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# The innovation shell, and barriers of disruptive innovation

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ABSTRACT: If we look at the technological possibilities offered by breakthrough results in computer sciences, materials sciences or biotechnology, we expect robust changes to take place in our everyday life in the near future. According to the expectations, these changes should reshape our society and economy in a major way. The possibilities offered by the breakthrough results, however, may only affect our lives if they are put to practical use. In our study we investigate the characteristics of the innovation process that creates the bridge between technological/theoretical possibilities, and practical innovations. We detect the main influencing factors that form the so called innovation shell. The innovation shell has three components: the corporate core (made up of ownership interests, managerial motivations, corporate culture and structure, and people); the innovation ecosystem (made up of research and financial infrastructure, and regulating institutions); and finally the values of customers and stakeholders. Some of these factors create barriers others create incentives for innovation. In this study, we focus on the former ones.

## 1 INTRODUCTION

The following quote by Harari characterizes well the zeitgeist regarding our expectations of the future: "A thousand years ago […] there were many things people didn't know about the future, but they were nevertheless convinced that the basic features of human society were not going to change. [… ]In contrast, today we have no idea how […] the world will look in 2050. We don't know what people will do for a living, we don't know how armies or bureaucracies will function, and we don't know what gender relations will be like (Harari 2018, pp. 226-227)." Most of those who are at least somewhat interested in future developments expect revolutionary changes that will transform the fundamentals of the society in the very near future.

The idea that our environment changes at an increasing rate is not new. The representativeness bias identified by Tversky and Kahneman (Thaler 2015) makes us believe that current and fresh memories describe the most influential trends. We might feel that the current changes are very fast, and have a deep impact on the society, but the real reason we feel that way may be because we do not have any memories of past changes. Greenwood et al. (2005) have shown that the weekly housework has decreased from 58 hours in 1900 to 18 in 1975 on the average in the USA thanks to the introduction of new household durable goods. These changes can safely be called revolutionary, but current generations have basically no memories of them.

The ignorance of our minds about past changes seems to be compensated by our tendency to be very imaginative about the future. Starting from 1972 experts on artificial intelligence have been surveyed many times, asking them about the expected amount of time needed to develop a human level artificial intelligence. The median of responses has been constantly fluctuating around 50 years (Bartha & Gubik 2018). Expectations about future changes are generally based

on our conception about technological possibilities; but we tend to forget that the pace and direction of technological development is also influenced by layers of the society that are very stable and only change at a very slow rate.

In this study we focus on the social influencing factors that can reroute and slow down the pace of technological development, and so they have a clear impact on our future as well. These social factors are institutional in nature, meaning that they change very slowly, and the change itself is influenced by the community through the political system, and public debates.

## 2 POSSIBILITIES AND REALITIES

Technological possibilities become a reality through institutions. Institutions affect the inception and diffusion of new ideas. Economics describes this process through the concept of innovation that has many models, but one of the traditional approaches, often attributed to Schumpeter, is the linear model, that is built on the invention-innovation-diffusion triangle (Stoneman 1995). These three steps are often separated by a long time from each other. Fuel cells, for example, have been perceived as a promising technology for more than a century. The slow diffusion of new technologies may be due to technological reasons, but it is also influenced by socioeconomic factors featured in Figure 1. This innovation shell summarizes the factors that are generally regarded as innovation bottlenecks in the literature: cost, knowledge, market, institutional and other barriers (OECD 1997).

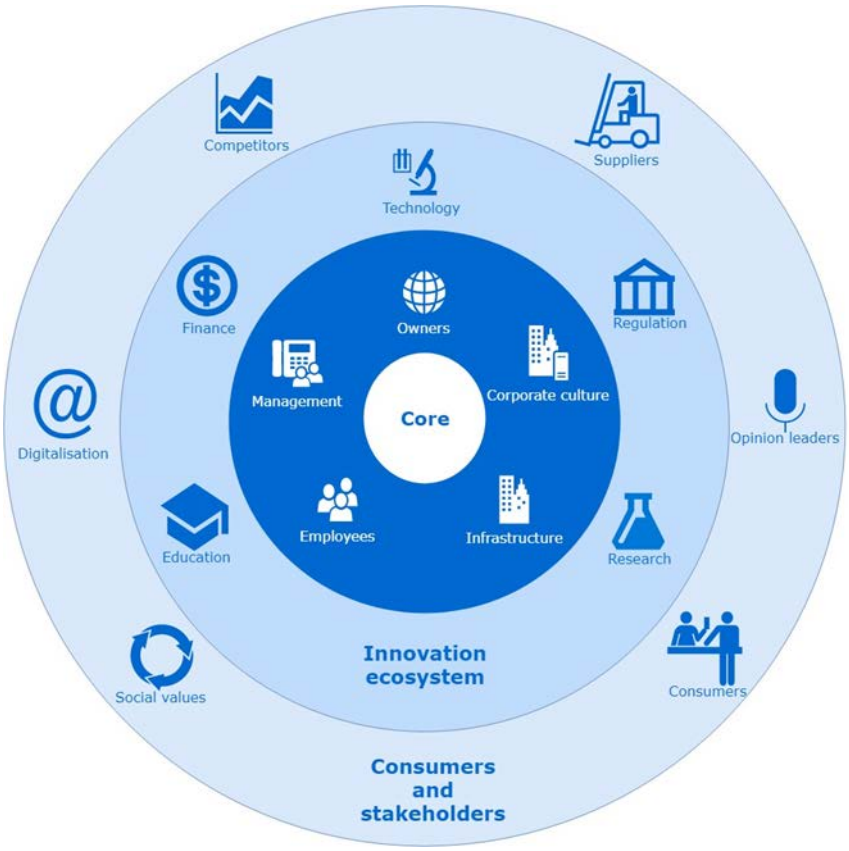


Figure 1. Innovation shell
Source: own elaboration

The corporate core consists of the internal factors that contribute to the conversion of technological possibilities and new ideas into marketable products. Ownerships interests and managerial motivations are crucial, since the Schumpeterian creative destruction process requires a long-term commitment. The corporate culture and the organisational structure are components that can both encourage and suppress new ideas. Finally, the role of employees is essential too, as they can be

the source of creative ideas, and they are the ones who follow through the innovation process characterised by distortions and inertia.

The corporate core functions as a part of the innovation ecosystem formed around the company. The extent to which the innovation processes of the firm are supported by the ecosystem depends on the quality of the ecosystem, and also on the level of embeddedness of the firm. Organisations doing basic research, and generating new technologies are one of the components of the innovation ecosystem. So are the market and government regulations, as well as the financial infrastructure that funds the innovation process. The incentives of the business/ economic environment influence the creation and introduction of innovation ideas. The capitalist system that is based on the private ownership of businesses, and regulations guaranteeing market competition favours innovation because it creates the incentives to generating a large number of innovative ideas (Erixon & Weigel 2016). A profound analyses also reveals that the strength of the incentives depends on firm size, ownership structure (these two being part of the corporate core), and on the actual rules of market competition (which are part of the innovation ecosystem).

The outer layer of the innovation shell consists of the consumers and other stakeholders. The diffusion and market success of innovation depends on the openness of the market and the consumers, and also on the rules that regulate the marketability of new products and ideas. The diffusion of some ideas can be slow because of the resistance of the community, others may be slowed down by the barriers created by rules and regulations. The latter barriers can also be explained by social uncertainty. When disruptive technologies appear, one typical reaction of the society is to try to limit uncertainties and feared negative consequences through creating prohibitively strict regulations. The regulation lag is also an issue, as the time needed to change the rules can well exceed the pace at which new technologies are developed.

## 3 RESEARCH AND/OR INNOVATION?

Even though the importance of the innovation process is unquestionable, the methods used to measure progress in this field are extremely limited. One of the common ways to measure innovation performance is to use research and development (R&D) expenditures as a proxy, but there is a fairly large difference between the two concepts. According to the Oslo Manual "An innovation is the implementation of a new or significantly improved product (good or service), or process, a new marketing method, or a new organisational method in business practices, workplace organisation or external relations" (OECD 2005, p 46). This definition reflects the Schumpeterian model.

While statistics on the innovation activity are scarce, R&D statistics are collected and distributed based on a standardised methodology. International and longitudinal comparisons are generally made using the expenditures per GDP indicator. R&D expenditures have slightly increased in the 1985-2015 period, the OECD average rose to 2.36% in 2015 (OECD 2018a). The number of patents has also grown, in 2015 142,714 patterns were filed, which is a 22.2% rise compared to 2000 (OECD.stat).

## 4 INNOVATION AND INNOVATION

Innovations can occur in many different forms, and this is the primary reason why no standardised measurement method has been developed so far. There is a clear difference between radical (or disruptive) and incremental innovation: incremental innovation is an improvement that is made within the framework of an already existing solution; radical innovation on the other hand breaks the old framework (Norman & Verganti 2014).

Most innovations are incremental in nature. They only bring a small amount of novelty, but are fairly safe and cost efficient. Modifications made to an already existing product that improve on the quality, or reduce prices represent a typical example to incremental innovation. The larger and

the more dominant a firm is, and the bigger control it has over its markets, the more its development strategy is shifted towards incremental innovation. This makes its financial performance more predictable, but it obviously slows down the pace of technological change.

Radical innovation has a number of barriers. One of these barriers is the firm itself, as most organisations strive to be stable and secure. These goals can be achieved if only those innovative ideas get the go ahead sign that fit the competencies, the profile, the manufacturing systems, the marketing methods, and the distribution channels of the firm (Norman, 2010). For these reasons radical innovations are often rejected by investors, but customers can also reject radically new solutions. As a result of these barriers, the vast majority of radical innovation projects fail. The chance of failure in case of radical innovations is 96% (Norman & Verganti 2014).

There is a distinctive ambiguity to the modern innovation activity. On the one hand statistics measuring innovation performance suggest a constant improvement, and an increasing rate of change. On the other hand radical innovation is extremely scarce. This scarcity means that the speed at which technological possibilities can be transformed into real products is actually very slow. The following sections introduce some of the components of the innovation shell, and highlight the barriers that slow down the innovation process.

## 5 THE CORPORATE CORE

The corporate core consists of components that can be directly influenced by the innovator, but the socioeconomic effects impact the core as well through trending business models and patterns. Narrow framing within the organisation in order to limit risk, or dispersed ownership are examples to such trends.

### 5.1 *Ownership structure*

While the majority of innovation efforts is attributed to large corporations (around two thirds of the R&D expenditure is spent by large enterprises in the OECD – OECD 2017a), the ownership structure of these firms has undergone major changes in the last few decades. Managerial and ownership tasks were separated as the share of financial investors as well as the company size has been rising. Managers and owners have different target functions, and the level and quality of information they have access to, is also different. Institutional investors and small shareholders typically treat their ownership stake as a financial asset, and so their main expectation towards the firms they own is stable and predictable business operation. Part of the predictability is the steady and calculated rise in firm revenues, and the predictability of the return on investments. If these indicators are stable, it is likely that share values and dividends paid will be predictable as well. The latter two factors determine the return rate of the company as a financial asset – the only indicator that institutional investors and small shareholders are really interested in.

While an increasing share of owners prefer companies with predictable financial results, radical innovation involves a great amount of uncertainty, meaning that companies involved in radical innovation projects cannot have predictable financial results. “Real” capitalist owners, the ones who have a clear picture in their minds about the firm’s vision, are happy to take risks and embrace uncertainty, but the number and share of these owners is on the decline. This is how the ownership structure can act as a barrier to radical innovation (Erixon& Weigel 2016).

### 5.2 *Management targets*

As owners prefer predictability, managers are overly cautious in development decision. The most common approach taken by managers is described as narrow framing by Thaler (2015). Narrow framing is a decision making method that is rooted in excessive risk avoidance, and a strong present bias. Managers using narrow framing break up the development efforts of the firm into different projects. The projects are treated and evaluated independently. Let’s assume that the firm has 10 quite risky projects (the chance of failure is around 50%), but they all have positive expected values! The rational choice would be to undertake all projects as the positive expected value would increase the overall value and profits of the company. Narrow framing, the fact that

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all projects have different leaders, and are evaluated individually, leads to the rejection of most of these projects.

A survey conducted by Innovation Leader and KPMG (2018) among 270 managers, confirms that narrow framing is indeed fairly common in development projects. The position of people responsible for innovation projects is also characterised by a high level of insecurity. 70% of the respondents agreed that support coming from top management is the most important incentive, but even if that is provided, intra-organisational struggle for corporate resources is very common. There are some specific characteristics based on firm size, type of innovation, and industry. Some firms have a dedicated department for innovation (this is typical in the pharmaceutical industry in case of radical innovations). In other cases the business units are involved in the development process directly (typical for incremental innovation). A common barrier is that the innovation process is not assigned to the proper unit or department, and there is no clear division of labour and responsibilities among the different units.

### 5.3 *Incentives of the corporate culture*

The IL-KPMG survey (2018) revealed that managers believe that cultural problems are the second biggest barrier in innovation processes (after intra-organisational struggles). Large firms that have a stable market position developed a corporate culture that discourages from risk taking, and according to many respondents, corporate culture specifically punishes and stigmatises failure. The larger the firm, the bigger a challenge it is to create incentives for risk taking, and to encourage people to adopt an entrepreneurial mind-set in general. It is no surprise that few are willing to take on risky projects in such an environment.

Most companies do not have a formal compensation plan for innovation projects. Around 50% of the respondents (IL-KPMG 2018) reported that there is some sort of compensation scheme available (that can take many forms, e.g. financial incentives, rewarding contributions to projects, corporate awards etc.), but 35% claimed that there is no incentives in place at all. No wonder employees often feel that they do not receive sufficient support for their efforts. Shortcomings were reported in the area of trying/testing new ideas, and tolerating mistakes, too (Accenture 2013).

### 5.4 *Employees*

People are just as important for the success of the innovation process, as physical resources or incentives. Surveys actually reveal that the main barrier of innovation is related to the human resources and culture. IBM compiled a report about the future of corporations that is based on 1130 interviews. The top three barriers identified were the following: 1) lack of supporting corporate culture; 2) financial limitations; and 3) problems with human resources (IBM 2008).

The attitude of employees is obviously crucial for the success of the innovation project. Innovation may require additional training for the employees, could lead to higher performance requirements, and in some cases can lead to layoffs as well. These are all possible explanation to why employees may not be enthusiastic about innovation. A survey conducted among 2500 German firms showed that employees are especially hostile towards innovation projects that 1) endanger jobs, 2) have high adaptation costs, and 3) increase the work load. The level of hostility is also dependent on the corporate strategy, innovation goal, the external opportunities of employees, and the market position of the firm. The survey ultimately concludes that employee resistance is larger against innovation projects targeted at enhancing the performance of the employees, than projects undertaken in order to increase customer satisfaction (Zwick 2000).

## 6 INNOVATION ECOSYSTEM

The innovation ecosystem is made up of elements related to the environment of the firm. The ecosystem may be actively influenced by the firms. The ecosystem approach is based on the older idea of regional innovation systems (Cooke et al. 1998), and it is widely accepted by experts that it is a primary influencer of the innovation process (see the summary prepared by Rücker Schaeffer 2018). We highlight three components of the ecosystem in this study.

### 6.1 *Technology and research*

Technological possibilities are created by organisations specialised in basic research (universities, research agencies). Several megatrends affect these organisations. The financing of universities has been changing for the past decades, and these changes represent a major threat for most of them. Financing uncertainties are coupled with negative demographic trends in the West, and these trends have led to an increasing globalisation in the higher education sector. Globalisation also means that basic research is often conducted in international networks.

Concentration is also a dominant trend is basic research. Big Data, the processing of extremely large databases with algorithms using machine learning, has been gaining ground in basic research projects (OECD 2016, 2018b). Big Data is highly resource intensive: there are only a limited number of large databases on the one hand, and the processing of the data requires a lot of processing power. But Big Data has an impact on businesses as well: digitally mature companies are also more innovative (Shawn 2018a). One of the significant effects of these megatrends is that knowledge is increasingly concentrated, and so it creates a geographical barrier to innovation in many regions.

### 6.2 *Regulations*

In some markets idea phrasing and devoted resources influence the pace of innovation; in other markets the regulatory environment is backward, most stakeholders have a vested interest in sustaining the status quo, and new technologies can only trickle down very slowly. The education sector is a good example to such a market: teaching methods and materials usually lag way behind the state of the art technology.

In health care the centralised nature of both the financing system and the service providers is the barrier that slows down the diffusion of new technologies. The development of a new drug cost $1.3 billion on average (Avik 2012), and the high development costs discourage innovation on the one hand, and lead to further market concentration on the other hand. Clinical tests and licensing regulations put a huge time cost on the development process. The time required to introduce a new drug to the market after filing the first patent application is 15.1 years on the average (Gingrich 2013).

The transport market is also an area where regulations significantly influence innovation. Self-driving cars are expected to bring revolutionary changes in this field, the number of accident could be reduced by 90% (Litman 2018). They could also reduce the time cost of commuting, the stress level, and the emission levels. The resistance of some stakeholders (transport service businesses, car manufacturers), and the uncertainty around responsibilities, the lack of proper regulatory background may delay the introduction of the technology until 2030, and it could be as late as 2050 when self-driving cars are widely used (Litman 2018).

The regulatory system has been becoming more complex due to natural needs, which leads directly to the outer layer of the innovation shell. Before we proceed, we highlight two further points.

- As people naturally want to avoid uncertain situations, we tend to create more and more rules to increase the predictability of human interactions in the society. This increases the comfort level in the short term, but creates barriers to radical innovation in the long term.
- In certain cases experts call for global regulations. Technologies like artificial intelligence could potentially create unforeseen threats of large magnitudes. In an extreme scenario they could create damages that could not be put right by ex post regulation. In such cases setting the principles up ex ante could be especially important (Tegmark 2017).

### 6.3 *Financing*

The megatrends discussed in the previous sections have changed the R&D and innovation funding priorities. Social challenges that go beyond the traditional growth and employment goals, security challenges created by the new technologies have led to new innovations objectives, such as data privacy, access to data and data sharing, creating incentives for cooperation and encouraging open

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innovation in general, and updating the framework for competition and intellectual property rights (OECD 2018b).

Starting from 2010-11 public funding of R&D projects (in per GDP terms) has been decreasing throughout the OECD (OECD 2018b), and the use of tax incentives has been on the rise (OECD 2017b).

## 7 CONSUMERS AND SOCIAL VALUES

Customers and other stakeholders form the outer layer of the innovation shell. Considerations regarding the role of the human factor were already discussed in case of the employees; this time we concentrate on the attitude of consumers and stakeholders toward market innovations. When new services or products are introduced to the market, the key to success is whether or not customers will understand and accept them. This is especially important in radical innovations, because destructive innovations can change existing habits, and can change beliefs as well. Resistance to change is part of human nature (Gatington-Robertson 1989); its extent is influenced by factors related to the customers and to the innovation. The personality, attitudes, value orientation, previous experience with innovation, perception and motivation are customer-related factors (Ram 1987). Relative advantage, compatibility, risk, complexity, and expectations about a better product are innovation-related factors.

Customer decisions are influenced by switching costs: these costs do not have to be paid if the old solution is chosen instead of the new one. A new word processor or a new keyboard layout may lead to more efficiency in the long run, but they increase the switching cost in the short term (Shapiro-Varian 1999). Innovations that create short term costs, and only offer long term benefits typically fail during the market introduction.

## 8 CONCLUSION

Technological possibilities impact the socioeconomic environment, and are introduced to our everyday life through the innovation process. Although the current zeitgeist prompts us to believe that our socioeconomic environment will be fundamentally changed in the next decades, some innovation barriers work against this expectation. More and more money is spent on R&D, the number of patents has been rising, but the positive trends seem to only affect incremental innovation. Incremental innovation only generates slow change; it incrementally introduces new versions of the original product that are somewhat better looking or performing, or a bit more efficient. If we only had incremental innovation during this century, we can tell for sure that our socioeconomic environment will not be fundamentally different 100 years from now.

Innovation that has a destructive effect on our environment is called radical innovation. This latter type of innovation is slowed down by a number of socioeconomic factors. These factors can be identified in all three layers of the innovation shell. Dispersed ownership, growing firm size and hierarchy, and the managerial approach shaped by the values of the institutional investors all contribute to the disappearance of classical innovators/leaders from the top of the corporate hierarchy. If innovator leaders are crowded out, the corporate culture also discourages from taking risks, and innovators lose out in the intra-organisational struggles fought over corporate resources. Further problems can be created by the attitude and the knowledge level of the employees.

Some elements of the innovation ecosystem can act as a barrier to radical innovation as well. As research becomes increasingly global and concentrated, many regions are left without basic research organisations. While the rules and regulations of the society and the economy make the environment more predictable, and some areas even call for a global system of rules, they also make radical innovation projects extremely expensive, and drag them out for a very long time. Deficiencies of the financing infrastructure form another barrier.

Finally, social values, negative attitude towards change is yet again a serious barrier. Employees fear the loss of their jobs, and the rise in their workload; customers resists new products because of the high switching costs.

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