Jari Kaivo-oja

FUTURES OF INNOVATION SYSTEMS AND SYSTEMIC INNOVATION SYSTEMS: TOWARDS BETTER INNOVATION QUALITY WITH NEW INNOVATION MANAGEMENT TOOLS

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1. INTRODUCTION

Today it is important to understand that innovation is no longer optional, but a necessary activity in every competitive industry or in service market. Global competition is intensifying. Customers have more options than ever before. All the products and services are at constant risk of being commoditized. Newcomers are disrupting established industries. In addition, the entire technology landscape is evolving at a staggering pace. To rise or to remain at the top of industry, companies must bring differentiated products and services to market, very quickly. Innovations are needed also in the public sector, not only in industries and in companies. Grand challenges of our time need grand innovations, which are probably going to be more or less systemic by nature. Global climate change, coming water crisis, poverty challenge, health and food problems, communication challenges and the sustainability of our planet will require proactive development of systemic innovations (see e.g. van Santen, Khoe & Vermeer 2010).

Innovations which are ultimately profitable are of interest to companies and society in general. If there are too many quality problems and systemic failures, innovation will not be profitable to a firm. Companies describe innovation as a key to increasing sustainable profits and market share. Politicians and many public agencies maintain that competitive advantage is now predicated on successful innovation. If we use Boston Consulting Group's Portfolio Matrix as theoretical framework, we can say that today's "Questionmarks" and "Stars" are expected to be tomorrow's "Milk Cows". The Economic logic of modern welfare states is based on the large scale existence of "Milk Cows" (Stern & Daimler 2009). Organizations failing to innovate are endangered species; evolutionary dead-ends in the global industrial eco-system. They will always be "Dogs" of the BCG approach. From this perspective it is important to develop favorable pre-conditions of successful innovations. (see e.g. Prahalad and Krishnan 2008, Teece 1986, Teece 2007).

A successful innovation process does not include too many quality problems: or at least these problems can be solved by the help of rigorous new thinking. In avoiding systemic innovation failures, customer-oriented *Jobs to Be Done* (JTBD) approach may be a very useful tool package (see Ulwick 2005, Ulwick & Bettencourt 2008). The JTBD includes (1) functional jobs (the task that customers want to achieve), (2) emotional jobs (personal and social jobs of a company) and (3) ancillary jobs (other jobs that customers want to get done before, during, or after they get their main job done). There are 6 work phases of the JTBD: (1) Market identification, (2) identification of jobs customers are trying to get done, (3) categorizing the jobs to be done, (4) creation of job statements, (5) prioritizing the JTBD opportunities, and (6) identification of outcome expectations regarding the job. By the help of the JTBD approach, many systemic failures can be avoided, because it helps companies determine the human needs a company is trying to fulfill. The JTBD approach underlines the importance of a customer approach. Also systematic innovation must meet human needs.

The aim of this e-book is to analyze the futures of modern systemic innovations and post-industrial innovation systems. The terms 'autonomous innovation' and 'systemic innovation' stem from Teece (1986). *Typically autonomous innovations have a character of modularity. Systemic innovations have a character of integrality.* Some authors use also a term 'architectural innovation', which includes both the characters of modularity and integrality. Here the modules of innovation remain intact, but innovation takes place in the way the modules are hooked together (see Henderson and Clark 1990).

In the following we focus more on systemic innovation, but some general aspects of innovation processes are discussed. The benefits of an integral systemic thinking in systemic change are related to the benefits of fine-tuning. There can also be benefits of communication costs, economics of substitution, set-up costs and systemic adaptation (see e.g. Langlois & Garzadelli 2008). The existence of these economic and social benefits explains the interest to develop new systemic innovations.

Fine-tuning constitutes systemic change to improve the performance of a service or a product. Integral systems may have advantages not only when users demand high performance in a technical sense but also when they need performance in the form of change, adaptability or agility. Today systemic innovations are an important part of technological and industrial system dynamics. They also have certain kinds of impacts on systemic problems and failures of modern companies and corporations. In this e-book the key issue is to discuss these systemic problems and provide some solutions to these problems.

Too often, in the context of innovation policy and its implementation, quality problems and possible systemic failures are not discussed in foresight analyses. This kind of approach is not a very smart one, because quality problems and systemic failures have considerable impacts on costs and on the productivity of companies' innovation process operations. To take care of the quality of innovations and systemic innovations is a big challenge for companies and other stakeholders of an innovation process. However, it is very important to focus on desired outcomes of innovation and avoid undesired outcomes of innovation. Outcome expectations of new idea or invention need more attention. This is one key message of this e-book. Today organizations are becoming more and more interdependent, but their parts increasingly display choice and behave independently. This situation increases the importance of systemic thinking. It increases also the importance of systemic innovations. Organizations are multi-minded and socio-cultural systems. Typically an organization is a voluntary association of purposeful members who have come together to serve themselves by serving the needs in the environment. In the environment we can identify more and more complexity and chaos. Thus two changes are taking place; first (1) co-evolution of interdependent systems and secondly (2) co-evolution of independent organizations. If we are not able to appreciate the significance of this dual change, we easily meet excessive structural conflicts, anxiety, a feeling of impotency and increasing resistance to change (see e.g. Gharajedaghi 2006, 9).

In some progressive cases innovation solves quality management problems. In some non-progressive cases, innovations cause new quality management problems. Thus, we can conclude that R&D experts and stakeholders must be critical towards new social and technological innovations. The functional logic of the whole product/service delivery chain (suppliers, manufacturers, distributors, value-added resellers, installers and consumers) may change because of new innovations. As we know, patents are granted for inventions, not for innovations. Customers buy innovative products, not inventive products or ideas. Thus, when organizations develop successful conditions for ideas, inventions and for innovations, they should think quality management problems in advance before serious problems and systemic failures emerge. Here, we need to underline that we cannot eliminate the existence of disruptive innovations. All the innovations are not "nice" incremental innovations.

On the other hand this e-book discusses the futures of innovation systems. The analyzed innovation systems are (1) micro-level innovation systems (niche level), (2) regional innovation systems (regimes) and (3) national innovation systems (or landscapes, see Geels 2007).

2. SYSTEMIC INNOVATIONS

During the industrial era, innovations used to form be a quite linear trajectory from new knowledge to a new product or service. Today innovation is not singular, autonomous or linear, but more systemic, non-autonomous and complex. The need for systemic innovations arises from complex interactions between many individuals, organizations and their operating environment. Systems are changing fast. Companies which are successful in realizing the full returns from their technologies and innovations are able to match their technological developments with complementary expertise in other areas of their business, such as enterprise-wide business process management, manufacturing, distribution, human resources, marketing, and customer service.

The big idea of systemic innovation model is that innovation is not divisible – 'good in elements' is no good at all. Innovation systems are only as strong as their weakest links. That is why systemic elements need more and more attention in companies and corporations. A small detail can ruin any big innovation.

Recent data and research findings show that systemic innovations diffuse slowly in project-based and service industries. The slow diffusion rate of systemic innovations is an alarming issue for companies and governments. Slow diffusion rate can also depend on the quality management problems faced during an innovation process. Industrial research in the U.S. clearly shows that systemic innovations diffuse more slowly than incremental innovations (see e.g. Hall 2004). There are probably less maintenance problems and systemic failures in the case of incremental innovation than in the case of disruptive innovation. Conventional types on incremental innovations are (1) technological innovation, (2) business innovation and (3) social innovation. Often these three kinds of innovations are systemically interconnected, because organizations can create better synergy and results by complementary innovation forms (see Fig. 1). It is important to understand that systemic changes in one of these three innovation types can lead to needs to change the other two innovation types as well. One key challenge in developing systemic innovations is to create good synergies between these three types of innovation. Typically a strategist must decide which element of systemic innovation is the most important and then organize other elements inside its strategic framework logic. Sometimes (1) technological aspect of innovation is a key issues, sometimes business innovation is a key issues and sometimes social innovation creates framework logic of new innovation. In every special case, other elements of innovation are sub-systems of larger systemic innovation. If a strategist does not have some kind of framework logic, ones must create strong synergy between all innovation elements.

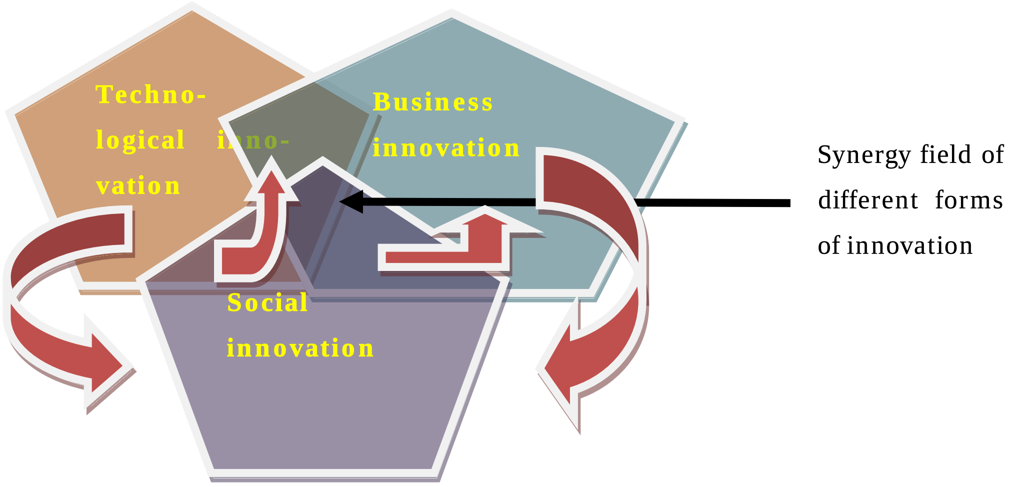


Figure 1.a *Systemic synergy of technological innovation, business innovation and social innovation*

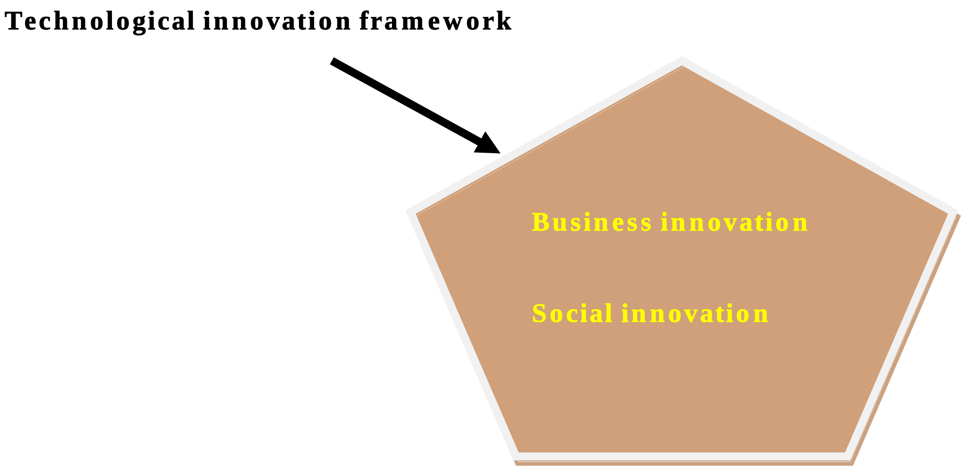


Figure 1.b. *Technological framework for a systemic innovation*

Business innovation framework

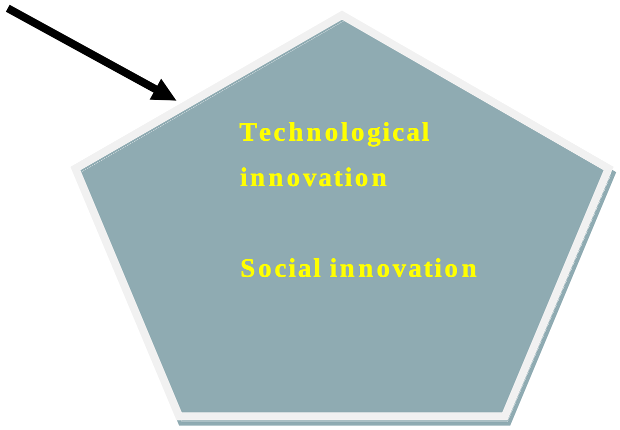


Figure 1.c. *Business framework for a systemic innovation*

Social innovation framework

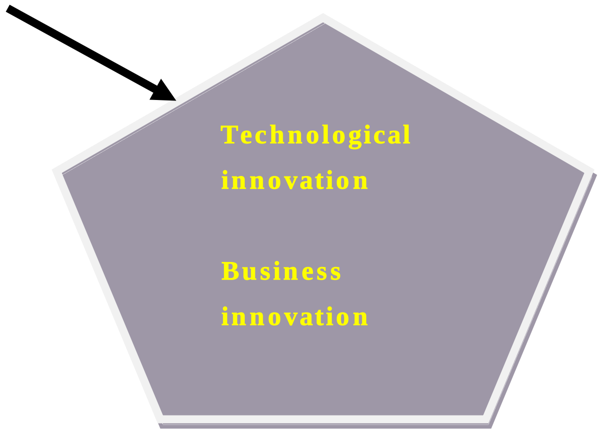


Figure 1.d. *Social innovation framework for a systemic innovation*

Thus there exist actually four basic models or future scenarios of systemic innovation. Let´s call this new logical framework *Kaivo-oja´s Basic Model of Systemic Innovation* (KBMSI).

The concept of systemic innovation has been used in business management and technology management research and literature since the 1980s. It was first proposed by Prof. David Teece, who distinguished between two types of innovations: autonomous innovation and systemic innovation (Teece 1984, 1988). An autonomous innovation is a product, module or specific component that can be introduced without changing other products, modules or components of the character. Innovation is thus independent or autonomous. Systemic innovation, on the other hand will require substantial changes to other components, products, modules or subsystems. The interdependence of systems and sub-systems is high. As a result, there are many management needs for systemic coordination, if we want develop systemic innovations.

Systemic concept of innovation has been used as an analytical planning and management tool for parsing the innovation process and the ways of organizing it. The nature of the innovation (whether it is autonomous or systemic) is seen to have a significant impact on how the innovation process should be organized. Typically systemic innovation has high management and coordination costs, and that is why tacit knowledge, informal communication and especially organizational learning play important roles in the implementation of systemic innovations (see e.g. Teece 1984, Langlois 1992, Chesbrough & Teece, 1996, Milway & Saxton 2011). Integration improves the flow of information and co-ordination of investment plans. It will probably also improve the professional quality of business plans and associated cost-benefit analyses.

Information and communication technologies accelerate the convergence of technological development. Because of this kind of developments, it has become more apparent that products, services, and technologies are linked ever more closely. Thus, *innovations are increasingly systemic in nature and that is why companies are no longer able to manage entire value chains* (Laat de 1999, Maula et al, 2005).

Expanding our understanding of systemic innovation thinking is critical as companies, corporations and industries continue to evolve into project-based forms of organization. For companies it is challenging that systemic innovations diffuse more slowly than incremental innovations in the project-based industries (see e.g. Hall 2004). Diffusion speed and operations of systemic innovations should be managed in a better way in SMEs and in the corporate world. Systemic innovation thinking requires multiple companies to change in a coordinated fashion.

Systemic innovations include often a strong element of organizational learning. According to recent research findings, there are four elements of organizational learning: (1) supportive leaders, (2) culture of continuous improvements, (3) intuitive knowledge processes and (4) defined learning structure. (Milway & Saxton 2011, 47). How should this kind of change process, including broad organizational learning, be managed? Typically, the solutions companies consider must map to the trajectory of company's strategy or a new innovative business model must be developed. Companies must make sure that have the best options available, at minimal risk. This means that companies must take organizational learning very seriously and try to access the skills and experience necessary to realize breakthroughs. The key of the future will be *systemic organizational learning with these four human-scale systemic elements mentioned above*.

Implementing systemic innovations requires a combination of skills associated with corporate foresight research, corporate planning and organizational change management. Trend analyses and especially trend prediction are needed in the innovation processes. The basic idea of trend analysis is to extrapolate how current systems will evolve in the future.

Darrel Mann (2007) has presented an extensive understanding of 35 universal technology trends, each of which progresses toward increasingly valued and ideal innovation. His technology trends are classified in three categories: (1) Space related trends, (2) time related trends and (3) interface related trends.

Time related technology trends of Darrel Mann (2007) are:

1. Action coordination,
2. Rhythm coordination,
3. Nonlinearity,
4. Mono-Bi-Poly (similar),
5. Mono-Bi-Poly (various), and
6. Macro to Nano Scale.

Space related trends are:

1. Smart materials,
2. Space segmentation,
3. Surface segmentation,
4. Object segmentation,
5. Macro to nano scale,
6. Webs and fibers,
7. Decreasing density,
8. Asymmetry,
9. Boundary breakdown,
10. Geometric evolution (linear),
11. Geometric evolution (volume), and
12. Dynamization.

Interface related trends are:

1. Mono-Bi-Poly (similar),
2. Mono-Bi-Poly (various),
3. Mono-Bi-Poly (including differences)
4. Damping,
5. Sense interaction,
6. Color interaction,
7. Transparency,
8. Customer purchase focus,
9. Market evolution,
10. Design point,
11. Degrees of freedom,
12. Boundary breakdown,
13. Trimming,
14. Controllability,
15. Human involvement,
16. Design methodology
17. Reducing energy conversions.

We can note that in *Mann's technology trend analysis* interface related trends dominate systemic change. After interface related trends come space related trends. The smallest category of technology trends is that of time related trends. By the help of this technology trend analysis we can create S-curve generations. Classic S-curve includes the following phases: (1) Conception, (2) birth, (3) growth, (4) maturity, (5) retirement, and (6) decay. Typically, to create higher level S-curve some kind of systemic changes like changes to a new system, creative solutions to contradictions or another means are required (Fig. 2). Many systems have the S-curve systemic logic.

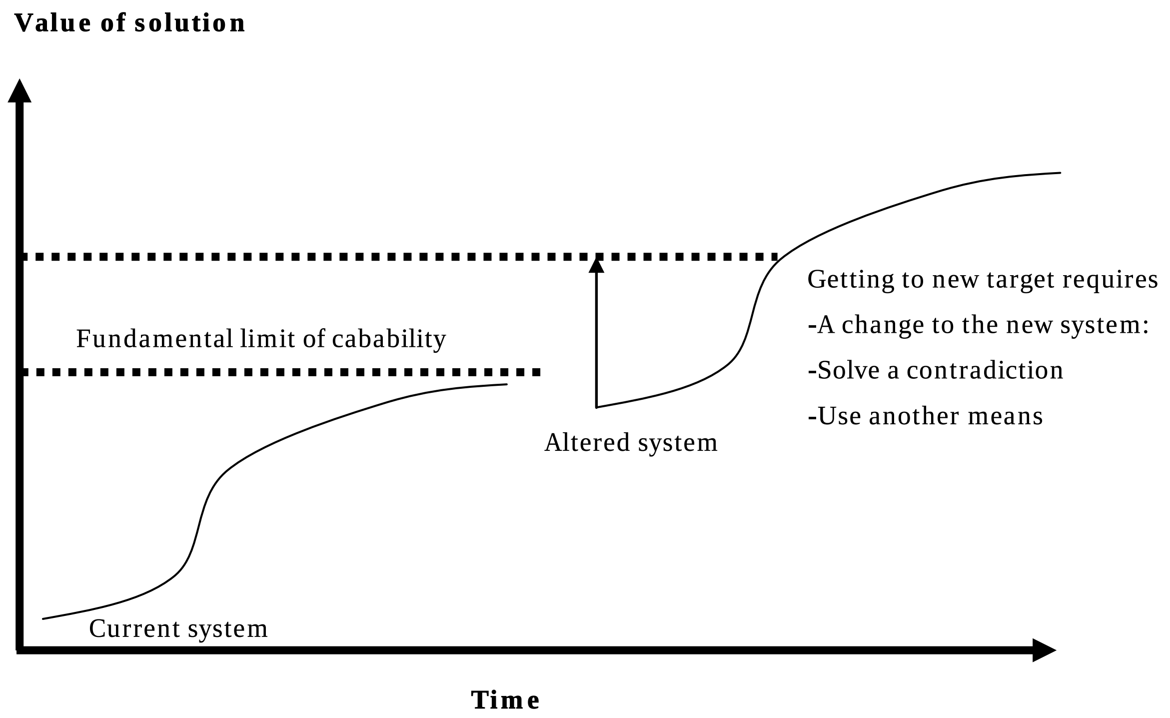


Figure 2. *S-curve generations (Silverstein, Samuel & DeCarlo 2009, 93)*

Thus, trend analyses can be used in many ways in the operations of transition management. There are many on-going changes, which erode competitive advantage of companies. *Imitation* is the most basic force. Successful distinctions are always eroded by imitation. Other important forces, which promote change, are inertia, sub-optimization, change of game and shift in paradigm (see Fig. 3). *Inertia* is responsible for the second-level tendencies and behaviors that delay reactions to technological breakthroughs. Third force is *sub-optimization*, which pushes one's strength to its limits and finally transforms the strength into a destructive weakness. Fourth force is *change of the game*, or transformation of the problem. This force is at the heart of a counterintuitive process that converts success into failure. The basis for competition changes and new competitive game emerges as soon as a competitive challenge is met. Thus, competition never ends. The last, fifth force is *shift of paradigm*. Behind the shift of paradigm can be new analytical approach (an analysis of independent variables, thus analytical thinking) or a new systemic approach (an analysis of interdependent variables, thus holistic thinking). Sometimes changes in the machine model, in the biological model or in the social model create shifts of paradigm. Thus, the last force that erodes competitive advantage is a shift of paradigm. (Gharajedaghi 2006, 4-9). In other words, there are many systemic forces which together erode competitive advantage of companies and corporations. These 5 forces are shaping market changes and our future.

On the basis of system theoretical approach to change, we can say that change is not a linear or one-dimensional issue. This is good to remember when we are talking about systemic change and systemic innovations. Systemic change is multi-dimensional management challenge.

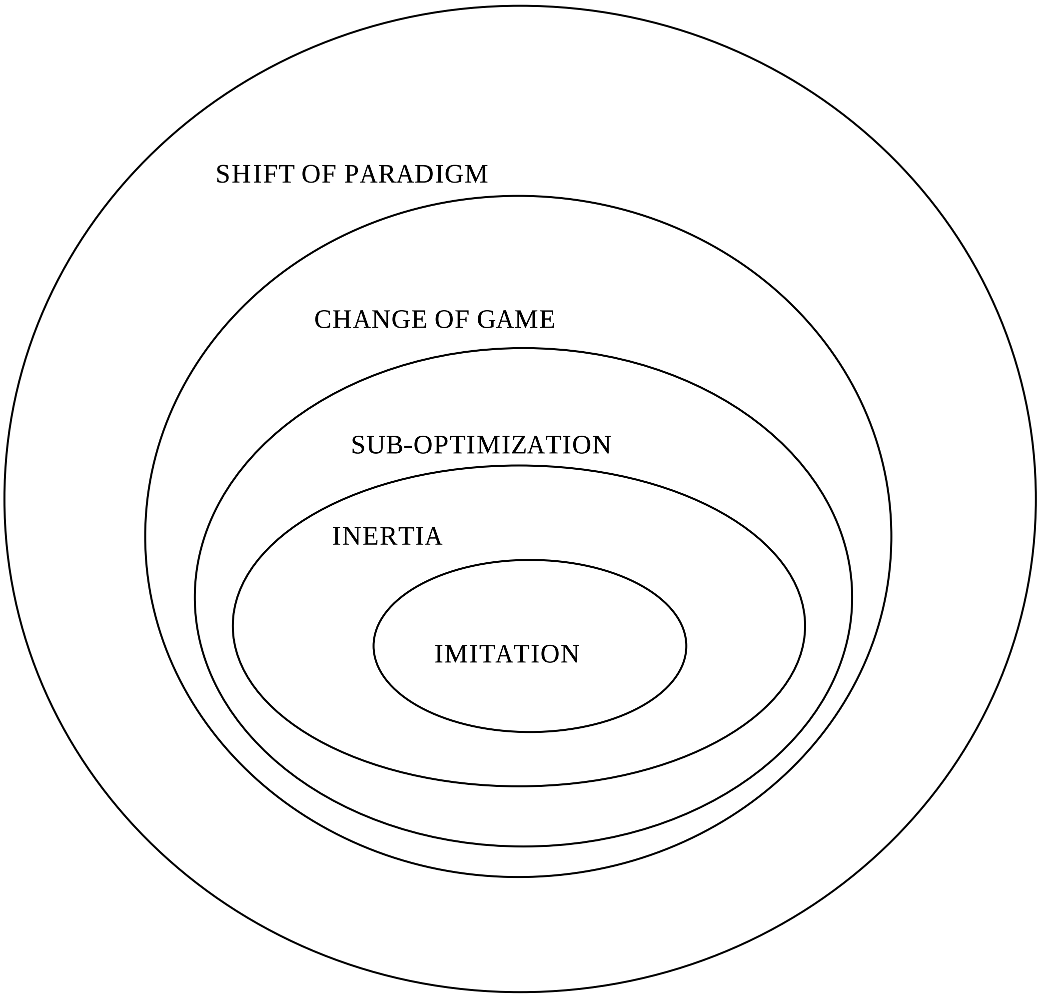


Figure 3. Hierarchy of systemic forces that erode competitive advantage of companies

There are three levels of transition management: (1) landscape level, (2) regime level and (3) niche level (Geels 2007). All the levels need foresight analyses to be successful. It is also obvious that networking and partnership strategies must be connected to systemic innovation thinking of SMEs and corporations. Linear thinking of traditional supply chain management is not the right way to manage systemic innovations or to prevent systemic failures and quality problems. Naturally it can be helpful to some extent but not a complete management model for systemic innovations. We need increasing use of enterprise resource (both material and immaterial) planning, service design thinking and the prefabrication of product/service component systems. There must also be a very strong link between foresight and change management in order to promote more efficient systemic innovation processes. As often said by many experts: “Talk is cheap”. Action and agility matter much more in the systemic innovation management.

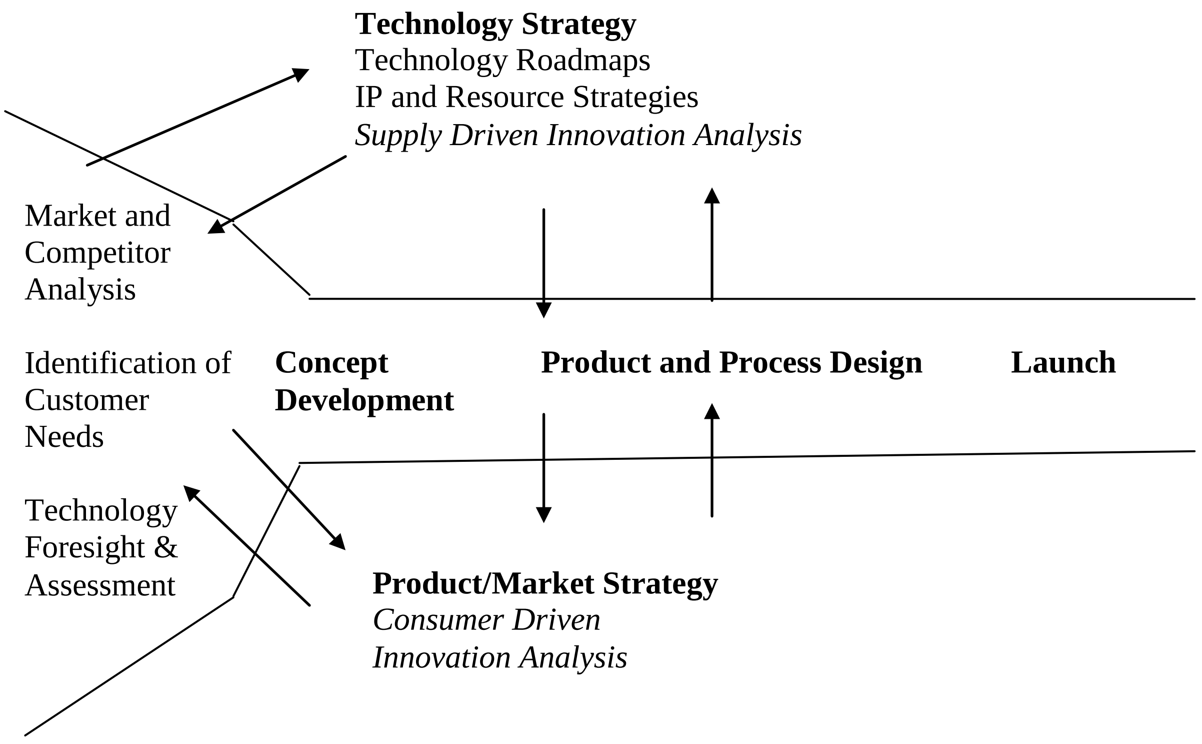
How to promote systemic innovations? It is possible to list some critical issues which have impacts on the speed of systemic innovation. The following issues are important ones, if we want to promote systemic innovations (Taylor and Levitt 2010):

(1) Decrease the span (number of specialist firms) of the systemic innovation process. This makes managing issues easier.
(2) If the systemic innovation impacts multiple experts/specialists on your project, project managers must create a dialogue forum that develops mutual trust for the firms impacted. They should also encourage regular meetings and discussions between impacted companies and even possibly require project team members to work in the same work space. Information sharing matters in a systemic innovation process.
(3) Project managers must know where systemic interdependencies lay in the project in order to understand how a systemic innovation can be adopted over the course of multiple projects (a systemic innovation program). If interdependence is significant, project managers must pay careful attention to managing the other constructs identified in this research.
(4) If the systemic innovation impacts the process of multiple specialists on the project, project managers should choose just one contractor from each specialist group and work with them on several projects. Over time, as inter-organizational routines are able to form, project managers can then begin to introduce new contractors to the bidding shortlist for each specialist firm type.

All these four aspects are relevant for avoiding quality problems of new innovation. We can expect more quality management problems, when

(1) there are *too many companies* in the systemic innovation process;
(2) there is *no dialogue forum* for the innovation project stakeholders;
(3) partners and stakeholders *do not identify systemic independencies*; and
(4) specialist groups use *too many contractors with very diversified responsibilities*.

We can define this evaluation procedure to be ***the SI Tool Package***. This SI Tool Package is suitable for systemic innovation analysis. Systemic innovations are highly non-linear and derive from evolving working practices, project collaborations and problem-solving routines. Systemic innovations are also driven by the EU and government regulations, client demand trends and new skills/capabilities supply. Systemic innovations take place between companies, consultants and clients. Systemic innovations do not necessary happen in the R&D labs, but they take place between organizational boundaries (cross-system boundary innovation), also in non-conventional settings. ***Interactive borderlines of systems*** are often a good source of new innovations. In addition, social and non-technical aspects of innovation process are very important (see Kaivo-oja 2009). The social dimension of innovation matters. In Fig. 4 a systemic framework for product and service development is presented. This framework integrates both supply and demand side thinking. In systemic innovation process it is necessary to integrate these two mainstream approaches. So called *prosumer approach* to systemic innovation is necessary if we want to see successful innovation processes.



Innovation systems

Figure 4. A systemic framework for product/service development

Many discussions in innovation incentives begin from the premise that intellectual property is the solution to the incentive problem. There are, however, other incentive mechanisms too. Intellectual property is just one incentive mechanism, in which rewards are given as limited market power. An innovation requires both an idea and an investment in it. The reward is linked to the social value of the invention. That is why companies and investors will, to some degree, compare social value and social cost when deciding whether to invest. Typically a competitive market is not giving enough incentive to invest in knowledge and in new innovations. Thus, the role of government is important in the process of creating strong incentives for innovation activity. Recent innovation research findings cannot give strong arguments that intellectual property rights are better or worse than public sponsorship. A critical question is the existence of well-designed incentive mechanism. In a well-designed incentive mechanism, rewards can be tailored to expected costs. Typically, a well-designed incentive mechanism can better aggregate private information of companies, to make better investment decisions and to delegate research efforts more efficiently (Schotchmer 2004, 58-59).

3. INNOVATION SYSTEMS AND THE PFI APPROACH

The first person to use the expression *`national system of innovation´* (NSI), was Prof. Bengt-Åke Lundvall (1992). After Lundvall, the concept was used by Prof. Richard Nelson (1993). The OECD and the European Union soon adopted the use of this expression. The systems of innovation approach and its development has been influenced by different theories of innovation such as interactive learning theories and evolutionary theories. The system of innovation approach is compatible with the theoretical notion that processes of innovation are characterized by interactive learning. Thus, constrains and motivational incentives of interactive learning are probably very important factors in innovation processes. Also psychological and motivational aspects matter in a systemic innovation process (see Santonen, Kaivo-oja & Antikainen 2011).

The systemic innovation approach underlines that the relations between organizations and institutions are crucial for the functioning and change of systems of innovation. Also specifications of different kinds of institutions and organizations matter. Thirdly, different kinds of institutional and organizational change are important in an analysis of the performance, structure and change of systems of innovation. (Edquist 2005, 60).

Conventionally the analyzed innovation systems are (1) micro-level innovation systems, (2) regional innovation systems and (3) national innovation systems. We can also analyze systems with Nine Windows or system operator approach (compare Silverstein, Samuel & DeCarlo 2009, 37). We can see micro-level innovation systems as sub-systems, regional innovation systems as systems and national innovation system as a super-system.

Key sub-system elements of the super-system are the Government, the academia and the industries as the Triple Helix model defines (Etzkowitz& Leydesdorff 1997). Customers are the fourth critical key element of super-systems (national innovation system). Key actors of innovations systems are: (1) Industries, (2) universities, (3) the government and (4) customers. If a more systemic approach is adopted, we can talk about the *Quartet Helix Model*, not only about the *Triple Helix*, because nowadays customer-driven innovation processes are becoming more and more popular. Some experts are talking also about *prosumer driven innovations*. The business of breakthroughs requires interaction between these 4 key players of a modern innovation process. Today the best companies and organizations have practices and processes in place to make sure that, from inception to manifestation, new ideas are transformed into real business value. Without consumer analyses and proactive involvement of consumers we cannot expect breakthroughs to real business value. Thus, there are many very good reasons why we should start talking about *the Quartet Helix Model.*

On the basis of beliefs on open innovation, online social networks, ubiquitous technology (r)evolution and Web 2.0 development, some researchers have proposed a new type of approach based on people-to-people interaction to support national innovation activities. With the aim of generating new ideas, our National Open Innovation System (NOIS) paradigm combines two rival innovation sources: (1) technology and social foresight research, and (2) customer needs and experiences (i.e. customer orientation strategy), while following the principles of Triple Helix. The resulting NOIS approach is an effective and comprehensive open innovation structure where university students and senior citizens are engaged as a significant resource for the business community, in order to fulfil the national innovation strategy as defined by the government (see more in Santonen, Kaivo-oja & Suomala 2007).

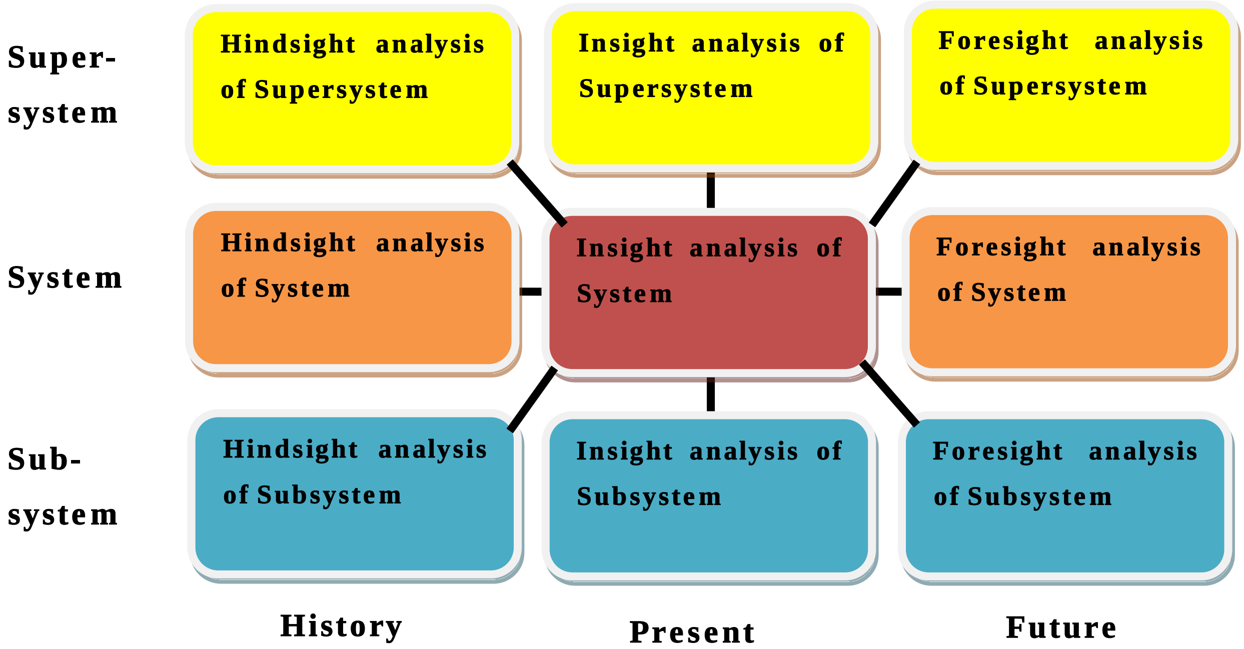


Figure 5. Nine Windows (or system operator) approach (a modified figure)

According to PFI (Profiting from Innovation) research tradition of systemic innovation we can use the following framework to investigate the obstacles and challenges of mass innovation process and the functioning of open innovation approach (Teece 1986, Teece 2006, 1138-1143). According to the PFI research tradition these kinds of 9 critical systemic issues are very important in the innovation system. The 9 critical systemic issues are the following ones (sections 3.1.-3.9.). Here we follow the basic ideas of PFI approach (Teece 1984, 1986, 1988, 2006).

3.1. Complementary innovations

Complementary innovation and complementary technologies are critical assets for the open mass innovation processes. Many technologies and innovations are systemic. That is why complementary innovations and technologies deserve special attention in the innovation process. Successful commercialization requires bringing together complementary technology and patents. If complementary innovations are not available, systemic innovation may also fail.

3.2. Supporting infrastructure

Supporting infrastructure is also a very important success factor for implementing innovations. New institutions, organizations and laws and the provision of complementary assets may be necessary before certain innovations can be developed. Public sector can provide a supporting infrastructure for innovations.

3.3. Capabilities

Capabilities create a critical constraint for an innovation process. Especially the diversity of capabilities is a critical factor. Capacity building can help solve various problems related to capabilities.

3.4. Finance

Finance is always a constraint for innovation process and successful commercialization of ideas. Availability of risk and venture capital is important for innovative organizations and companies.

3.5. Decision framework

Decision framework is an important factor in innovation processes. Decision-making processes in organizations can support innovations or not support them. Typically imposing a broader "outside view" (Kahneman and Lovallo 1993) is likely to assist in generating a less biased view. A limited cognitive framework may cause serious problems for innovation implementation.

3.6. Supply chain issues

All innovations are connected to some kind of supply chain. Typically there are three basic alternatives: (1) outsourcing, (2) collaboration and (3) internalization in relation to a supply chain choice (Teece 2006, 1140). Innovators must make decisions in relation to supply channels and chains. Wrong decision may destroy successful commercialization of ideas, inventions and finally also innovations.

3.7. Standards, increasing returns and network effects

Katz and Shapiro (1994) have emphasized the importance of network effects and increasing returns in the context of innovation processes. Dominant design and associated standards can also create increasing returns and network effects. Wrong design choices can lead to a loss of network effect and returns.

3.8. The multi-invention licensing option

If an innovation is systemic, the multi-invention licensing option is an important aspect of innovation process. Today in the field of biotechnology and microelectronics many inventions are systemic. Wrong licensing arrangements may be harmful for new innovations.

3.9. Intangibles and knowledge management

Intangibles and knowledge management is a big issue in innovation processes. A good knowledge base promotes learning and innovation processes. Investments in intangible capital are a big trend in leading firms of the global markets. Strong intellectual rights and ownership of the complementary assets are together a foundation of successful innovation process.

As a summary, we can present Figure 6, where all the relevant systemic aspects of the PFI literature are mentioned.

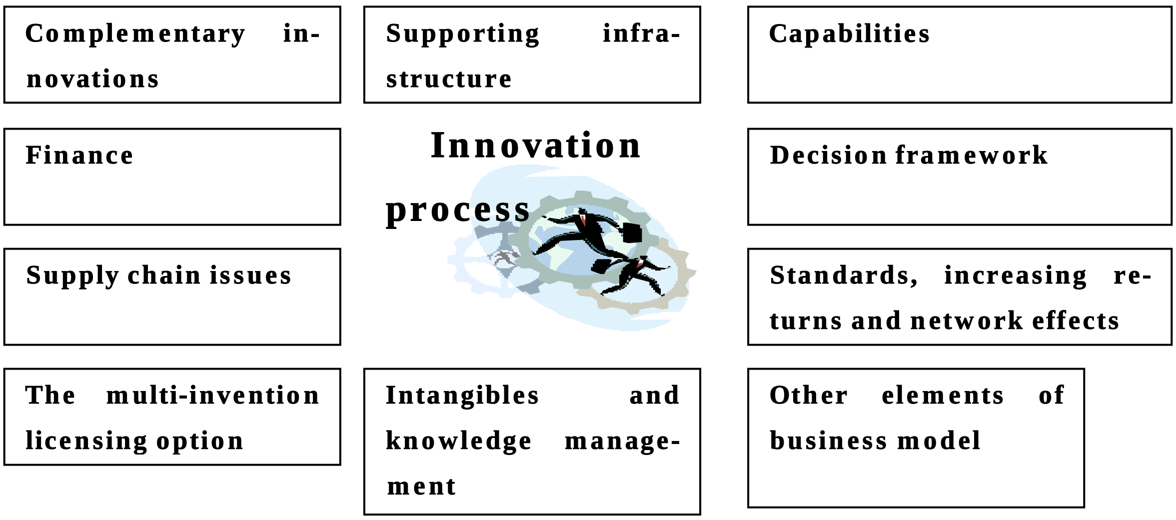


Figure 6 Innovation process and 9 systemic aspects of PFI literature

Tools to manage quality and system failure problems in the context of innovation processes are presented shortly. On the basis of PFI literature (Teece 1986, 1996), it is possible to give the following recommendations to avoid system problems and failures when new innovation systems are adopted. The PFI- check list includes the following tasks:

(1) Analyze *potential complementary innovation/s* critically before adopting a new innovation.

(2) Check out *financial risks* of new innovation investments.

(3) Analyze critical *supply chains* connected to your own production and supply chains.

(4) Check out potential *multi-invention licensing options*.

(5) Do an *analysis of critical infrastructures* needed for your own production and supply chains.

(6) Analyze *non-financial risks of new innovation investment*. Pay a special attention to intangibles, human capabilities and knowledge systems.

(7) Use *a broad decision framework* instead of too narrow decision framework.

(8) Analyze all *standard requirements* of your own production system and supply chains.

(9) Do a critical analysis of your own *business model*. Do you need some changes in it? (see Johnson, Christensen & Kagermann 2010, Nunes & Breen 2011).

We can define this evaluation procedure to be ***the PFI Tool Package***. Many quality and systemic problems can be avoided by using this procedure based on PFI literature. This PFI Tool Package is suitable for a systemic innovation analysis. Many systemic failures can be avoided by using the PFI Tool Package.

The role of business model is a very critical issue for many companies. Some authors say that a smart business model may be even more important than a systemic innovation as such. A good business model remains essential to every successful organization, whether it is a new start-up venture or established and successful player in the business (see more in Magretta 2010, Johnson, Christensen & Kagermann 2010).

The critical systemic elements must be organized with strong win-win logic. If there is not win-win logic, there will be more risks of future success than in a case where some kind of win-win logic exists. Sometimes economists talk about incentives. So agents must have strong motivation and social and economic incentives to implement a complex systemic innovation. In the construction of system innovation strategy, we must take into consideration *three Cs, the company itself, the customer and the competition* (see e.g. Ohmae 1991).

Especially customers must adopt and accept the systemic innovation. This 3 Cs model is a conventional strategic triangle. The job of innovation strategist is to achieve superior performance inside a company, in consumer (or end-user) markets and in relation to potential competitors. There must be right kind of economic and social incentives, which promote the functioning of complex elements of systemic innovation (see e.g. Santonen, Kaivo-oja & Antikainen 2011). In innovation strategy, one must first seek a clear understanding of each systemic element of a situation, and then one must make the fullest use of human brain power to restructure the systemic elements in the most advantageous way.

To sum up discussion in this e-book, we must admit that creation, discovery and innovation are mysterious processes. Scholars and especially economists are reasonably certain that incentives matter. *That is why we must think incentive structures inside a company, in the customer markets and among competitors* (see more in Scotchmer 2004).

4. OPEN INNOVATION PARADIGM AND SYSTEMIC INNOVATIONS

The paradigm of closed innovation says that successful innovation requires control in organizations and institutions. In the closed innovation model organizations must generate their own ideas, and then develop, build, market, distribute and support them on their own.

An alternative key concept of modern innovation studies is the concept of open innovation. Open innovation is an innovation research paradigm that assumes that firms can and should use external ideas as well as internal ideas, and internal and external paths to market, as the firms look to advance their technology. Thus, open innovation has been proposed as a new paradigm for the management of innovation (Chesbrough 2003). The open innovation concept is closely related to (1) user or consumer driven innovation, (2) cumulative innovation, (3) know-how trading, (4) knowledge management, (5) innovation democracy, (6) mass innovation, and (7) distributed innovation (see Hippel 1986, Hippel 2005).

The idea of co-creation is also closely related to open innovation paradigm. *The co-creation principle* has four components: (1) experience mind-set, (2) context of interactions, (3) engagement platforms and (4) network relationships (Ramaswamy & Gouillart 2010, 35-36). All these elements promote open innovations. Today many companies, like Apple, Starbucks and Nike, have adopted this approach to innovation management. Many promising results have already been reached by the co-creation approach.

Open innovation is defined as “the use of purposive inflows and outflows of knowledge to accelerate internal innovation, and to expand the markets for external use of innovation, respectively” (Chesbrough et al. 2006, 1). Technology acquisition and technology exploitation are key elements of open innovation thinking (Lichtenthaler 2008). Technology exploitation includes purposive outflows of knowledge. Purposive inflows refer to technology exploration. Technology exploration refers to activities which enable organization to acquire new knowledge and technologies from the outside.

In a fully open innovation model, firms or organizations combine both technology exploitation and exploration in order to maximize the value of their technological and other capabilities. Open innovation is a management challenge for SMEs and larger corporations, but it is also challenge for educational and academic organizations. Closed innovation model assumes a different kind of systemic approach to innovation process than the open innovation model. This is an interesting difference between these two alternative innovation models. In a closed model, incentives and constrains do to not promote knowledge sharing. In open innovation model an innovation system promotes knowledge sharing. Thus we can conclude that a particular innovation system determines whether closed or open innovation model works in reality.

In Table 1 difference between open and closed innovation thinking is presented and key quality management (QM) problems are defined.

Table 1. Closed system, open system and systemic QM problems

Systems	Quality management problems
Closed systems	Problems with information sharing, not too much information and knowledge. Lack of information may cause many quality management problems and systemic failures. **Key question:** How to have enough information inside an organization to avoid these problems?
Open systems	Maximize value of organizations´ technological and other capabilities: Information load may cause many quality management problems, if there is not any well-functioning systemic co-ordination mechanism. **Key question:** How to organize effective information sharing without creating quality management problems?

Transparency compared to closed systems approach requires a new way to think about innovation and a different path forward as ideas come in and begin to show promise.

It is important to understand that open innovation and open systems approaches are something different compared to old "suggestion boxes". Whether you have an old-fashioned "suggestion box" or provide simple online tools, you've got to have a process to capture, and more importantly, to manage and evaluate incoming ideas. Typically traditional R&D folk are used to a stage-gate process,. It's no big surprise they'll still want similar tools to manage open innovation. Good and functioning tools provide great benefits: (1) Department heads can cull through the volume of crowd-sourced ideas to weigh and prioritize where to spend the organizations' time/money, (2) idea contributors want to know their ideas are heard, and taken seriously, (3) innovators need to know who/where the other innovators are, and (4) with the right tools, social-media style idea challenges can be posted to solve some of the organizations more pressing issues (Handrick 2011).

Open innovation supports the fact that valuable ideas can come even from inside as outside the company or corporation. These ideas can also go from inside or outside the company to the market. Thus, companies can benefit from open innovation. One of the main advantages is that organizations can benefit from their wide range of experts. Companies or individuals from the outside of the organization can create innovative ideas for a company. Companies who have a new fresh look at the company can generate ideas which could not arise by people within the organization. Important applications of the open innovation paradigm are digital network applications and new social media applications. By these new tools the time-to-market can be decreased. (see e.g. Chesbrough, 2006).

5. QUALITY MANAGEMENT PROBLEMS AND INNOVATION SYSTEMS

First, creating and developing innovations requires innovative abilities. In Figure 7 key innovative abilities are defined (Gharajedaghi 2006, 43). We can make some important notes on the basis of Fig. 7:

- Innovation process requires not only innovators, but problems solvers, imitators (doers) and problem formulations.
- Ability to find similarities and to find differences is the fundamental driver for innovations.
- Both low and high abilities are needed in innovation processes.
- Plurality in functions, structures and processes is needed in innovation processes.

All these notes are important for the creation of systemic innovations. Plurality of function, structure and process is at the core of systems theory of development. It makes the high/high a systemic possibility and choice of reality. Better solutions lead high/high solutions. Quality of innovation is based on these actions. If there is great diversity of actions, better quality level is probably developed. It is very important to understand that first we must create pre-conditions for high quality and when it is done, we can start to evaluate quality aspects of services, products and systemic innovations. Often, people expect that new innovations are created without these pre-conditions and actions of innovation. This kind of wrong assumption automatically leads to bad quality of innovations. Plurality maintains that systems can have multiple structures and multiple functions and they can be governed by multiple processes. To sum up, systemic thinking, as such, helps us to create better innovations.

Ability to find similarities among objects which seem to be different		Ability to find differences among objects which seem to be similar: Low	Ability to find differences among objects which seem to be similar: High
	High	PROBLEM SOLVERS	INNOVATORS
	Low	IMITATORS DOERS	PROBLEM FORMULATORS

Figure 7. Innovative abilities (Gharajedaghi 2006, 43)

Tools to manage QM problems in the context of innovation processes are presented shortly in this chapter. Typically QM problems are found to be: (1) in the technology transfer of innovations, (2) in the maintenance technology development of new innovations, (3) in the use of methods for the investigation of quality and durability (or sustainability) of new innovations, (4) in the analysis of pro-ecological aspects of new innovations (systemic eco-innovations and eco-innovations) and (5) in the use of testing tools of innovation quality.

Thus, in most cases PFI and SI Tool Packages are useful for innovation stakeholders. Where testing is concerned, *Haner's innovation quality test* (Haner 2002) is a suitable tool.

As proposed by Haner (2002, 34-35), innovation quality must be assessed in three domains, in (1) product/service level, in (2) process level and in (3) the enterprise level. Potential measures for the individual domains are (cf. Ahmed and Zairi 2000):

A. Product/service-related measures:

- value added to the customer
- costs against targets
- stability of design
- product return on investment
- product performance level, etc.

B. Process-related measures:

- time to market
- efficiency and productivity improvement
- staffing level effectiveness in product development
- project management effectiveness
- flexibility increase, etc.

C. Enterprise-related measures:

- acceptance rate throughout the workforce
- understanding customer needs
- turnover generated with innovative products
- patent ratio
- rate of successful innovation attempts, etc.

Table 2 summarizes some key aspects of typical QM problems and associated solutions.

Table 2. QM problems and potential solutions to manage systemic innovations and innovation systems

QM problems	Solution tools and methods
Challenges of better customer satisfaction	Use JTBD tool package
Technology transfer of innovations	Use PFI Tool Package
Maintenance technology development of new innovations	Use SI Tool Package
Methods for the investigation of quality and durability (sustainability) of new innovations	Use PFI Tool Package
Grand challenges aspects of new innovations (including systemic eco-innovations and autonomous eco-innovations)	Use PFI and SI Tool Packages together
Testing tools of innovation quality.	IQ Tool Package (Haner 2002)

Innovation quality measurements provide a management tool for leaders and managers in a company. We can call this system ***the IQ Tool Package***. This IQ Tool Package is suitable for individual innovations, either social or technological innovations. Here it is important to note that in quality management both hard and soft Ss matter. Hard Ss are strategy, structure, and systems. Soft Ss are style, shared values, skills and staff. In conventional U.S. management hard Ss are managed well, but in Japanese management soft Ss are manager in a better way (see Pascale & Athos 1981). Thus, *we must combine U.S. and Japanese management styles to manage systemic innovations*.

There are various outcomes of innovation quality. The best companies have strong product/service innovation quality (IQ), strong process IQ and strong enterprise IQ. Typically, companies have problems in some domains. Only in very exceptional cases all the domains of IQ are strong (Haner 2002, 33-36).

Thus, almost all the companies are having some problems in their IQ and innovation management systems. By focusing on these problems and developing new ways to handle them better results can be achieved.

6. SUMMARY

Many scholars argue that enhancing innovation and value creation within a globalized knowledge economy requires new recipes for success. Key issues in the innovation process are (1) innovation systems, (2) systemic innovations and (3) open innovations. Today useful information, knowledge and competence are widely disseminated outside the boundaries of a firm. This kind of situation is challenging if we want to avoid quality management problems associated with novel innovations.

Implementing systemic innovations requires a combination of skills associated with corporate foresight research, corporate planning and organizational change management. Trend analyses and especially trend prediction are needed in the innovation processes. The basic idea of trend analysis is to extrapolate how current systems will evolve in the future. As we noted in this e-book, Darrel Mann has presented an extensive understanding of 35 universal technology trends, each of which progresses toward increasingly valued and ideal innovation. This trend analysis framework is universal and useful tool in the identification of future trends.

One key scientific contribution of this e-book is a new model of systemic innovation. Thus there exist actually four basic models or future scenarios of systemic innovation. Let´s call this new logical framework of systemic innovation *Kaivo-oja´s Basic Model of Systemic Innovation* (KBMSI) as presented in this e-book.

On the basis of system theoretical approach to change, we can outline that change is not linear or one-dimensional issue. This is good to remember when we are talking about systemic change and systemic innovations. Systemic change is multi-dimensional management challenge. When we manage systemic innovations, we must pay attention to many dimensions of change, to imitation, to inertia, to sub-optimization, to change of game and to paradigm shifts.

In this e-book I also noted that in quality management both hard and soft Ss matter. Hard Ss are strategy, structure, and systems. Soft Ss are style, shared values, skills and staff. In conventional U.S. management hard Ss are managed well, but in Japanese management soft Ss are manager in a better way. Thus, my recommendation is that *we must combine U.S. and Japanese management styles to manage systemic innovations.*

One important note of this e-book is that we need to start talking about *the Quartet Triple Helix Model*, not any more about *the Triple Helix Model*, because *consumers are now the fourth pillar of national innovation system*. One key note of this e-book is that key players of systemic innovation are consisting of four parts: Industries, the government, the academy (universities) and consumers. Innovations are now *prosumer driven*, requiring both production and consumption side co-operation. Also, because of networking and globalization, closed national innovation systems are becoming more *national open innovation systems*. Thus, the *NOIS paradigm* is going to emerge (Santonen, Kaivo-oja & Suomala 2007).

The aim of this article was to analyze the futures of modern systemic innovations and post-industrial innovation systems. Innovations form an important part of technological and industrial system dynamics. They also have certain kinds of impacts on maintenance and sustainability problems. In some progressive cases an innovation solves quality management problems. In some other non-progressive cases, innovations are causing new quality management problems. Also systemic innovations can be disruptive, and they can change rules of game, and they can also create paradigm shifts.

Thus, we can conclude that R&D experts and stakeholders of a systemic innovation must be critical towards new social and technological innovations. In this article we have presented new approaches to manage quality management problems in the contexts of innovation systems, systemic innovations and individual innovation processes. We have also discussed open and closed innovation paradigms. Key difference in relation to the systemic innovation perspective is that in open innovations co-operation in information sharing is a key issue for the management of quality management problems. In a closed innovation process the internal competences of an organization determines its ability to avoid systemic quality management problems.

According to this e-book, key tools for innovation quality management (and avoiding system failures of innovation process) problems are:

(1) utilization of the JTBD tool package,
(2) the PFI Tool Package,
(3) the SI Tool Package and
(4) the IQ Tool Package.

All these four tool packages can be motivated by the research findings of international innovation research as explained in this comprehensive e-book. The use and heuristic logic of these tools are presented in this short e-book. I hope that these tools help companies and public sector organizations to manage systemic innovations in better ways leading them to new success stories of systemic innovations.

As a summary, we can note that *the PFI Tool Package is suitable for broader innovation systems*. We can also note *the SI Tool Package is suitable for systemic innovations* and *the IQ Tool Package is suitable for individual technology or service innovations*.

Systemic thinking is not easy, because it requires insightful information and knowledge about landscape of innovations, regimes of innovation management and niche level of innovation. Systemic innovations often include a strong element of organizational learning. According to recent research findings, there are four elements of organizational learning: *(1) supportive leaders, (2) culture of continuous improvements, (3) intuitive knowledge processes and (4) defined learning structure*. Typically, the solutions companies consider must map to the trajectory of company's strategy or a new innovative business model must be developed. Companies must make sure that they have the best options available, at minimal risk. This means that companies must take organizational learning very seriously and try to access the skills and experience necessary to realize breakthroughs. The key word of the future will be *systemic organizational learning with these four human-scale systemic elements mentioned above.*

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