have the skills to fulfil more than one critical function in an organization. A common combination of roles is the pairing of gate keeping and idea generating. Another role couplet is between entrepreneuring and idea generating. All of the critical innovative roles, whether played singly or in multiples, can be fulfilled by people from multiple disciplines and departments.

Career-spanning role changes

People are likely to contribute differently at different stages in their career. This does not reflect a change of personality, although such changes do seem partly due to the dynamics of personal growth and development. For instance a young potentially multiple role contributor enters a company, what roles can he play? None, because he is inexperienced, has no feeling with the company, etc. So for many young professionals the job environment moves too slowly from encouraging idea generating to even permitting entrepreneurial activities.

4. Managing the critical functions for enhanced innovation

To increase organizational innovation, a number of steps can be taken that will facilitate implementation of a balance among the critical functions.

Manpower planning

The critical functions concept can be applied usefully to the recruiting, job assignment and development or training activities within an organization. In recruiting, an organization needs to identify not only the specific technical or managerial requirements of a job, but also the critical function activities that the job requires. To match a candidate with the job, recruiting should also include identification of the innovation skills of the applicant.

[28] See table p.279

Performance measures and rewards

We all tend to do those activities that get rewarded. It is important to recognize the distinct contributions of each of the separate critical functions. Rewarding an individual for the performance of a critical function makes the function both more discussable and manageable. However, what is seen as rewarding for one function may be seen as less rewarding, neutral or even negative for another function because of the different personalities and needs of the role fillers.

The preceding sections demonstrate that the critical functions concept provides an important way of describing an organization's or a project team's resources for effective innovation activity.

It is clear that all five functions are essential to innovation and it is the very rare person who can do all five equally well, the clear need for a new kind of teamwork was also developed. The critical functions concept provided the framework for the selection of people and the division of labour on the 'innovation team' that became the nucleus for all new R&D programs. In summary, to the extent that innovative outcomes, rather than routine production, are the outputs sought, we have confidence that the critical functions approach will afford useful insights for organizational analyses and management.