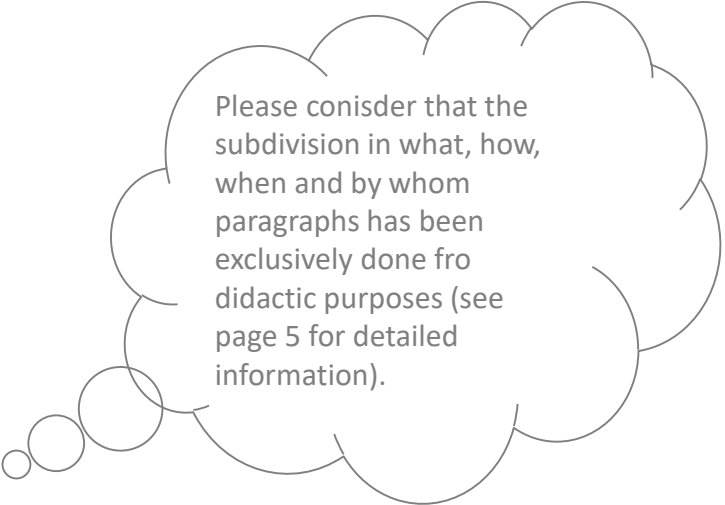


The framework of technological innovation

The framework of technological innovation - index

Contents

- **Introduction**
- **«What»**
 - **technological innovation's targets**
 - **product's and process' innovations**
- **«How»**
 - **incremental and radical innovations**
 - **modular and architectural innovations**
 - **link with organization's characteristics.**
 - **companies classification towards innovation.**
 - **open innovation**
- **«When»**
 - **life cycle's curves**
 - **punctuated Equilibrium Model**
 - **the evolution of innovation's processes**
- **«Whom (by)»**
 - **resistance to change and communication**
 - **creativity**
 - **entrepreneurship**



Please consider that the subdivision in what, how, when and by whom paragraphs has been exclusively done for didactic purposes (see page 5 for detailed information).

The framework of technological innovation - introduction

Look at next page's cases.

- what one should take into account passing from one product or from one process to another? By the way, why the question is «from one product or from one process to a another»?

May be you've been able to give an answer, but ...

- do you think that your answer is exhaustive?

I see you're in doubt, and you're right, so ...

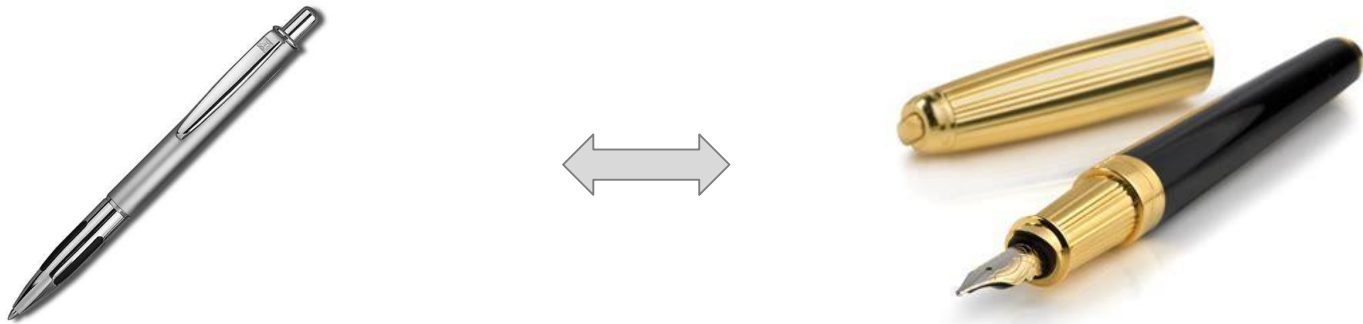
- do you think that the application of MOT concept would be suitable in order to carry out a complete analysis?

I got you answered «yes», that's ok. Anyway, why you said «yes»? May be because the MOT issues outline an effective analysis process and that's ok as well. Anyway, in order to do it you need to deepen your knowledge, isn't it?

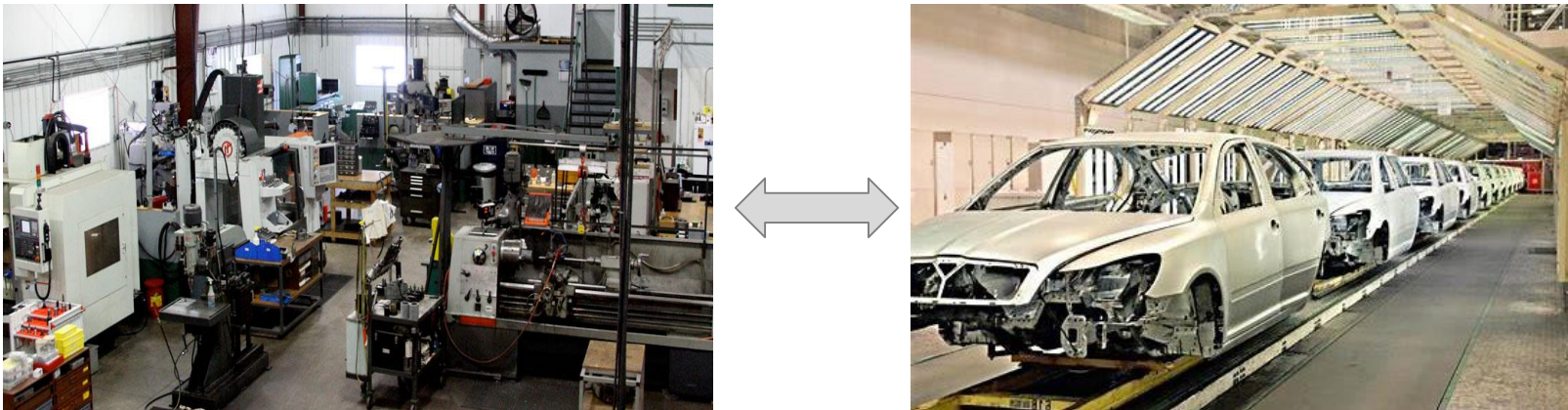
This lecture's note is just in order to help you about.

The framework of technological innovation - introduction

- ... from a product to another



- ... from a process to another



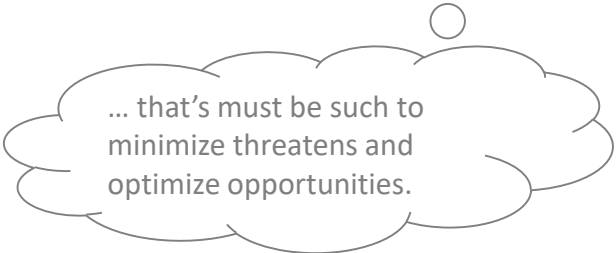
The framework of technological innovation - introduction

Now, just with the aim to give you some useful information that could be useful for your analysis on the technology you could implement (in other words: information useful for MOT concepts' deployment), it would be useful to focus some issues that have been summarized as:

- «**what**» → what process and/or product is the technology directed towards?—May be some opportunities could arise by the implementation of the new technology?
- «**how**» → what's the innovation's depth? Looking at my company, which technology could it approach? Would the approachable one be effective?
- «**when**» → when should I consider the implementation of new technology?
- «**by whom**» → whom innovation can spring by? What should be people key characteristics?

The framework of technological innovation – «what»

- There isn't any undoubted answer about the objectives of technological innovation. Such issue is quite sensible if you take into account that a priori the aim of a technological innovation must be consistent with a company's strategy, that's in a specific company it could be to consider all the innovation's factors. ◦



... that's must be such to minimize threatens and optimize opportunities.

- In other words:
 - in order to have a thorough view one must consider several proposals of technological innovations' classifications.
 - anyway, thinking at the correlation between technological innovation and organizational change, managerial tools must almost always be updated.

The framework of technological innovation – «what»

➤ 1° classification

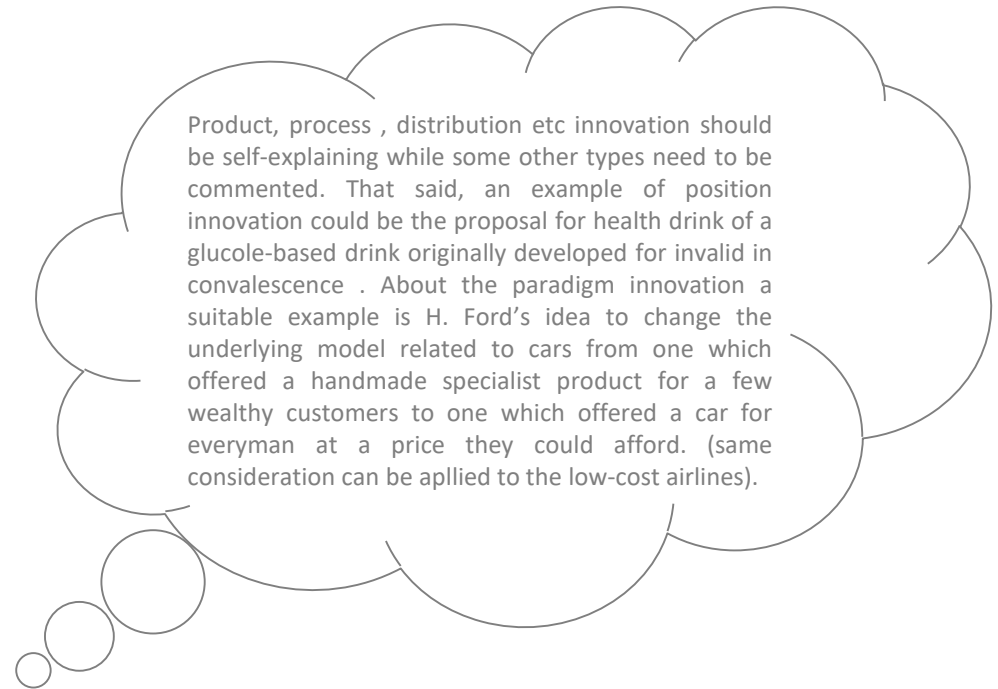
- **product** technologies
- **production** technologies
- **distribution** technologies
- **information** technologies
- **management** technologies

[F. Betz - Managing technological innovation]

➤ 2° classification

- 'product innovation' – changes in the things (products/services) which an organization offers;
- 'process innovation' – changes in the ways in which they are created and delivered;
- 'position innovation' – changes in the context in which the products/services are introduced;
- 'paradigm innovation' – changes in the underlying mental models which frame what the organization does.

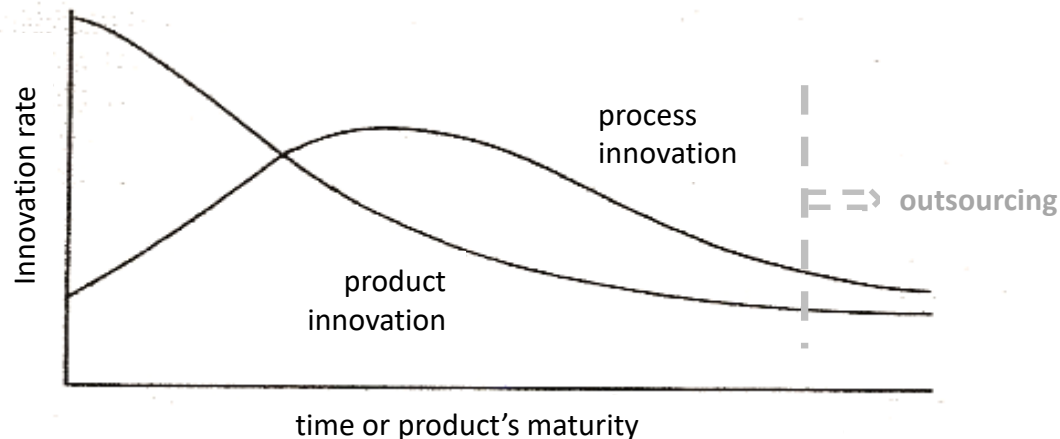
[J. Tidd, J. Bessant, K. Pavitt – Managing Innovation]



The framework of technological innovation – «what»

Just some important comments:

- usually an innovation type involves some other types. For instance, a product innovation implies a certain degree of process' updating and, may be, of distribution, management etc, technologies.
- by the way, it's to note the link between product and process innovation, as shown by the below picture (see «life curves» as well, page 23).



- It's also to note that when a product become a commodity (a commodity is a product whose production process is easily accessible) the whole is outsourced, so «outsourcing» is another issue to be contemplated in technology management .

The framework of technological innovation – «what»

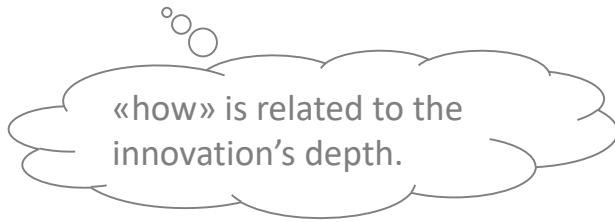
Some other hints are specifically related to processes' innovation, about which the question is «which process should the priority be given to»? The answer is related to the status of the process.

Figure 2-1 Key Activities in Identifying Processes for Innovation

- Enumerate major processes
- Determine process boundaries
- Assess strategic relevance of each process
- Render high-level judgments of the “health” of each process
- Qualify the culture and politics of each process

[T. Davenport - Process Innovation]

The framework of technological innovation – «how»



Now, looking at the black pen on the left, is there more difference between group 1 pens or group 2 ones? ... The answer is easy!

The framework of technological innovation – «how»

... the answer is easy, and it helps us to introduce the concept of the **innovation depth/intensity**, that's, as first step, can simply get distinguishing between:

- **incremental innovation**: Incremental innovation is a series of small improvements or upgrades made to a company's existing products, services, processes r methods → ... so **it means to do better what is done.**



... incremental innovation is linked to the **continuous improvement** concept.

- **radical innovation**: supplant existing products, services, processes r methods → ... so **radical innovation is new to the company's world.**

The framework of technological innovation –

«how»

➤ ... but where the small improvements related to incremental innovation come from? The answer is easy: being the incremental related referred to what is done they will come from the experience gained by the people who work on current products, services etc. By the way, the incremental innovation gets importance when several improvements steps are done, so it needs the commitment of many people.



**the incremental innovation
process is bottom up**

➤ ... and what about the radical innovation? Being related to new things, (generally speaking) radical innovation can't come from people involved on what is done. but from technicians, researchers etc. And whom are such technicians committed from? They can be committed just from the company's top level, which decided that the «some new things» are vital for the company.



**the radical innovation process is
top down**

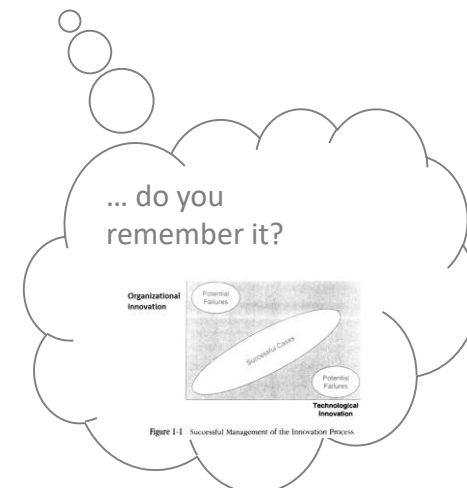
The framework of technological innovation –

«how»

the incremental innovation process is bottom up

- What does in practice mean bottom up and top down?
- They're referred to the communication's flow, so «bottom up» means that the flow is from the workers (blue collars, clerks etc.) to the managers and «top down» from the managers to the workers.
- **Why should workers give information (that's improvement suggestions) to the managers or pay attention to the the management's indications?**
- **That's the key question, it depends by the management's ability to innovate itself in a consistent way, that's to impact on organizational behaviour.**

the radical innovation process is top down



The framework of technological innovation – «how»

... as additional information of the previous page

Figure 1-3 Process Improvement versus Process Innovation

	<i>Improvement</i>	<i>Innovation</i>
Level of Change	Incremental	Radical
Starting Point	Existing process	Clean slate
Frequency of Change	One-time/continuous	One-time
Time Required	Short	Long
Participation	Bottom-up	Top-down
Typical Scope	Narrow, within functions	Broad, cross-functional
Risk	Moderate	High
Primary Enabler	Statistical control	Information technology
Type of Change	Cultural	Cultural/structural

[T. Davenport - Process Innovation]

The framework of technological innovation – «how»

Another classification of innovation depth refers to the «modular design» in confrontation of «integral design».

Now, modular design is based on modules, which can be meant as base components whose insertion in a defined architecture lets the achievement of the an innovated product or service (typical modular products are Ikea furniture).



That said, there are:

- **two possible innovation's lines: on modules and on architectures,**
- **... and two possible innovation intensity, again incremental or radical.**

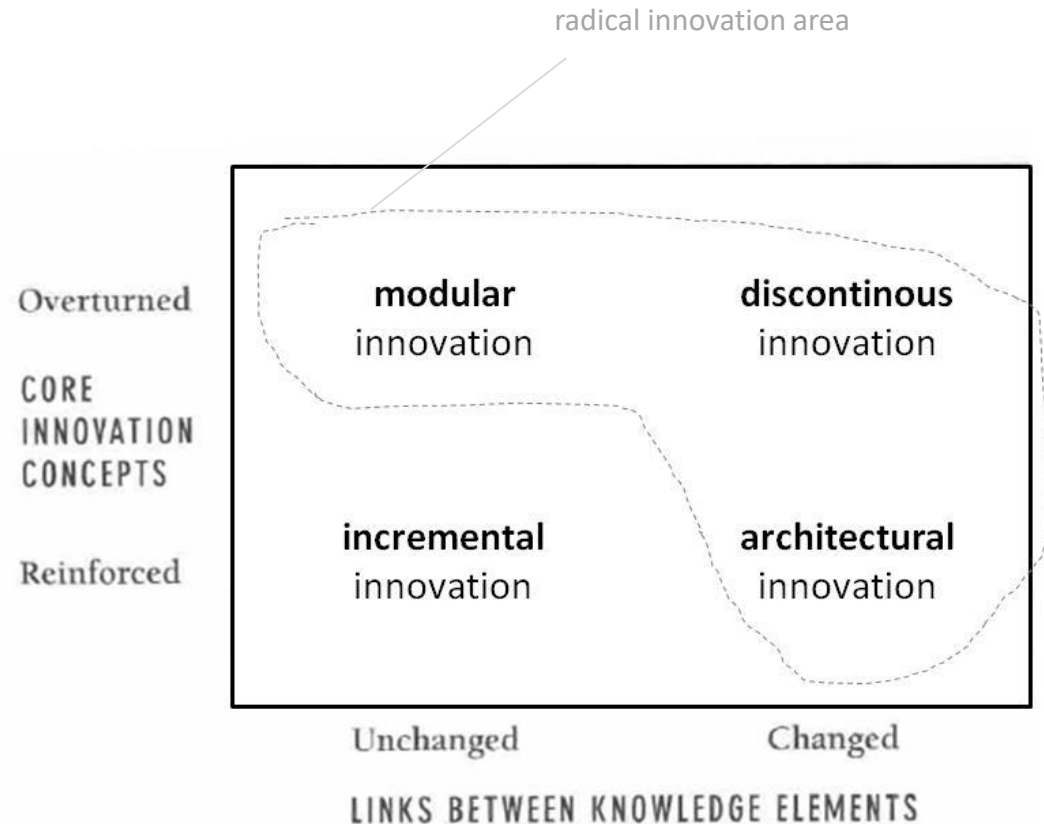


FIGURE 1.4 Component and architectural innovation

[J. Tidd, J. Bessant, K. Pavitt – Managing Innovation]

[elaborato da J. Tidd, J. Bessant – Managing Innovation]

The framework of technological innovation – «how»

Now:

- first cars manufacturer in the world should have been AC in the UK, in 1904 (it just closed in 1908).
- first producer of aspirine has been Bayer AG in 1899
- first mobile phone has been developped by Motorola in 1973 and marketed by BellSouth in 1994.
- ...

That said how many producers of cars, aspirine, mobile phones are there now?

- Important manufacturers for cars should be about eight-ten (but one century ago only in the US they were seventy).
- the aspirine's producers now could be hundreds,
- Wikipedia lists no. 159 mobile phone's manufacturers.



A question arises:

- **Why some companies are the first and some others follow?**
- The answer isn't easy ... **anyway one could sensibly say that it depends by companies' strategies and characteristics** (may be by fotuitousness as well). A classification od companies toward innovation is given on next page.

The framework of technological innovation – «how»

So, another answer to «how innovate» is related to the companies' wills and opportunities to be:

- pro-active
- active
- reactive
- passive

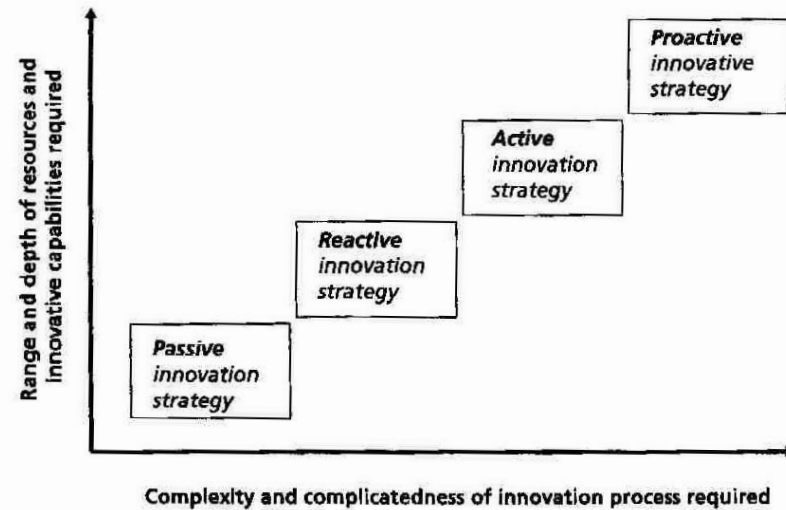


Figure 4.2. Four levels of innovation strategy

	Proactive	Active	Reactive	Passive
Objectives	Technological and market leadership	Not being first to innovate, but being prepared to follow quickly	Wait and see. Follow a long way behind	Do what is demanded by customers or dominant firms
Type of technological innovation	Radical and incremental	Mainly incremental	Entirely incremental	Occasionally incremental

[M. Dodgson, RD. Gann, A. Salter - The management of technological innovation]

The framework of technological innovation – «how»

«So, the key point is the choice to be pro-active rather than active or reactive?»

«Yes and no! “Yes” because choices depend by a sound company’s policy, “no” as such policy (naturally) depends by the **company’s dimension and by the business sector** it belongs».



- **Generally speaking communication (that’s targets’ sharing) is better in small companies, viceversa such companies have a poorer vision on external systems and lower access to resources.**
- **On the other hand, pro-active strategy can be mainly typical of chemical and pharmaceutical sector (for instance: the introduction of new active ingredient) or spring from radical break-through of products or services (for instance: the initial friendliness of Apple devices when it proposed McIntosh system).**

TABLE 2.2 Advantages and disadvantages for small firm innovators

Advantages	Disadvantages
Speed of decision making	Lack of formal systems for management control, e.g. of project times and costs
Informal culture	Lack of access to key resources, especially finance
High quality communications – everyone knows what is going on	Lack of key skills and experience
Shared and clear vision	Lack of long-term strategy and direction
Flexibility, agility	Lack of structure and succession planning
Entrepreneurial spirit and risk taking	Poor risk management
Energy, enthusiasm, passion for innovation	Lack of application to detail, lack of systems
Good at networking internally and externally	Lack of access to resources

[J. Tidd, J. Bessant, K. Pavitt – Managing Innovation]

The framework of technological innovation – «how»

- Anyway, one could ask «Taking the choice not to be passive, how a company should work? What's the key factor?»
«The key factor is to pay attention to what is happening, in other words: to be **keen on learning**»

- «In practice what does "keen on learning " mean? How to implement it?
«the implementation of "keen on learning" springs from the deployment of "search + select + implement" phases and by the systematic application of the deployment output (see next page for instance)».

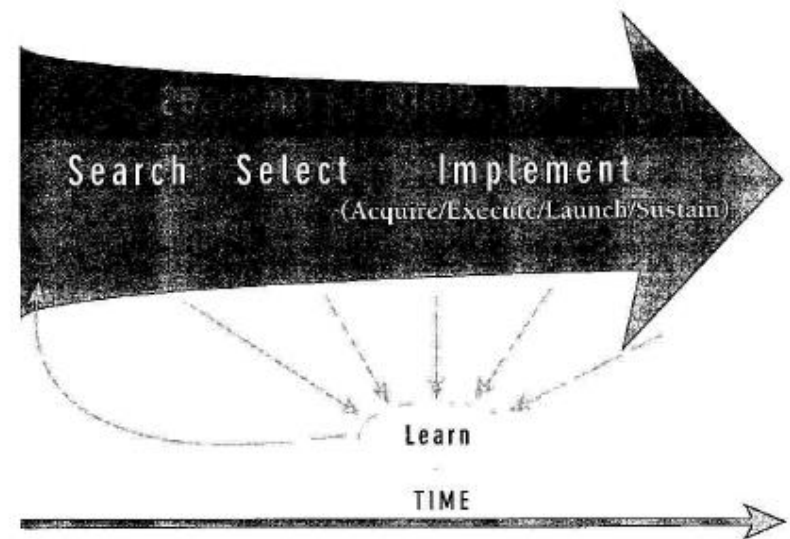
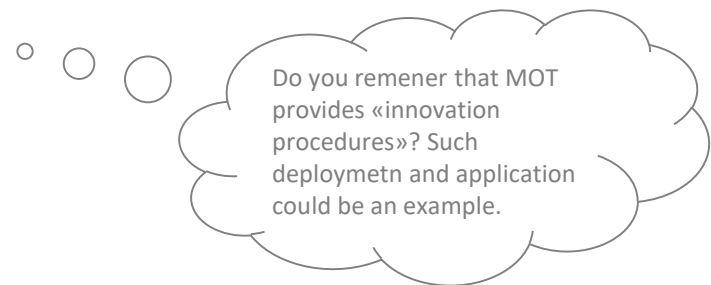


FIGURE 9.1 Innovation process model

[J. Tidd, J. Bessant, K. Pavitt – Managing Innovation]



The framework of technological innovation – «how»

➤ Search

- ✓ Define the boundaries of the marketplace
- ✓ Understanding market dynamics
- ✓ “Trend-spotting”
- ✓ Monitoring technological trends
- ✓ Technological forecasting
- ✓ Integrated future search
- ✓ Learning from others
- ✓ Involving stakeholders
- ✓ Involving insiders
- ✓ “Mistakes management”
- ✓ Communication and connection

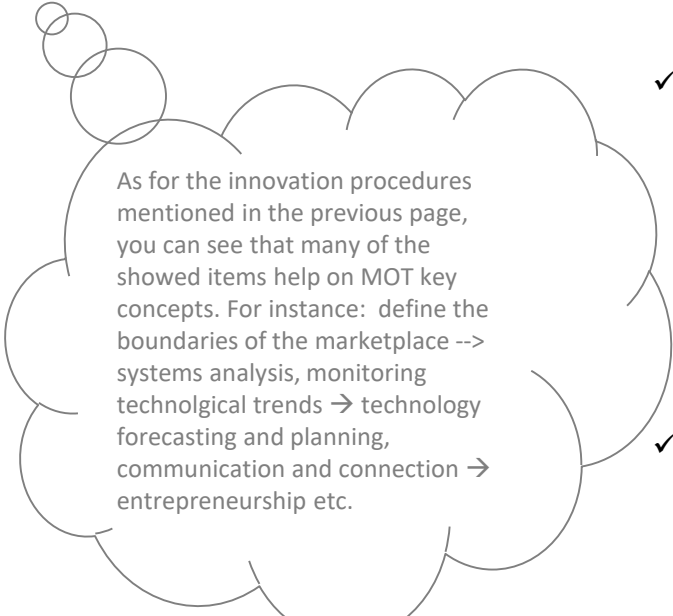
[abstract from]. Tidd, J.
Bessant, K. Pavitt –
Managing Innovation]

➤ Enabling

- ✓ Routines to help strategic analysis
- ✓ Routines to help strategic choice
- ✓ Portfolio management approaches
- ✓ Building a business case
- ✓ Building coalitions
- ✓ Routines to help strategic monitoring

➤ Implement

- ✓ Acquire
 - Key abilities in technology transfer
- ✓ Execute
 - Emerging good practices in implementation of innovation projects
 - Early involvement
 - Concurrent working
 - Appropriate projects structures
 - Team working
 - Shared project vision
 - Advanced support tools
- ✓ Launch
 - Customer testing
 - Test marketing
 - Develop a marketing strategy
 - Develop a marketing plan
 - Develop a support organization
 - Launching into an internal market – change management
- ✓ Sustain
 - Enabling learning and re-innovation



As for the innovation procedures mentioned in the previous page, you can see that many of the showed items help on MOT key concepts. For instance: define the boundaries of the marketplace --> systems analysis, monitoring technological trends → technology forecasting and planning, communication and connection → entrepreneurship etc.

The framework of technological innovation – «how»

An important point related to previous page is the reference to external entities, that is implicitly from many issues showed in the previous page (for instance: learning from others, involving stakeholders, technology transfer etc.). That's subtends the **«need of cooperation»**, whose content is summed-up by **open innovation concept**, showed by the below table.

BOX 6.3

Open innovation

Chesbrough's principles of open innovation can be summarized as:

- Not all the smart people work for you
- External ideas can help create value, but it takes internal R&D to claim a portion of that value for you
- It is better to build a better business model than to get to market first
- If you make the best use of internal and external ideas, you will win
- Not only should you profit from others' use of your intellectual property, you should also buy others' IP whenever it advances your own business model
- You should expand R&D's role to include not only knowledge generation, but knowledge brokering as well

Source: Chesbrough, H. (2003) *Open Innovation: The New Imperative for Creating and Profiting From Technology*, Harvard Business School Press, Boston, MA.

The framework of technological innovation –

«when»

«When do you think that your product or service needs innovation?»

«Simply when some new implementations of scientific discoveries or technical solutions are going to oust them (in other words: when such product or service are outdated)»

«How can you judge them?»

«the **concept of life cycle (or S curve) helps**, that's one could analyze the life-cycle»

Life cycle curve simply divides the life of an item (product or service) into three segments and compares them with suitable performance's indexes. Such segments are:

- New invention period → exponential growth of the performance index.
- Improvement period → linear growth of the exponential index
- Maturity period → exponential decreasing of the performance index

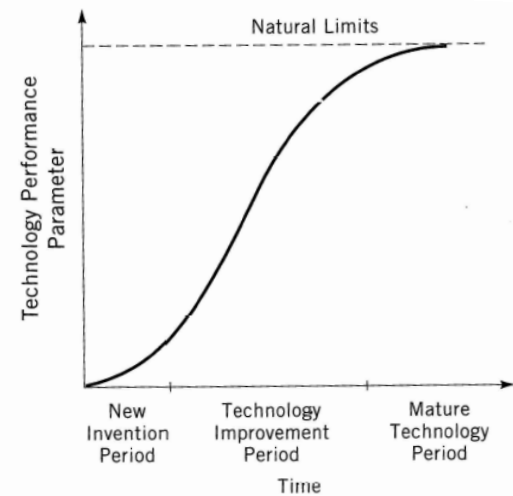


Figure 11.4. (a) Core technology industrial life cycle. (b) Rates of product and process innovations. (c) Technology S-curve for core technology of product system.

[F. Betz - Managing technological innovation]

An item begins its obsolescence after reaching the max of its maturity period.

The framework of technological innovation –

«when»

More in detail:

- after one product has reached got the max of its curve, the life of a innovative product begins.
- the second drawing shows the cases of four yarns (cotton → rayin → nylon → polyester).

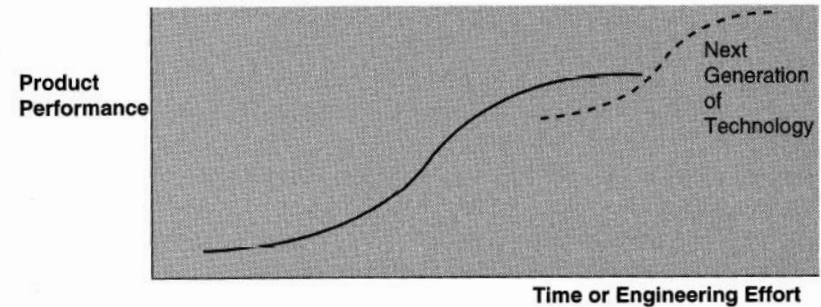


Figure 3-2 The Technology S-Curve

SOURCE: Adapted from C. M. Christensen, 1992.

[J. Etlie- Managing Technological Innovation]

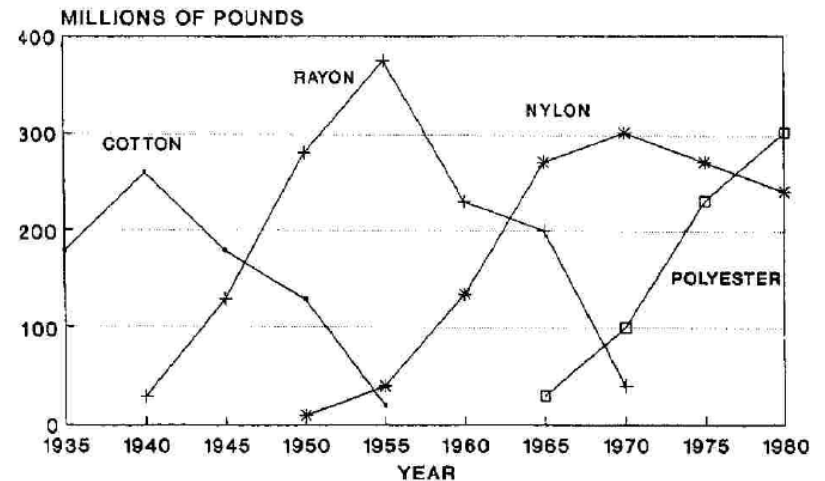


Figure 4.4. Product line lifetimes in tire cord materials.

[F. Betz- Managing Technological Innovation]

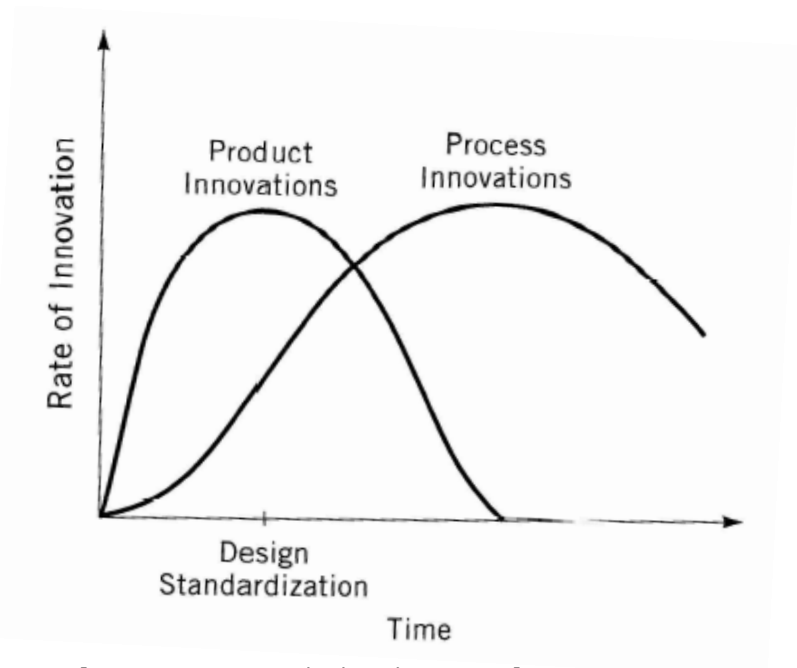
The framework of technological innovation –

«when»

A further important note:

When a product has reached its maturity, efforts are directed to process innovation, that's in order to decrease the cost of the product or in other words to increase the process efficiency

- **during initiation and improvement period the competitiveness of a product is related to its rate of innovation.**
- **after its maturity, the competitiveness of a product is based on its cost's reduction, which is let by the increase of the process efficiency.**



The framework of technological innovation – «when»

Interesting information can come from the **Punctuated Equilibrium Models**, which says that a product is fully innovative when its performances are about two orders higher than the previous ones (the drawings show the cases of aircraft and computers).

Figure 1b. Seat-miles-per-year capacity of the most capable plane flown by U.S. airlines, 1930–

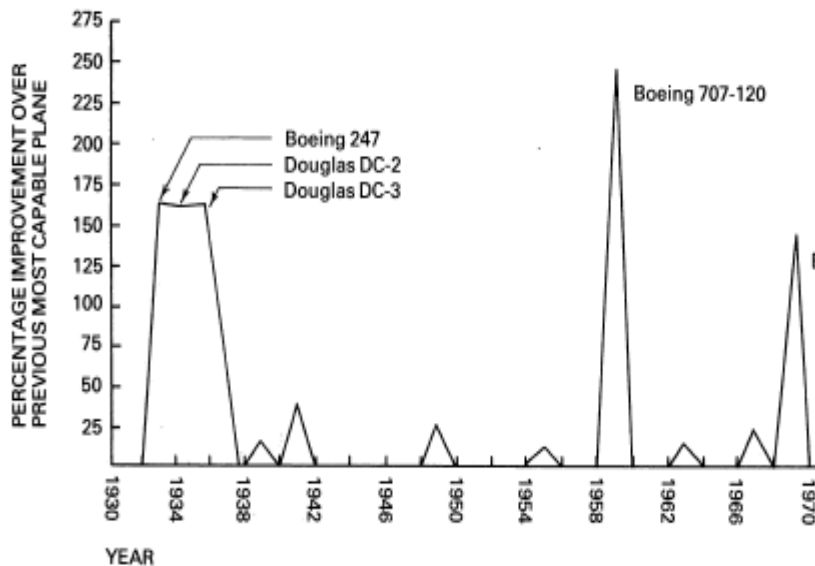
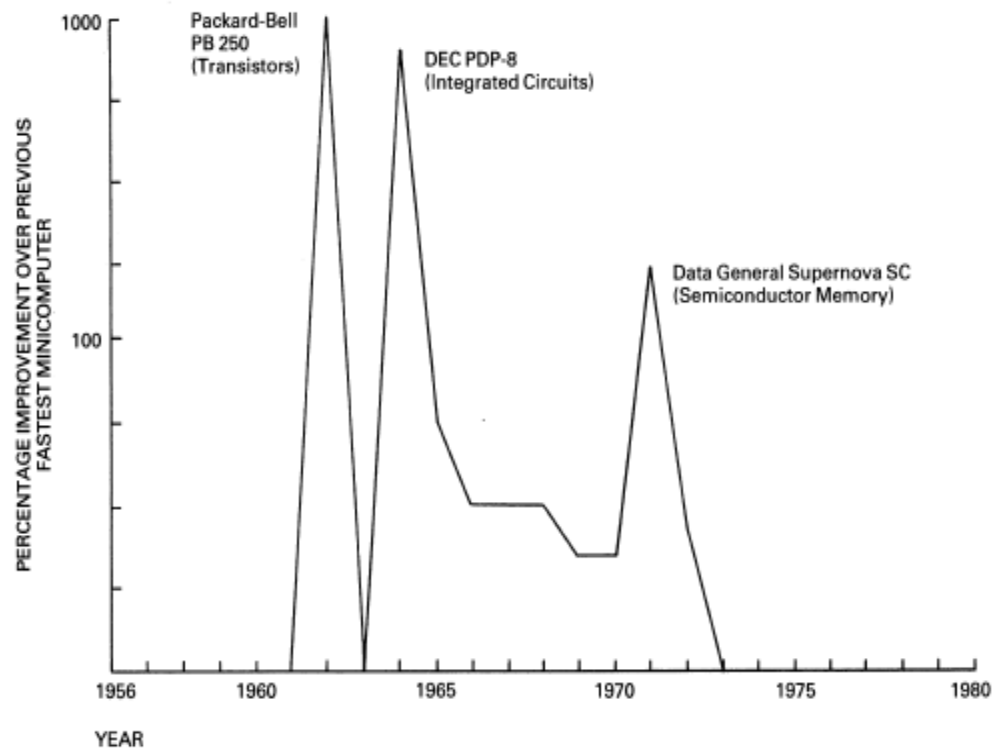


Figure 1c. Central-processor-unit cycle time of the fastest minicomputer in production, 1956–1980.



Technological discontinuities and organizational environments – M. L. Tushman, P. Anderson – Administrative Science Quarterly, 1986]

Note: The vertical scale is logarithmic, because the impact of transistors and integrated circuitry on processor speed was so great.

The framework of technological innovation – «when»

Besides the obsolescence of the product that an S Curve concept could show, of course **the time of innovation comes when the customers (the market in general) ask something different by the current product.**

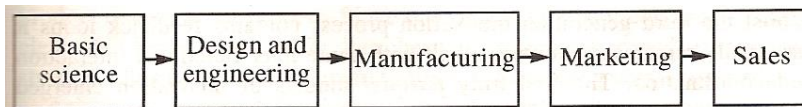


Figure 4.3 Technology push (first generation) (1950s – mid 1960s)

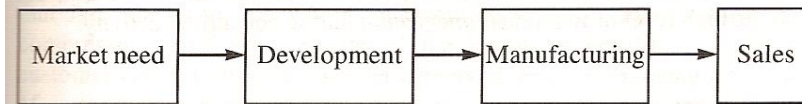
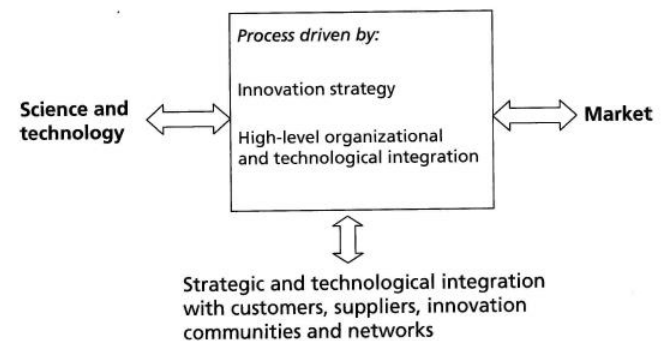


Figure 4.4 Market pull (second generation) (late 1960s – early 1970s)

[M. Dodgson, R. Rothwell - The handbook of technology innovation]



Fifth-generation innovation process... (Strategic and integrated)



3.5. Fifth-generation innovation process

Such consideration is not specifically related to the product or service, but to the innovation process. Roughly speaking, and taking into account that the time to market is a key factor, that means to guarantee the **max flexibility of the innovation process.**

The framework of technological innovation – «whom»

«whom» (to be meant as «by whom») is related to people characteristics the innovation can spring from, so it's an issue linked to the organization analysis (next lecture's note will deal with it), anyway there are some key points that it's useful to keep in mind in the technological innovation framework. They're:

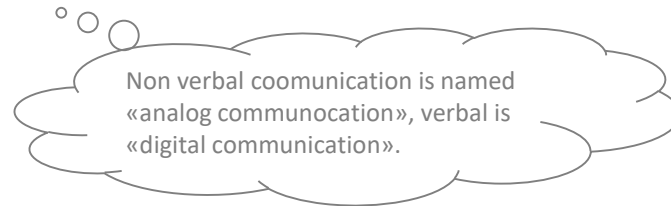
- **Resistance to change**
- **Creativity**
- **Entrepreneurship**

The framework of technological innovation –

«whom – resistance to change»

News (for instance a different working way related to an innovated product) can induce uncomfortable situation for some people (sometimes for most people), so the resistance to change arising.

- The only way to smooth resistance to change is a **suitable communication**. On such issue it's important to consider that one's behaviour is much more important than words. accordingy to the context communication can range from coercion to persuasion).



- Anyway, communication must be properly planned. Indeed **it's linked to power management** inside the organization, that to the ability and possibility to modify other people's behaviour (accordingy to the context communication can range from coercion to persuasion).

The framework of technological innovation –

«whom – creativity» i/ii

- Creativity is mentioned as one of the production's factors, so one of the key conditions necessary to «make things».
- It comes how to promote creativity:
 - of course an important factor is the **organizational climate**.
 - then, last but not least, the **self-motivation**.

Organization climate definition.

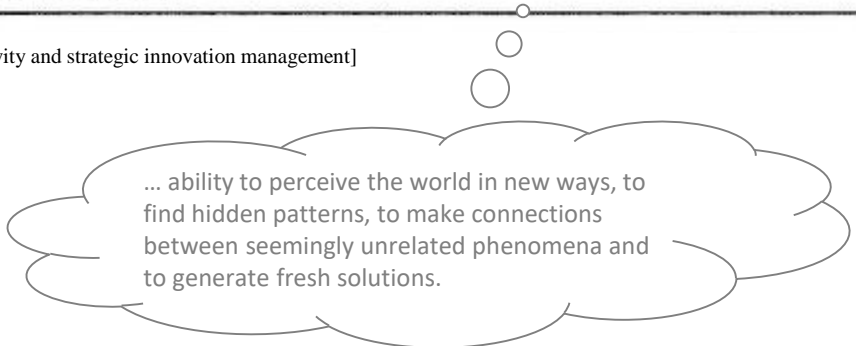
"*Psychological* climate is defined as the individual employee's perception of the psychological impact of the work environment on his or her own well-being (James & James, 1989). When employees in a particular work unit agree on their perceptions of the impact of their work environment, their shared perceptions can be aggregated to describe their *organizational* climate (Jones & James, 1979; Joyce & Slocum, 1984)."

[https://en.wikipedia.org/wiki/Organisation_climate]

Table 1.2 The factors of production

Factor	Description
Land	Refers to physical land and other natural resources, e.g. the land that a building is constructed on, oil that is extracted from under the sea, the land, forests, and fish reserves. Providers of land receive rent.
Labour	Refers to physical and mental effort – e.g. stacking shelves in a supermarket, or calculating the final financial accounts of a company. Providers of labour receive wages.
Capital	Exists at two levels. First of all we have financial capital. But more importantly, this is used to purchase physical capital that goes into making other things. Physical capital consists of machinery, equipment, tools, etc. Providers of capital receive interest.
Enterprise	Is the skill of combining the other factors of production. Entrepreneurs are the risk takers that set up and run business enterprises. Entrepreneurs receive profit.
Creativity	Creativity is a core competency for leaders and managers and one of the best ways to set companies apart from the competition. Corporate creativity is characterised by the ability to perceive the world in new ways, to find hidden patterns, to make connections between seemingly unrelated phenomena and to generate solutions. Generating fresh solutions to problems, and the ability to create new market offerings, processes for a changing market, are part of the intellectual capital that give a company its competitive edge (Bilton, 2007). Creativity is a crucial part of the innovation equation.

[M. Goodman, S. Dingli – Creativity and strategic innovation management]



... ability to perceive the world in new ways, to find hidden patterns, to make connections between seemingly unrelated phenomena and to generate fresh solutions.

The framework of technological innovation –

«whom – creativity» ii/ii

- Now, of course the organizational climate is part of the managers' job, and how to stimulate self-motivation?
- There's just an answer: **be curious!**
Don't forget to cultivate different interests (from fine arts till engineering itself, literature, sports, dancing, friendship etc.

... of course during individuals' life some (may be several) bad times can arise, so one will have to face «primary needs» before the above interests. Anyway, it's important to note that keeping a link with such interests can help to solve bad periods.

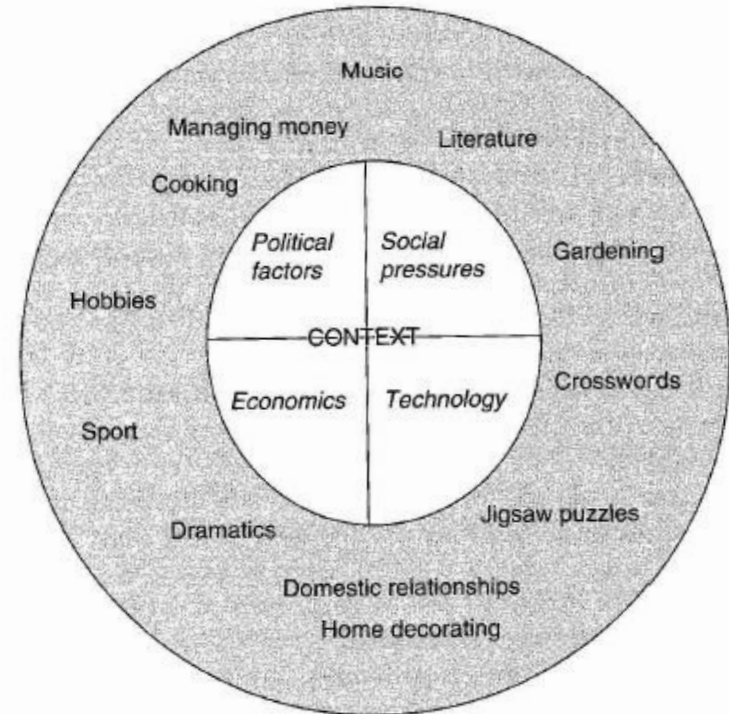


Figure 4.3 Activities that entail personal creativity.
Source: M.R.V. Goodman, Durham University.

[M. Goodman, S. Dingli – Creativity and strategic innovation management]

The framework of technological innovation –

«Entrepreneurship»

Entrepreneurship is usually associated to make money or to start new businesses, anyway it's important to think of it like a **propellent force for improvement.**

Entrepreneur: a person who makes money by starting or running businesses, especially when it involves taking financial risks.
[Oxford Dictionary]

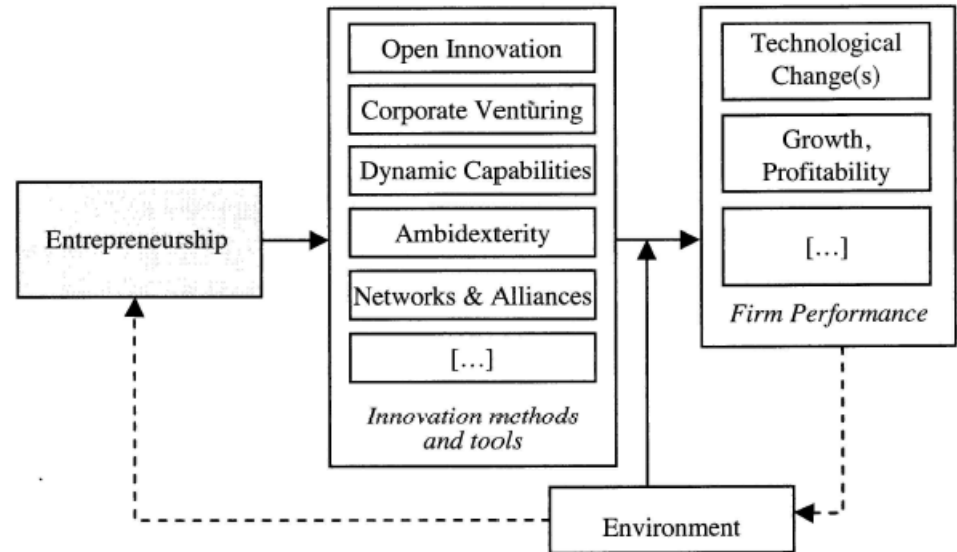


Figure 1.1 Conceptual map of the relation between entrepreneurship, innovation and technical change

[Entrepreneurship and technological change – L. Cassia, T.Minola, S. Paleari]

Examples of “Breakthrough” Improvements (*continued*)

Motorola reduced the time to respond to a customer request for a pager from 3 weeks to 2 hours.

Ford reduced the number of people involved in vendor payment from 500 to 125.

Federal Mogul, a large auto parts manufacturer, reduced the time to develop a new part prototype from 20 weeks to 20 days, tripling the likelihood of customer acceptance.

Many IT organizations changed to a RAD (rapid application development) process for application building to cut total development time from 2 years to 4 months.⁸

Hewlett-Packard cut the time to design a printer and get it into production from 4 years to 22 months.

Marks & Spencer cut its supply cycle for food in its stores from 10 days to 2, improving the choice of fresh food to shoppers.

Digital Equipment, at its Albuquerque work-station line, reduced inventory from 16 weeks to 3 while reducing defect rate from 17 to 3 percent.⁹

VF Corporation shortened the time for restocking retailers with Wranglers, Vanity Fair, Lee, Jantzen, etcetera from 70 days to 7.

Iomega Corporation reduced the time to make disk drives from 28 to 1.5 days. This dramatically reduced its inventory-holding costs and defect rate (because the cause of a defect was found at the end of a 28-day cycle was difficult to isolate).¹⁰

DuPont cut its production cycle for Kalrez, a rubbery plastic, from 70 days to 16 and cut its order-filling lead times from 40 days to 16. It also boosted on-time deliveries to 100 percent.

United Electric Controls Co. cut delivery times of industrial sensors and control products from 12 weeks to 3 days.

The framework of technological innovation – App. 2

Table 4.1. Some ideal type innovation strategies

	Proactive	Active	Reactive	Passive
Objectives	Technological and market leadership	Not being first to innovate, but being prepared to follow quickly	Wait and see. Follow a long way behind	Do what is demanded by customers or dominant firms
Type of technological innovation	Radical and incremental	Mainly incremental	Entirely incremental	Occasionally incremental
Knowledge sources	Science; in-house R & D; Collaboration with technology leaders; demanding lead customers	In-house R & D; Collaboration with technology leaders, customers, and suppliers	Competitors; customers; purchase of licenses	Customers
Innovation expenditure	Basic and applied R & D; products and services new to the world; operations; education and training	Applied R & D; products and services new to the firm; operations; marketing; education and training	Focus on operations	No formal activities
Risk acceptance	High-risk projects included in portfolio. Take big bets	Medium–low risk projects. Hedge bets	Projects all low risk. Wait and see.	No risks taken. No bets.
Main forms of appropriability	IPRs; complementary assets; secrecy; speed	Complementary assets; speed	None	None
Typical firms	DuPont; Apple; Qantas; Singapore Airlines	Microsoft; Dell; BA	European and Asian budget airlines, such as Ryanair and Air Asia	Third- and fourth-tier automotive suppliers

[M. Dodgson, R.D. Gann, A. Salter - The management of technological innovation]