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INNOVATION CONCEPTS AND TYPOLOGY – AN EVOLUTIONARY DISCUSSION

This paper is devoted to the analysis of evolution of innovation concepts, aspects and types. First emergence and evolution of different aspects and concepts of innovation are analyzed, and then the development of innovation concepts from a historical perspective and finally an overview of the types of innovation classifications developed in the literature are given. Complementary the different definitions of innovation are described and analyzed in detail. The main goal of the article is to identify, describe and visualize the development trend of innovation conceptualization and understanding over time.

JEL Classification: B10, B20, O31, O32, O33, Q55.
Keywords: innovation concepts, innovation types, aspects of innovation, innovation systems, innovation ecosystems, typology of innovation, product innovation, process innovation, service innovation, marketing innovation, organization innovation, business innovation.

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Introduction

During the last thirty years, innovation has evolved as the synonym for the development of nations, technological progress and driver of business success. Innovation nowadays is not simply the "creation of something new" but also a panacea for the solution of board range of problems. The term "innovation" is more and more often used – by policymakers, marketing specialists, advertising specialists and management consultants – not as a strict scientific concept but as metaphor, political promise, slogan or a buzzword.

Recently the "need for innovation" fever appears in all spheres of science [Nowotny, 2006, 2008; Godin, 2008]. Even biologists recently begin to find features of innovation behavior in the animal world [Reader and Laland, 2003] in which specialists try to find drugs that stimulate people innovation activity [Greely et al., 2008].

More and more exotic types of innovation start to develop like "blue ocean innovation" [Kim and Mauborgne, 2005], "frugal innovation" [Tiwari and Herstatt, 2011], and "organic innovation" [Moore, 2005]. The main subject of innovation is now not only the innovator himself but also such "archetypes" as "customer anthropologist" [GE and Stone Yamashita Partners, 2005] and "roadblock remover" or "innovation faces" like "cross-pollinator" and "caregiver" [Kelley and Littman, 2005].

But throughout history innovations and innovators have not been always appreciated and (as well as inventions and inventors) and have long been rejected by society. Until the end of the 18th century innovators were untrustworthy adventurers, and crooks for society, and just like heretics for the Church. Thus innovation has long been perceived as any deviation from the political, societal or religious norms. This was especially evident until the 19th century at which time innovation was not a subject of scientific research. It was only since the middle of the 19th century innovation came into the field of scientific research implicitly. The early 1900-s witnessed the birth of the first theories of innovations. Since the second half of the 20th century the concept of innovation started to spread over the different fields of science. The time span between 1960-s and 1990-s can rightly be called the golden age in the study of innovation. However in the last ten years the concept of innovation began to gradually shift from strong scientific definitions to management concepts, slogans and buzzwords.

This paper is organized as follows. The first section discusses different aspects and concepts of innovation. The second section analyses the development of the innovation concept in historical perspective. Finally the third section highlights the types of innovation classifications developed in the literature. The conclusion summarizes the basic thesis of the whole work.

Concepts of innovation

In the classical Schumpeterian interpretation technical change is defined as "a historic and irreversible change in the method of production of things" and "creative destruction" [Schumpeter, 1934]. According to this definition technical change in practice can be implemented in forms related to:

- the implementation of goods (products) that are new to consumers, or higher quality than their previous counterparts;
- the implementation of production methods that are new to specific industries and economic activities in which they are used;
- the opening of new markets;
- the use of new sources of raw materials;
- the implementation of new forms of competition that lead to structural changes in the industries of their implementation.

In line with the Schumpeterian concept, innovation is related to changes (large-scale (radical) or small (incremental)) that have a significant impact on the structural changes in individual industries and market segments. In this approach, new production methods are not necessarily based on new scientific discoveries. The first use of technologies that have already been used in other industries can also be attributed to new methods. Since innovation is associated with the processes of manufacturing of the product and its use, the contents of this concept in international literature is based on different principles and each cluster of definitions has its specific characteristics [Linton, 2002].

The basic definitions and types of innovation (sometimes referred to as "shapes" or "typology" of innovation) are given by the Organization for Economic Cooperation and Development (OECD) in a series of manuals. The latest revision of these manuals is the Oslo Manual which defines innovation "the implementation of a new or significantly improved product (good or service), or process, a new marketing method, or a new organizational method in business practices, workplace organization or external relations" [OECD, 2005, p. 46].

An earlier OECD definition describes innovation as: "… all those **scientific, technical, commercial and financial steps** necessary for **the successful development and marketing** of **new or improved** manufactured products, the commercial use of new or improved processes or equipment or the introduction of a new approach to a Social service. R&D is only one of these steps." [*OECD*, 1981].

In these two examples an evolution of the notion "innovation" becomes apparent. While in 1980-s the focus was on steps of innovations, the main focus switched to innovation

implementation and innovation typologies. More recently methodologically switches to distinguish innovation from other changes are evident.

In general two major (conceptual) aspects of innovation can be distinguished: [Cooper 1998, Gopalakrishnan and Damanpour 1997]:

- innovation as a process that encourages change (the result of the emphasis on innovation);
- innovation as an event, object, or a discrete product, characterized by novelty.

However since this classification is very broad it can be split further. "Innovation as event, object or a discrete product" can be separated into several aspects: "innovation as event", "innovation as physical object" and "innovation as something new (new process or method for organization of something". Over time, a more detailed classification of aspects of innovation was developed. For example, Godin (2008) defines 12 concepts of innovation which can be described as follows:

A: innovation as process of doing of something new:

- innovation as imitation;
- innovation as invention;
- innovation as discovery;

B: innovation as human abilities to creative activity:

- innovation as imagination;
- innovation as ingenuity;
- innovation as creativity;

C: innovation as change in all spheres of life:

- innovation as cultural change;
- innovation as social change;
- innovation as organizational change;
- innovation as political change;
- innovation as technological change;

D: innovation as commercialization of new product

Another detailed classification of the aspects and dimensions of innovation is given by Ram, Cui and Wu (2010). The authors distinguish the following five aspects of innovation:

- innovation as something new;
- innovation as a conduit of change
- innovation as a process;
- innovation as a value driver;
- innovation as an invention.

The variety of innovation characteristics is expressed by many different definitions. Different innovation definitions reflect the broad spectrum of aspects of innovation. Barnett (1953) considers **innovation as something new: "**any thought, behavior, or thing that is new because it is qualitatively different from existing forms". Drucker (1985) and O'Sullivan & Dooley (2009) describe **Innovation as a conduit of change:**

- Innovation is the specific tool of entrepreneurs, the means by which they exploit change as an opportunity for a different business or a different service. It is capable of being presented as a discipline, capable of being learned, capable of being practiced [Drucker, 1985];

- The application of practical tools and techniques that make changes, large and small, to products, processes, and services that results in the introduction of something new for the organization that adds value to customers and contributes to the knowledge store of the organization [O'Sullivan & Dooley, 2009].

Innovation as a process is thoroughly defined by Aiken and Hage (1971) and Rasul (2003). Thus, Aiken and Hage (1971) see innovation as **"**… the generation, acceptance, and implementation of new ideas, processes, products, or services…. for the first time within an organization setting". Rasul (2003) defines innovation as "… the process whereby ideas for new (or improved) products, processes or services are developed and commercialized in the marketplace". Beyond the process dimension Wang & Kafouros (2009) recognize **innovation as value driver: "**Innovation through infusion of new products and services, and provide impetus to emerging economies by opening up opportunities of international trade". Zaltman, Duncan and Holbek (1973) see **innovation as invention: "…** a creative process whereby two or more existing concepts or entities are combined in some novel way to produce a configuration not previously known by the person involved".

However scholars increasingly distinguish innovations and inventions (Table 1). Innovation and invention have reasonably different meanings in dictionaries. For example, according to Webster's New Dictionary (electronic version) innovation[4] is:

1: the introduction of something new

2: a new idea, method, or device

According to this Dictionary invention[5] is:

1) discovery, finding

2) productive imagination: inventiveness

3) something invented: as

(1): a product of the imagination; especially a false conception

[4] http://www.merriam-webster.com/dictionary/innovation#
[5] http://www.merriam-webster.com/dictionary/innvention#

(2): a device, contrivance, or process originated after study and experiment

(3) and / or a short keyboard composition featuring two- or three-part counterpoint

4) the act or process of inventing

Other examples for differentiation of innovation and invention in scientific literature are summarized in Table 1.

Table 1: Innovation and invention concepts in scientific literature

Author(-s) of model	Innovation	Invention
Freeman, 1982	**Innovation is the introduction of change** via something new.	**Invention is the creation of a new** device or process.
Senge, 1990	**'idea' becomes** an **innovation** only when **it can be replicated** on a meaningful scale **at practical costs**	**Idea** has been '**invented**' when it is **proven to work in the laboratory.**
Rouse, 1992	**Innovation is the introduction of change** via something new.	**Invention is the creation of a new** device or process.
O'Sullivan and Dooley, 2009	Innovation **is more than the creation of something novel**. Innovation also includes the exploitation for benefit by adding value to customers. Invention is often measured as the ability to patent an idea.	Invention **need not fulfill any useful customer** need and need not include the exploitation of the concept in the marketplace.

Source: authors' adaptation from Freeman (1982), Senge (1990), Rouse (1992) and O'Sullivan and Dooley, (2009).

One of the first example of contradistinguishing innovation and invention in literature in the field of economics is provided by Stamp (1929, 1934). Then this was further developed by Schumpeter. According to Schumpeter invention can be seen as the act of "intellectual creativity" and invention "is without importance to economic analysis" [Schumpeter, 1939, p. 105]. The innovation is the act of applying or adopting invention. Therefore, innovation is already an economic decision in the Schumpeterian logic. Some scholars [for example Freeman, 1982; Rouse, 1992] show the differences between inventions and innovations, which are mainly determined by the practical application of innovation. Heunks (1998) defines innovation as the successful technical and economic implementation of the idea whereas O'Sullivan and Dooley (2009) consider innovation in contrast to the present invention more than creating something new but also including the use of a new product with benefits adding the value to consumers. Another widely used concept defines innovation as a tool for the creation of new knowledge [Acs, Anselin and Varga, 2002; Strambach, 2002]. In this context, a new concept is based on the position that the use of new products, services, processes and paradigms that are embedded into existing innovation leads to new ways of thinking and new knowledge. This iterative cycle of knowledge and creation of new knowledge, in turn, leads to an intensification of innovative processes.

In their book "Innovation management: context, strategies, systems and processes" Ahmed and Shepherd (2010) define 6 aspects of innovation (Table 2).

Table 2: 6 aspects of innovation by Ahmed and Shepherd

Aspect of innovation	Focus of definition
Creation (invention)	**Use of resources** (people, time and money) to **invent or develop** a **new product, service**, new way of doing things, new way of thinking about things.
Diffusion and learning	On acquiring, supporting or using a product, service or ideas.
Event	Discrete event, such as the development of a single product, service, idea or decision.
Change (incremental or radical)	Enacting of change. Some innovations are minor adjustments whilst other innovations are radical or discontinuous in nature.
Process (firm-level)	innovation is not a single act, but a series of activities that are carried out by a firm to lead to the production of an outcome (namely, the innovation).
Context (region, nature, etc.) level process	Act beyond the confines of an individual or firm. Focus on institutional frameworks, socio-political networks, and proximal factor endowments as important factors in the act of innovation.

Source: authors' adaptation from Ahmed and Shepherd, 2010.

The analysis of innovation aspects shows that since the first innovation definitions were developed the discussion of innovation aspects has progressed substantially. Innovation is seen not only as process of change or physical object but also as instrument of change and the condition for this change. Thus the aspects of innovation can be summarized as follows:

- innovation as something new (some real object: product, service or software);
- innovation as process of doing, creating something new;
- innovation as the instrument for doing, creating something new;
- innovation as condition (environment) for doing something new;
- innovation as idea (concept) of something new;
- innovation as human abilities for doing something new;
- innovation as process of change.

Following the analysis of the basic aspects of innovation in their historical development we now look more closely on definitions of innovations in different studies to see how these definitions reflect the aspects of innovation.

From definitions we can see that the key feature of innovation is the presence of the element of novelty (newness) which also allows for different interpretations [Knight 1967; Gopalakrishnan & Damanpour 1997; O'Sullivan & Dooley 2009]. It has been recognized by a number of scholars that the criterion "novelty" cannot be the sole criterion of innovation but inventions or ideas become innovation in course of their transformation into application that is used in practice [Robertson 1967; Mohr 1969; Walker 2006].

Many conceptual definitions of innovation were developed in the late 1960-s. For example Robertson (1967) defines innovation as "a process by which a new idea, behavior, or thing, which is qualitatively different from existing forms, is implemented and applied in practice" [Robertson, 1967, page 14]. Other innovation studies of the late 1960-s also focus on the concept "innovation as something new (or source of novelty)". According to Mohr (1969), innovation can be a source for creating a "new" that can be developed product or process that is

new to her followers (adoption unit) [Mohr, 1969]. Introducing the concept of innovation, the author describes in his work an innovation as "the successful introduction into an applied situation of means or ends that are new to that situation" [Mohr, 1969, p. 112].

It shows that in 1960-s, innovation was interpreted mainly with reference to "conceptual aspects" without taking into account the complexity and diversity of definitions and generally considered in relation to companies but not to markets or countries [Carroll, 1967; Robertson, 1967; Mohr, 1969]. In the 1980-s and 1990-s a number of important methodological principles have been proposed, reflecting, in particular, the classification features of innovations such as "new to firm", "new to market" and "new to the world economy" [Kwon and Zmud, 1987; Bacon and Butler 1998].

Rogers` definition of innovation is also important for understanding the links between innovation and the newness [Rogers, 2003]. In his understanding innovation is "an idea, practice, or object that is perceived as new by an individual or other unit of adoption" [Rogers, 2003, page 12]. This definition clarifies the essence of the term "new" on the basis of hypotheses' about the independence of "novelty" from the life time of innovation, the environment in which it operates and the characteristics of an adopter of innovation. In accordance with this definition, the criterion of "novelty" of innovation is determined by the choice and the perception of innovation of its adopters (followers). This means that the idea, object or practice is considered innovative during the period of its perception as "new" by the representative adopters. However the idea, object or practice is classified as an innovation, regardless the fact that other followers in the system cannot attribute this idea, object, or the practice of innovation because of their earlier acceptance or knowledge about the innovation. In this context, it is also understood that the availability of information and knowledge on innovation does not distort the criteria of "novelty" and innovation is perceived as "something new" by the representative follower up to the moment of its use in practice. In the development of Rogers` concept of re-invention Walker in his research has synthesized the definition of innovation [Walker, 2006]. According to Walker innovation is "a process through which new ideas, objects, and practices are created, developed or reinvented and which are new and novel to the unit of adoption" [Walker, 2006, page 313].

However not only the "new" was the main conceptual aspect in definitions of innovation [Kwon and Zmud, 1987; Rogers, 2003; Walker, 2006]. In particular, several researchers [e.g. Vergragt, 1988; Dakhli and de Clercq, 2004] put forward the hypothesis that the changes associated with innovation, should be considered in a social context in terms of their users. Accordingly, at the institutional level, innovation must be seen as a social process, not a scientific discovery. That allows to estimate its impact on the structure and procedures of organizations namely users. Eventually the goal of innovation is creation of value added and a

positive impact on the operation and development of organizations. Therefore, innovation may include only the changes that have favorable consequences for organizations.

In subsequent developments, O'Sullivan and Dooley (2009) articulated the hypothesis which is important for the conceptualization of innovation. Their assumption is that innovation is the process of implementation of changes directed to increasing the value of the product for the user, as well as to contribution to the development of knowledge for the adopter of innovation. This concept of innovation as a factor contributing to changes more explicitly reflects the multiple aspects of innovation definition.

The innovation as a value driver concept is very important for assessing the efficiency of innovation. In this concept, innovation is defined as a source of competitive advantage and is seen as a decisive factor for economic growth and the basic condition of company development in a competitive environment [Johannessen, 2009]. From an organizational point of view, the adoption of innovation may lead to improved operational efficiency; create better working practices, competitive advantage and flexibility that ensure sustainable development of companies in a dynamic changing business environment.

Another widely used concept defines innovation as a tool for the creation of new knowledge [Acs, Anselin and Varga, 2002; Strambach, 2002]. In this context, a new concept is based on the position that the use of new products, services, processes and paradigms that are embedded into existing innovation leads to new ways of thinking and new knowledge. This iterative cycle of knowledge and creation of new knowledge, in turn leads to an intensification of the innovation processes.

Studies on radical and incremental innovations are also relevant for the conceptualization of innovation [Ettlie, Bridges and Okeefe, 1984; Brettel et al., 2011]. Radical innovation is considered in economic theory as a driving force for economic growth since Schumpeter works [Schumpeter, 1934, 1942]. In further theoretical studies, the term was associated with the content of the various concepts and definitions [Ettlie, Bridges and Okeefe, 1984; McDermott, O'Connor, 2002; Tellis, Prabhu and Chandy, 2009].

In different studies the terminology used and the definition of radical innovation vary greatly depending on the specifics of the research [Dewar, Dutton, 1986; Verganti, 2008]. For the identification of such type of innovations, the following concepts were used: “really new” [Schmidt and Calantone, 1998; Song and Montoya-Weisse, 1998], “breakthrough” [Rice et al., 1998] and “discrete innovation” [Priest and Hill, 1980]. Another problem is associated with the measurement of radical innovation. For example, in Schumpeterian theory there is no clear distinction between radical and other types of innovations. According to Schumpeter “creative destruction” replaces the old technology and expands new business opportunities that may be

subject to quantitative measurement. Authors such as Dahlin and Behrens, associate the degree of radicality of inventions to the nature of ideas, on which innovation activity is based, as well as to content of new knowledge or systematic data in innovation [Dahlin and Behrens, 2005].

The complex nature of the innovation concept is mirrored in the definitions of innovation in different studies in late 1970-s and 1980-s as well as in 2000-s. These definitions commonly highlight the complex nature of innovation processes. The **linear models of technological innovation** are useful for describing key steps in the R&D process and in documenting projects but are not particularly helpful in understanding the process in real time. Linear models describe what happened but not how it happened, and tend to reinforce the belief in a kind of orderliness which does not exist (Carlsson, Keane and Martin, 1976). In other models **innovation cuts across a broad range of activities**, institutions and time spans. If any part of the pipeline is broken or constricted, the flow of benefits is slowed [Botkin, Dimancescu and Stata, 1983]. Models that **depict innovation as a smooth**, well-behaved **linear process badly misspecify** the nature and direction of the causal factors at work. Innovation is complex, uncertain, somewhat disorderly, and subject to changes of many sorts. Innovation is also difficult to measure and demands close the coordination of adequate technical knowledge and excellent market judgment in order to satisfy economic, technological, and other types of constraints – all of them simultaneously. The process of innovation must be viewed as a series of changes in a complex system not only of hardware, but also of the market environment, production facilities and knowledge and the social contexts of the innovation organization (Kline and Rosenberg, 1986).

Innovation is not just about technology development rather it includes the way of financing, the way of marketing and marketing relationships, the way of creating strategic partnerships, the way of dealing with governments. The innovative nature of doing business has to be pervasive in the company, and had to look at **more than just technology development**. [Rasul, 2003].

Still these definitions mainly imply that **innovation is** a synonym for **new products** but neglect or at least do not fully stress **strategy innovation**, such as entering new markets with existing products. Also **supply chain innovations** and **value-adding service innovation** are barely considered in the innovation context although they deliver additional customer value and have reasonable impact on the origins of the next generation of innovation from companies; perspectives by allowing real time responsiveness. Such strategy based innovations are a new frontier that many firms have never pursued [Tucker, 2004].

In summary the following conclusion can be done form this analysis:

1) Innovation definitions are connected not only with newness but also with change and efficiency in terms of market conquest and fast promotion of new products.

2) Innovation can’t be conceptualized by accurate, comprehensive and generally accepted definition (like for example “inflation”, “amortization”, “debt” and other established and generally accepted economic terms).
3) Innovation is board concept and for different fields of science different aspects of innovation matter. For example for economic theory, innovation is close to the “new” concept while for management “value (competitive advantage) creation” feature of innovation matters.

The following chapter draws a picture of the historical evolution of the innovation concept.

Development of the innovation concept in the historical perspective

A comprehensive analysis of the historical development of the innovation concept can be found in Godin (2008)[6]. Further the **historical development of concept of innovation** will be presented in summarized from (based on Godin (2008) analysis). A detailed analysis of the evolution of innovation studies as well as concepts and models of innovations since the 1890-s until the 2000-s ordered by decades is shown in the annex tables.

Pre 19th century

According to Godin (2008) innovation had no relationship with creativity, originality and application. Innovating meant imposing change to the established order and faced implicit and explicit resistance especially from church and society. Opposition to innovation existed in all spheres of life: economics, politics, law, science, education and religion [Godin, 2008]. There was a negative perception of innovation and innovators. Because of weak development of science innovators were seen as heretics and suspicious people since in many cases only the innovators themselves could explain what they did and that their inventions were something good and useful for society.

Second half of 19th century – first half of the 20th century

Further Godin (2008) shows that there was a gradual shift towards a more positive perception of innovation in this time. Theories of innovation started to develop in many fields of science accompanied by a tendency towards explaining revolutionary changes in all spheres of life by innovations [Godin, 2008].

The first theories of innovation were developed in the field of sociology [Tarde, 1890, 1896, 1998, 1902]. There innovation was seen as the change in social constructs such as grammar, language, law, religion and so on. However, the first use of term "innovation" in sociological literature is found in Hart (1931) and then started to spread over the other "innovation studies" in sociology [Gilfillan, 1935, 1937; Ogburn, 1941]. The term "technological change" was preferred by sociologists [Stern, 1927, 1937; Chapin, 1928, Davis, 1940]. Then in the anthropology innovation was understood as cultural changes [Smith et al., 1927]. First theories of technological inventions emerged in psychology [User, 1929; Rossman, 1931] and the first prototypes of innovation diffusion models also came from sociology [Ogburn, 1922; Chapin, 1928; Gilfillan, 1935]. Some similar "models" were used in anthropology – cultural change as a result of contact between cultures [Redfield et al. 1936; Barnett et al., 1954].

[6] The deep analysis of innovation models (on conceptual level) development in historical perspective is described in Marinova and Phillimore (2003) as one chapter in Shavinina's fundamental book "The international Handbook on Innovation". The "classical" five-generation model of innovation (management) was introduced by Rothwell (1994). But here author uses the "innovation management approach" and classifies five generations of innovation models in line with development of innovation management methods.

Anthropologists also were among the first making effort to quantify technological innovation as acceleration and growth of material culture. The first analysis of the effects (social) of technological inventions was done by Stern (1937). The first conceptualization of innovation was also done in sociology – Chapin (1917) identified innovation as social experiments.

First prototypical approaches to the analysis of technological (technoeconomic paradigms) paradigm developed by Dosi [1982, 1988], Freeman and Perez [1982] and Perez [1988] can traced back to the original sociological work by Odum [1937] and Davis [1940] – the "techniways" concept.

Sociologists and anthropologists looked at innovation as a broad paradigm concept. For these specialists innovation (or technological invention) was a phenomenon (process of paradigm – in social or cultural context- change) and broad construct. Therefore, anthropologists and sociologists took the "macro-level" view or, more precisely, the "society-level" view on innovation. For them innovation was the background of social or cultural changes. Their analysis was more descriptive rather than strongly mathematically computable.

Economists took the other view on innovation. They looked more on the technical side of innovation. For economists innovation was in the first place a means (or tool) for competitive struggle, a method to increase productivity, new products, processes or services and only after that "the concept itself", the innovation per se. The pioneer here was Schumpeter[8] with his creative destruction concept [Schumpeter, 1932, 1934] and the classification of technical change types [Schumpeter, 1912]. Schumpeter also was one of the pioneers in the innovation vs. invention dichotomy discussion [Schumpeter, 1939]. Among the first documented discussions in economic literature in the form of article in a scientific journal was done by Stamp (1929) [Godin, 2008]. Pareto (1935) initiated the innovators vs. conservators discussions in economics, Pigou and somewhat later Hicks and Robinson developed the first theories for the classification of technologies [Pigou, 1924; Hicks, 1932; Robinson, 1938].

The Cobb-Douglas production function can be seen as the fist mathematical model representing the technological change [Cobb and Douglas, 1928; Douglas, 1948]. In 1930-s the first computational analysis of technological usage and its link with the growth of productivity was run in the USA by leading centers for economic research (NBER, Bureau of Labor Statistics and Work Projects Administration).

In the 1940-s, especially in the second half after World War II, the growing trend in innovation studies was seriously broken but still some innovation studies can be mentioned here,

[8] We can also go further back in the history and remember such "milestoners" of technical change in economics such as Adam Smith with his ideas on efficient labor division for increasing the wealth of nations [Smith, 1776]; Frederick List with his concepts of "national system of production" and "mental capital" [List, 1841]; and, finally, Karl Marx with his ideas on science as the source of production force growth and approaches to conceptualization the technological competition phenomenon [Lundvall, 2007].

such as the first work on economics of technological change by Maclaurin (1947, 1949, 1953) and on the conceptualization of technological innovation as new combination of means of production [Lange, 1943 following Schumpeter, 1939].

In 1950-s the following milestones in the development of innovation concepts can be summarized [Godin, 2008]:

- the emergence of the organizational innovation concept [Cole, 1959 followed by Aitken, 1965];
- the emergence of the innovation as commercialized invention (new product) concept [Jewkes, 1958];
- the emergence of the innovation as activity and process concept in sociology [Nimkoff, 1957]
- the first studies on the analysis of the internal logic of the innovation process [Carter and Williams, 1957];
- studies on innovation diffusion [Brozen, 1951; Carter and Williams, 1957, 1958, 1959];
- the first seminal work in the line of "innovation and economic growth" [Solow, 1957];
- first works on research evaluation [Rubinstein, 1957; Quinn, 1959]

Also the first "think tanks" for innovation studies appeared, e.g. Research ANd Development Corporation (RAND, USA, 1948); the National Science foundation (NSF, USA, 1950) and the Asian Institute of Technology (AIT, Thailand, 1959).

The analysis of the development of innovation studies in the first half of the 20th century shows that during the first half of the 20th century the basis of innovation studies and innovation concepts was established.

1960-s – 1990-s

Innovation was considered the main instrument of competitive struggle in business and between nations [Godin, 2008] and the development of statistics of innovation, namely the development of methodology of innovations at the international level. The leading "think tanks" on innovation studies were founded, namely:

- Science and Technology Policy Research Unit (SPRU, UK, 1966);

- Fraunhofer Systems and Innovation Research Institute (Fraunhofer ISI, Germany, 1972);

- the University of Leiden Centre for Science and Technology Studies (CWTS, the Netherlands, 1982);

- UNU-MERIT (research and training center of United Nations University (UNU) and Maastricht University (UM) Netherlands, 1986);

- Science and Technology Policy Institute (STEPI, South Korea, 1987);
- National Institute for Science and Technology Policy (NISTEP, Japan, 1988);
- Centre for European Economic Research (ZEW, Germany, 1990);
- Centre for Science Research and Statistics (CSRS, Russia, 1991);
- International Science and Technology Center (ISTC, Russia, 1992);
-Technology Center of the Academy of Sciences of the Czech Republic (1994);
- Institute for Prospective Technological Studies (IPTS, Spain, 1994);
- Institute for Statistical Studies and Economics of Knowledge (ISSEK, Russia, 2002).

The predominant type of innovation was technological innovation, however concept of non-technological innovations was also under scrutiny analysis. Innovation was purely a scientific concept, being considered the "Golden age" for the concept of innovation with key concepts and models developed. These are [Marinova and Phillimore, 2003; Godin, 2008 as well as search in Web of Science and Scopus]:

- Technological innovation system and national innovation system models [Lundvall, 1985, 1988, 1992, 1993; Freeman, 1988, 1991, 1995; Dosi et. al, 1988; Nelson, 1993];
- Financial innovation concept [Myers and Nicholas, 1984; Miller and Merton, 1986; Allen and Gale 1988; Ross, 1988];
- User innovation concept [von Hippel, 1986, Fleck, 1988];
- Technological paradigms model [Dosi, 1982, 1988];
- Technoeconomic paradigms model [Freeman and Perez, 1988; Perez, 1983];
- Application of evolutionary models in innovation studies [Mansfield et al., 1981; Nelson and Winter, 1982];
- Innovation avenue model [Sahal, 1981];
- Innovation complexes model [Gann, 1991, 2000];
- Social innovation concept [Chambon and Devevey, 1982; Laville, 1994];
- Eco-innovation concept [Fussler and James, 1996; James, 1997].

Increasingly quantitative studies were undertaken researching [Rothwell, 1994; Godin, 2008]:

- **the internal logic of innovation processes** [Myers and Marquis, 1969; Langrish et al., 1972; Hayvaert, 1973; Rothwell et al., 1974; Schock, 1974; Szakasits, 1974; Rothwell, 1976; Rubenstein et al., 1976; Utterback, 1975; Cooper, 1980];
- the **innovative behaviors of organizations** [Burns and Stalker, 1961; Wilson, 1966; Mulkay and Turner, 1971; Hage and M. Aiken, 1970; Zaltman et al., 1973];
- **research evaluation** [Quinn, 1960; Hodge, 1963; Horowitz, 1963; Yovits et al., 1966; Lipetz, 1965; Seiler, 1965; Dean, 1968].

Also OECD launched the first edition which turned later in a series of its "Innovation studies Manuals":

- the Frascati manual on "The Measurement of Scientific and Technical Activities: Proposed Standard Practice for Surveys of Research and Development" [OECD, 1963];
- the Oslo Manual for "innovation measurement" [OECD, 1992];
- the Patent Manual with "data on patents and their utilization as science and technology indicators" [OECD, 1994];
- the TBP Manual as a "Proposed Standard Practice for the Collection and Interpretation of Data on the Technological Balance of Payments" [OECD, 1995] and
- the Canberra Manual "Measurement of Human Resources in Science and Technology" [OECD, 1996].

2000-s and further

Innovation more and more became a buzzword and slogan in the 2000-s. Any change in any sphere of life now is considered an innovation but in many cases without any underlying scientific rationale. Innovation isn't a pure scientific concept any longer but more a catchword for attracting investors, a useful word for top management to understand business success and failures, a beautiful slogan for nice wording used in advertising campaigns for consumer goods but also for political programs. The main spheres of discreditation of the scientific concept of innovation are marketing (through advertisement) and public policy (through election promises and ambitious "Programs of Innovation Development").

However, the "fundamental" innovation theories such as for example national innovation system model continued and still continue to develop further. Moreover complementary concepts evolve, e.g. the financial innovation concept, the eco-innovation concept, the user innovation concept and the social innovation concept as well as the collaborative innovation concept.

This trend of simplification of the innovation concept is not a disaster or something bad rather allows the identification of the driving forces behind this trend. These are:

1. The **Change of the essence of the scientific society,** e.g. the shift from the "closed science" model to the "open science model". Currently the platform to discuss the problems of innovation are not only peer-reviewed journal and national and international scientific conferences but also different thematic web-sites, such as http://www.innovation-creativity.com/ http://www.innovation-management.org/ http://www.innovationexcellence.com/ among others. Since these sites are designed for audiences with different levels of education and knowledge,

their main goal is explaining the complex concepts and models in simple words with attractive pictures and graphs in many cases without academic rigor in terminology.

2. A c**hange in innovation models.** The era of "good old" fundamental models like the national innovation system model and evolutionary models of innovation is gradually drawing to its decline at least at their original setting. The main factor of this is the lack of reliable, comparable and "long term" (in terms of time-series length) country-level data on innovation activities and in many cases on R&D activities. The paradox of situation is the following: we have well-developed fundamental models and strong mathematical tools for their implementation, but we lack of data which should be downloaded into the models. So the innovation models "had to" shift from the macro-level to the company level. New models of innovation such as the disruptive innovation theory or the value chain evolution theory by Christensen and Raynor (2003); the strategic innovation process model by Allan Afuah (2002); Geoffrey Moore's category-maturity life cycle model (2005), or Gary Hammel's business strategy innovation model (2000) can be classified as "schematic" models. Although these models are complex in their nature and based on different hypotheses with regard to the innovation strategy of the firm they can't be identified as the "ancestors" of for example national innovation system models. Rather they can be seen as a branch of this model or as continuation of technology-push and market-pull models. These models are more suitable "for investors" or "for end users" rather than these can be considered fundamental models. They use more fuzzy terminologies and more "visual", e.g. easy to understand and less strict concepts of innovation than the fundamental theories of innovation.

3. **Shifts in innovation policy.** National innovation policy gradually shifts from "top-down priority setting" to "bottom-up priorities setting". For example the EU countries as well as other developed countries started to coordinate their national STI policies with regarding responses to Grand Challenges. Such responses are linked with specific sometimes uniquely localized segments, e.g. sectors, parts of the national innovation system. Their understanding and modeling requires new terms and concepts hence the old established concepts of innovation may not be applicable here. These concepts are specific by definition and cannot be comprehensive and commonly applicable concepts of innovation. For example in developing responses to climate change the logic of product/process innovation can hardly be used. Instead new concepts of innovation such eco-innovation, sustainable innovation or friendly for environment innovation (and so on) should be used here.

Therefore, the main tasks for theoretical innovation studies and studies on the basic concepts of innovation will be the following:

- systematization of very broad and sometimes vague terminology;

- development of strict and easily applicable criteria for what can be treated as innovation;
- development of a more or less structured classification of innovation types;
- development of a new, well-structured terminology for “almost innovation”, “like innovation” and “close to innovation” changes (reforms, novelties, novations, etc.) in design, process, organization, products, services, institutions among others.

The following chapter discusses the consideration of innovation types in statistical measurement and analysis.

Classification of innovation types in modern statistical practice

In line with the evolution of the innovation concepts different types of innovation were developed. The innovation classification has gone a long way in its historical development from the "classical" product and process innovation to such exotic types as the "blue ocean innovation" and "frugal innovation". In the following the main emphasis will be given not to the process of historical development of innovation classification but on ways in which innovation types can be classified. Several types of innovation classification can be distinguished:

1. **"Multitype" classification.** Here all types of innovation are grouped into several non-crossed classes. This classification is the most widespread in the literature. The "classical" typology of innovations here is the classification of innovation types proposed by OECD. The main types of innovations in accordance with OECD methodology can be summarized as follows (Table 3).

Table 3: Typology of innovation in the OECD methodology.

Type of Innovation	Field of Application	Distinctive Characteristic
Product innovation	Innovations **related to goods and services.**	Significant improvements in the **technical specifications, components and materials** in the embedded software in the degree of friendliness to the user or other functional characteristics.
Process innovation	Implementation of **new or significantly improved methods of production or delivery** of the product.	Significant changes in **technology, production equipment** and / or **software.**
Marketing innovation	Implementation of **new methods of marketing,** including significant changes in design or packaging of the product during its storage, market promotion and market-based prices/	Increasing in the degree of **consumer satisfaction**, creating **new markets** or **new, more favorable market position** for production companies to increase sales.
Organizational innovation	Implementation of new **forms and methods of organization of business companies**, the organization of jobs and external relations.	Implementation of **business practices** in the organization of **workplaces or in the external relations** previously used for organizational method that represents the result of the implementation of strategic decisions.

Source: authors' adaptation from OECD Oslo Manual, 3rd edition (2005)

Bessant and Tidd (2007) distinguish four types of innovation (Table 4). A close look at this classification shows that their classification is quite similar to the OECD innovation methodology. Here production innovation is clearly the analogy of product innovation; position innovation can be treated as marketing innovation in OECD concept[9]. Meanwhile paradigm innovation is a broader concept than organization innovation since it encompasses all changes in company behavior and strategy according to its definition. "Paradigm innovation" in Bessant and Tidd' typology is very broad and can in principle encompass all other three type of innovation

[9] The "process innovation" is excluded from analysis since this type of innovation is the same in OECD methodology and in the concept of Bessant and Tidd.

since "shifts in modus operandi of some industry" can be the consequences of Production, process or position operation.

Table 4: Example of multitype classification of innovation types

Type of innovation	Essence of innovation
Production innovation	Introduction of **new products and services or changes to products and services** that has added benefits for the customer or it meets market need.
Process innovations	**Introduction of new device, method, tool or knowledge** to produce a product or render a service.
Position innovation	**Positioning of a certain product** in a specific industry / business segment.
Paradigm innovation	**Shifting of long-held assumptions** about **the modus operandi of some industry** or businesses.

Source: authors' adaptation from Bessant and Tidd (2007).

2. The other approach to classify innovations is setting in the basis of **classification of the degree of "strength" or "power" of innovation**. Thus the degree of innovation ranges from "incremental" to "technological revolutions" [Freeman et al., 1982], from "regular" to "revolutionary" etc. Coccia (2006) in his work identifies seven levels of innovation intensity (from "lightest" to "revolutionary") and provides examples of classifications of innovations according to their innovation intensity. Garcia and Calantone (2002) provide a comprehensive review of innovation classification types and distinguish different types of innovation categorizations according to the number of innovation types in each classification. In table 5 some examples for the classification of innovation types according to the innovation intensity by Coccia (2006) and Garcia and Calantone (2002) are given. Examples with two types of innovations in classifications will be considered further.

Table 5: Example of classification of innovation types according to the degree of innovativeness

Authors	Types of innovations
Mensch, 1979	Improvements → basic innovation → fundamental innovation.
Freeman et al., 1982	Improvements → continuous → radical → new technological systems → change of techno-economic paradigms → technological revolutions.
Kleinschmidt and Cooper, 1991	Low innovativeness → moderate innovativeness → high innovativeness.
Wheelwright and Clark, 1992	Incremental → new generation → radically new.
Freeman, 1994	Unrecorded → incremental → minor → major → systemic.

Source: authors' adaptation from Garcia and Catalone (2002) and Coccia (2006).

3. **Multilayer classification of innovation.** This typology of innovations distinguishes several levels of innovation classification. One of the first classifications of such type can be found in work of Johnson and Jones (1957). It should be noted that authors use the term "new products", while "innovations" they take in quotes: "… Just what is a new product? There are

“improved products”, “new uses”, “new markets for old products”, “related new products”, "unrelated new products," "innovations," and other terms in common use ... ” [Johnson and Jones, 1957, p. 51–52]. Scholars distinguish two direction of newness (technological and market) and three degree of this newness in each direction (Table 6). It should be noted that analogous types of classifications of innovations will be repeated in future studies (for example Moore, 2005; Kumar, 2005). But in these new studies authors will use the term “innovation” without quotes.

Table 6: Example of multilayer classification of innovation types

Type of innovation	Degree of technological newness	Definition of innovation
No market change		
Reformulation	Improved technology	Maintaining an optimum balance of cost, quality, and availability in the formulas of present company products.
Replacement	New technology	Seeking new and better ingredients or formulation for present company products in technology not now employed by the company.
Strengthened market		
Remerchandising	No technology change	Increasing sales to consumers of types now served by the company.
Improved product	Improved technology	Improving present products for greater utility and merchandisability to consumers.
Product line extension	New technology	Broadening the line of products offered to present consumers through new technology.
New market		
New use	No technology change	Finding new classes of consumers that can utilize present company products.
Market extension	Improved technology	Reaching new classes of consumers by modifying present products.
Diversification	New technology	Adding to the classes of consumers served by developing new technical knowledge.

Source: authors’ adaptation from Jones and Johnson (1957).

Other examples of such type of innovation classifications can be found in the work by Zawislak et al. 2011 (Table 7). The authors identify two types of innovations: technology-driven and business-driven. Each of type is divided into two subtypes.

Table 7: Example of multilayer classification of innovation types (in Zawislak, 2011)

Type of innovation	Essence of innovation
Technology-driven innovation	
Technological Innovation	Development of **new design, new materials** and **new products**. In addition, they include the development of machinery, equipment and new components.
Operations Innovation	**New processes**, improvements in existent processes, introduction of **modern techniques**, new layouts, etc. It allows the firm to produce products with quality, efficiency, flexibility with the lowest possible cost.
Business-driven innovation	
Management Innovation	Development of **management skills which reduce the "internal friction"** between different areas of the firm. It is intended to **create new methods of management** and **new business strategy**, improve decision making and inter-functional coordination, etc.
Transaction Innovation	Development of **ways to minimize transaction costs** with suppliers and customers. It is intended to **create new commercial strategies, improve relationships with suppliers, streamline market knowledg**e, etc.

Source: authors' adaptation from Zawislak (2011).

Another example of such a classification of innovation types can be found in the work by Walker, Avellaneda and Berry (2011). Here the authors identify four types of innovation (Table 8). But only one type of innovation (process innovations) is subdivided into three subtypes.

Table 8: Example of multilayer classification of innovation types (in Walker, Avellaneda and Berry, 2011)

Type of innovation	Sphere of application	Distinctive characteristic
Ancillary innovations	Concerned with working across boundaries with other service providers, users or other public agencies.	Successful adoption is dependent on factors outside an organization's control.
Service innovations	New services offered by public organizations to meet an external user or market need: they are concerned with what is produced.	Occur in the operating component and affect the technical system of an organization and include the adoption of goods (which are material) and intangible services, which are often consumed at the point of production.
Process innovations	Affect management and organization. They change relationships amongst organizational members and affect rules, roles, procedures and structures, communication and exchange among organizational members and between the environment and organizational member.	Concerned with how services are rendered.
Subcategories of process innovations		
Organization innovations	Innovations in structure, strategy, and administrative processes; improvements in an organization's practices and the introduction of new organizational structures.	Concerned with an organization's primary work activity and changes in the social system.
Marketization innovation	Modifying the organization's operating processes and systems to increase the efficiency or effectiveness of producing and delivering its services to users.	Concerned with methods to purchase and deliver services and revenue generation, and reflect the core new public management themes of contracting, externalization and market pricing of public services.
Technological innovations	Associated with changes in physical equipment, techniques and organizational systems.	Include information technology, hardware (physical equipment) and software (organizational systems).

Source: authors' adaptation from Walker, Avellaneda and Berry (2011).

4. **Dichotomical classification.** According to this classification, only two non-crossed types of innovation are distinguished. It also should be noted that in this classification two

innovation types are the opposite. Examples of such type of innovation classification in different dimensions are shown in the Table 9.

Table 9: Examples of dichotomical classification of innovation types in scientific literature

Authors	Types of innovations
"Strong" innovation/"weak" innovation dimension	
Arrow, 1962; Gilbert and Newbery, 1982	Non drastic/drastic
Priest and Hill, 1980	Incremental/discrete
Utterback, 1996	Evolutionary/revolutionary
Schmidt and Calantone, 1998; Song and Montoya-Weisse, 1998	Really new/radical
Rice et al., 1998	Breakthrough/incremental
Freeman, 1994; Balachandra and Friar, 1997	Radical/incremental
Coccia, 2005	Elementary(micro-incremental)/cluster(new technological system)
"Genuine innovation" / renovation dimension	
Norman, 1971	Variations/reorientation
Maidique and Zirger, 1984	True/adoption
Yoon and Lilien, 1985	Original/reformulated
Rorthwell and Gardiner, 1988	Innovations/renovations
"Everyday" innovation / disruptive innovation dimension	
Grossman, 1970	Instrumental/ultimate
Myers and Tucker, 1989	Radical/routine
Christensen, 1997	Sustaining/disruptive
Other dimensions	
Robertson, 1967; Anderson and Tushman, 1990	Discontinuous/continuous
Dosi, 1988	Market pull/technology push

Source: authors' adaptation from Garcia and Catalone (2002) and Coccia (2006).

5. **Dually-dichotomical classification of innovation types.** This type of innovation classification encompasses two dichotomous classifications of innovation simultaneously. Several examples of dually-dichotomical classification of innovation types developed in the scientific literature can be found in the Table 10.

Table 10: examples of dually-dichotomical classification of innovation types in scientific literature

Authors	Types of innovations
Abernathy and Clark, 1985	Regular/revolutionary; Niche/architectural
Henderson and Clark, 1990	Incremental /radical; Modular/architectural
Moriarty and Kosnilk, 1990	Incremental/ radical; Evolutionary market/evolutionary technical
Tidd, 1995	Incremental/breakthrough; Architectural/fusion
Chandy and Tellis, 2000	Incremental /radical market breakthrough/ technological breakthrough

Source: authors' adaptation from Garcia and Catalone (2002) and Coccia (2006).

A more detailed analysis of this classification of innovation types is shown in the work by Abernathy and Clarck (1985, Table 11). The authors distinguish radical vs. regular and niche vs. architectural types of innovation (Table 11).

Table 11: Example dually-dichotomical classification of innovation types (Abernathy and Clarck, 1985)

Type of innovation	Definition of innovation	Distinctive characteristic
Regular Innovation	Involves change that builds on established technical and production competence and that is applied to existing markets and customers.	Can have a significant effect on product characteristics and thus can serve to strengthen and entrench not only competence in production, but linkages to customers and markets.
Radical Innovation	Disrupts and renders established technical and production competence obsolete.	Is applied to existing markets and customers, alters the parameters of competition, as well as by the shifts it causes in required technical competence.
Niche Innovation	Sales maximization in which an otherwise stable and well specified technology is refined improved or changed in a way that supports a new marketing thrust.	In some instances, niche creation involves a truly trivial change in technology, in which the impact on productive systems and technical knowledge is incremental.
Architectural Innovation	Defines the basic configuration of product and process, and establishes the technical and marketing agendas that will guide subsequent development.	Lays down the architecture of the industry, the broad framework within which competition will occur and develop.

Source: authors' adaptation from Abernathy and Clarck (1985).

6. **Linked to steps of innovation process classification**. Geoffrey Moore (2005) identifies 14 types of innovation according to his category maturity life cycle – the degree of maturity of new technology (Table 12).

Table 12: Example of "linked to steps of innovation process" classification of innovation types (Moore, 2005)

Type of innovation	Essence of innovation
Product leadership zone	
Disruptive Innovation	Creating new market categories based on a discontinuous technology change or a disruptive business model.
Application Innovation	Developing new markets for existing products by finding unexploited uses for them, often by combining them in novel ways.
Product Innovation	Focuses on existing markets for existing products, differentiating through features and functions that current offers do not have.
Platform Innovation	Interposes a simplifying layer to mask an underlying legacy of complexity and complication, thereby freeing a next generation of offers to focus on new value propositions.
Customer intimacy zone	
Line-Extension Innovation	Structural modifications to an established offer to create a distinctive subcategory.
Enhancement Innovation	Continuation of trajectory begun by line extensions, driving innovation into finer and finer elements of detail, getting closer and closer to the surface of the offer with less and less impact on the underlying infrastructure.
Marketing Innovation	Differentiating the interaction with a prospective customer during the purchase process.
Experiential Innovation	Value here is based not on differentiating the functionality but rather the experience of the offering.
Operational excellence zone	
Value-Engineering Innovation	Extracting cost from the materials and manufacturing of an established offer without changing its external properties.
Integration Innovation	Reducing the customer's cost of maintaining a complex operation by integrating its many disparate elements into a single centrally managed system.
Process Innovation	Focusing on improving profit margins by extracting waste not from the offer itself but from the enabling processes that produce it.
Category renewal zone	
Value-Migration Innovation	Redirecting the business model away from a commoditizing element in the market's value chain toward one richer in margins.
Organic Innovation	On this path the company uses its internal resources to reposition itself into a growth category.
Acquisition Innovation	Solves the problem of category renewal externally through merger and acquisition.

Source: authors' adaptation from Moore (2005).

The author identifies four stages (zones) of category maturity: product leadership zone, customer intimacy zone, operational excellence zone and category renewal zone. Different types of innovation are linked with each of these stages.

The analysis of the different approaches of the classification of innovation gives the following picture of innovation types:

1) Process innovation, product innovation, service innovation etc 'classic types' of innovation are included in many studies on innovation typologies (Block A in the Table 13).
2) The second cluster is so-called "new" types of innovation. These originated 5–10 years ago and had not yet become the "classic" ones. They include types of innovation such as frugal innovation, red ocean innovation, organic innovation and other numerous – and in many case "very exotic" from the point of view of a strict terminology –types of innovation (block B in Table 13). These types of innovation are used mainly in models developed for the management of innovation and in business models for new products (services). Therefore these types are more "attractive" and catchy than purely scientific and strict (in their definition).
3) The third block is types of innovation classified according to the degree of innovation. Therefore radical, breakthrough or revolutionary innovation can be classified as "strong innovation" while non-drastic or minor innovation will be treated as "weak innovation" (Block C, Table 13).
4) Finally, innovations can be classified in dichotomical manner. In this case the following controversial pairs of innovation types can be identified: open/closed innovation, radical/incremental, product/process and so on (Block D, Table 13).

Table 13: Summary of innovation types

Block A "Classical" types
Product innovation/Process innovation/Service innovation/Marketing innovation/Organizational innovation/Design innovation/supply chain innovation.
Block B "New" types
Frugal innovation/Red ocean innovation/Blue ocean innovation/Experience innovation/Value-migration innovation /business model innovation/organic innovation / …
Block C "Innovativeness degree" type
Weak innovation Incremental/routine/minor/regular/non-drastic/basic innovation; **medium strength** Architectural/niche(creation)/modular/fusion/evolutionary/sustaining innovation; **Strong** Radical/major/breakthrough/disruptive/revolutionary/paradigm/fundamental/discrete innovation.
Block D "Dichotomical" types
User-driven/supply-side innovation
Open/closed innovation
Product/process innovation
Incremental/radical innovation (and other examples of "strong"/"weak" classification of innovation)
Continuous/discontinuous innovation
Instrumental/ultimate innovation
True/adoption innovation
Original/reformulated innovation
Innovation/renovations

Source: classification of innovation types given in the table is based on the analysis of literature on innovation typology.

In conclusion it can be shown that the innovation typology has gone similar development path as the concept of innovation itself. It has evolved from a more or less structured system to a very complex and challenging to structure system of classifications. In addition the bulk of this classification can hardly be classified as classification with a strict terminology.

Conclusion

The paper analyzed concepts, aspects, definitions and types of innovation. It showed a broad range of definitions, types and classification concepts exist in academic literature. Hence there is no common understanding of the term innovation, its shapes and finally impact rather the term innovation is used according to the purpose of use. In summary we conclude:

1) The innovation concept has a long history of development. Until the end of the 19th century innovations and innovators were explicitly or implicitly denied and decried by society. Since the last decades of the 19th century until the 1960-s the interest on innovation has grown and a basis for thorough innovation studies was established. The 1960-s towards the 1990-s can be called the "golden age" for the conceptualization of innovation in different shapes. During this period the key concepts of innovation and well-structured models for the analysis of innovation processes were developed. In the 2000-s innovation became more and more a buzzword and conception of innovation developed towards a vaguer concept. The innovation models shifted from the macro level to the individual firm level but still there is no unified and commonly accepted understanding of the innovation concept.
2) The innovation typology shifted from a more or less well-structured system to a system with a large number of very different elements (types). Along with the already well-established types of innovation ("classic types" such as product or process innovation), there are also completely new types of innovation (such as frugal innovation or organic innovation). These new types of innovations are often called differently by different authors and rarely share a commonly understood concept.
3) The understanding of aspects of innovation developed from "innovation as process" and "innovation as an object" to a more precise understanding of innovation "as a tool for change" and innovation as "the context of changing environments" as well as innovation as "human abilities for doing something" and innovation as "change" itself. Hence these diverging understanding imply manifold impacts and allow the design of ever new or modified management concepts for innovation.

4) The trends in the evolution of innovation concepts and typology pose the following challenges on researches engaged in innovation studies:

- a new generally accepted and strict terminology for new types and concepts of innovation needs to be developed;
- new innovation concepts and types need to be integrated in a well-structured system;

- the development of strict criteria for separation of true innovation from “dramatic changes”, “minor improvements” and other novelties, novations and reforms which cannot be treated as innovation.

Eventually the challenge will be to further develop and refine the innovation definition and classification of innovation types and streamline them into a usable and understandable set of definitions, concepts and types which are of use for academics and practitioners. For private sector practitioners this is of utmost importance since it shows that too many different concepts appeared in the last years which are more of marketing and advertising style rather than adding real value to company operations. In the political sphere such understanding should emphasize the potential impacts of innovation for the given political and societal goals but these need a clear communication beyond the respective communities involved. Overall innovation needs to be considered as investment with a long time-horizon. There is still the assumption that actors (companies or countries) investing in innovation are the most successful ones but in reality the dimension of impact from innovation continues to be under researched and at least partially neglected. Furthermore marginal innovation is obviously the preferred innovation type for companies which are obliged to report to investors on quarterly basis. A changing understanding of the nature of innovation and its implications is hence needed.

Annex

Table A.1. Development of innovation concepts and models in its historical developments (pre-1920-s – 1930-s)

Pre 1920-s
- first **theories of innovation in sociology**, innovation is seen as social change (changes in grammar, language, religion, law, constitution, economic regime, industry and arts) [Tarde, 1890, 1895, 1898, 1902]; - first **classification of technical changes** [Schumpeter, 1912]; - first appearance of **innovation as social experiment concept in** sociology [Chapin, 1917]
1920-s
- first **linear "models" of invention – imitation** sequences in sociology [Ogburn, 1922]; - first appearance of **innovation as social invention** concept in sociology [Bernard, 1923; Chapin, 1928; Weeks, 1932] - theoretical **classifications of technologies** in economics [Pigou, 1924; Hicks, 1932; Robinson, 1938]; - **innovation as cultural change concept (**changes in culture traits, but also inventions in agriculture, trade, social and political organizations (law, customs, religion, family) and technology) in **anthropology** [Smith et al. 1927] - term "**technological change"** instead of "innovation" in the **first innovation studies in sociology** [Stern, 1927, 1937; Chapin, 1928]; - first works on **innovation in public institutions** [Chapin, 1928]; - first study **geometrical laws of diffusion of inventions** [Chapin, 1928]; - **production function** logic as interpretation of **technological change** [Cobb and Douglas, 1928]; - **technical change** as **creative destruction** concept in economics [Schumpeter, 1928]; - first **discussion on innovation vs. invention** in economic literature [Stamp, 1929]; - first **theories on technological inventions in psychology** [Usher, 1929]
1930-s
- first appearance of **innovation as novelty concept** in sociology [Kallen, 1930]; - first **qualitative analysis of productivity as an indicator of technology usage** in the US scientific organizations such as National Bureau of Economic Research, Bureau of Labor Statistics and Work Projects Administration [1930-s]; - first **theories on technological inventions in psychology** [Rossman, 1931]; - analysis of the shift of **innovation process from "lonely innovator" into organized laboratories** [Hart, 1931; Gilfillan, 1935] - first effort to analyze technological innovation as acceleration and growth of material culture by quantitative methods [Hart, 1931]; - one of the **first use of term "innovation" in sociology** [Hart, 1931]; - first **theories on technological inventions in psychology** [Rossman, 1931]; - first appearance of **innovation as social invention** concept in sociology [Weeks, 1932]; - theoretical **classifications of technologies** in economics [Hicks, 1932; Robinson, 1938]; - **technical change** as **creative destruction** concept in economics [Schumpeter, 1932, 1934]; - first **discussion on innovation vs. invention** in economic literature [Stamp, 1934]; - first **survey of industrial incentives to invention** [Rossman, 1935]; - one of the **first effort** to **contradistinguish innovators in conservators** in the economic literature [Pareto, 1935] - technological **invention as social concept** idea [Gilfillan, 1935]; - first **linear "models" of invention – imitation** sequences in sociology [Gilfillan, 1935]; - **term "innovation" starts to spread over the innovation studies in sociology** [Gilfillan, 1935, 1937]; - first "**approaches" to innovation diffusion theories in anthropology** – cultural change as a result of contact between cultures [Redfield et al., 1936]; - analysis of **"technicways" in sociology** (some analog to technological paradigms in Dosi (1982, 1988) and technoeconomic paradigms in Freeman & Perez (1988) and Perez (1983)) [Odum, 1937]; - first **analysis of social effects of technological inventions** [Stern, 1937]; - **innovation as deviant behavior concep**t in sociology [Merton, 1938]; - further discussion on innovation vs. invention in the economic literature [Schumpeter, 1939]; - technological innovation as new combinations of means of production [Schumpeter, 1939]

Note: milestones in development of innovation studies were identified on the basis of analysis of Rothwell (1994), Marinova and Phillimore (2003) and Godin (2008) papers, as well as on the basis of material of Web of Science, Scopus and Google Scholar databases.

Table A.1 – Development of innovation concepts and models in its historical developments, continuation (1940-s – 1950-s)

1940-s
- analysis of **"technicways" in sociology** (some analog to technological paradigms in Dosi (1982, 1988) and technoeconomic paradigms in Freeman & Perez (1988) and Perez (1983)) [Davis 1940]; - term "**technological change"** instead of "innovation" in the **first innovation studies in sociology** [Davis, 1940]; - first works on **innovation in public institutions** [McVoy, 1940]; - **term "innovation" starts to spread over the innovation studies in sociology** [Ogburn, 1941]; - technological innovation as new combinations of means of production [Lange, 1943]; - first works in the economics of technological change [Maclaurin, 1947, 1949, 1953]; - further development of **production function** method [Douglas, 1948];
1950-s
- more "mature" **discussion on diffusion and imitation of innovation** in economics [Brozen, 1951]; - **innovation as the first commercialization** of new product idea in economics [Maclaurin, 1953]; - **comprehensive theory of innovation in anthropology** [Barnett, 1953]; - first "**approaches" to innovation diffusion theories in anthropology** – cultural change as a result of contact between cultures [Barnett et al., 1954]; - one of the **first use of term "technological innovation" in the economic literature** [Maclaurin, 1953]; - development of methods of **qualitative analysis of technological innovations** proposed in Hart (1931) [Hart, 1957, 1959]; - first works on **research evaluation** [Rubinstein, 1957; Quinn, 1959]; - further **development of innovation diffusion concept** [Carter and Williams, 1957, 1958, 1959]; - innovation as activity and innovation as process concepts in sociology [Nimkoff, 1957]; - residual in production function as technology [Solow, 1957]; - one of the first attempt to **analyze the internal logic of innovation process itself** [Carter and Williams, 1957]; - first theories of **technological development in sociology** [Jewkes, 1958]; - **innovation as commercialized invention concept in sociology** [Jewkes, 1958]; - first works on **organizational innovations** [Cole, 1959]; - more **constructive view** of Merton thesis on **innovation as deviant behavior** [Dubin, 1959]
1960-s
- **further development** of the **research evaluation studies** after their start in the late 1950-s [Quinn, 1960; Hodge, 1963; Horowitz, 1963; Yovits et al., 1966; Lipetz, 1965; Seiler, 1965; Dean, 1968]; - first studies on **scientific innovation in sociology** [Ben-David, 1960a, 1960b; 1964; 1966; Mulkay, 1969]; - emphasis on the **role of the marketplace in innovation process** [Cook and Morrison, 1961]; - **some opposition to the term "innovation"**: "innovation has come to mean all things to all men" [Ames, 1961, p. 371]; - studies on **innovative behaviors of organizations** [Burns and Stalker, 1961; Wilson, 1966]; - more **developed theories of innovation diffusion and imitation** in economics [Mansfield, 1961; Posner, 1961; Schmookler, 1966]; - first use the term "lead user" [Enos, 1962]; - **board theory of innovation in sociology** [Rogers, 1962]; - **some opposition to the term "innovation"**: "we shall do better without the word innovation" [Machlup, 1962, p. 179]; - **first edition of methodological manual for collecting statistics on R&D:** Frascati manual (The Measurement of Scientific and Technical Activities: Proposed Standard Practice for Surveys of Research and Development) [OECD, 1963]; - development of theories of **organizational innovations** [Aitken, 1965]; - developed **methodology for measurement the technological innovations** through **patents** [Schmookler, 1966]; - first studies on **scientific and technological productivity** [Pelz and Andrew, 1966; Myers and Marquis, 1969]; - one of the first use the term "innovation" in the economics [Schmookler, 1966]; - first **governmental survey of technological innovation** *per se* [Charpie Report; US Department of Commerce, 1967]; - first **empirical studies on innovation process** [Myers and Marquis, 1969]; - further developments in theory of political innovation [Walker, 1969; Mohr, 1969]

Note: milestones in development of innovation studies were identified on the basis of analysis of Rothwell (1994), Marinova and Phillimore (2003) and Godin (2008) papers, as well as on the basis of material of Web of Science, Scopus and Google Scholar databases.

Table A.1 – Development of innovation concepts and models in its historical developments, continuation (1970-s – 1980-s)

1970-s
-further development studies on innovative behaviors of organizations [Hage and M. Aiken, 1970; Zaltman et al., 1973]; - development of studies on scientific innovation in sociology [Mulkay and Turner, 1971; Mulkay, 1969, 1972a, 1972b, 1975]; - further theoretical developments on the concept of innovation as the first commercialization of new product (process) [Freeman, 1971; 1974; SPRU, 1972]; - emphasis on the **importance of scientific autonomy and independence** for the **flourishing of science** [Merton, 1973]; - further development of **empirical studies on innovation process** [Langrish et al., 1972; Hayvaert, 1973; Rothwell et al., 1974; Schock, 1974; Szakasits, 1974; Rothwell, 1976; Rubenstein et al., 1976; Utterback, 1975]; - **some opposition to the term "innovation"**: "use of the term innovation is counterproductive" [Roberts and Romine, 1974, p. 4]; - technological imperatives model [Rosenberg, 1976]; - need-pull model of innovation [Roessner, 1979; Herbert and Hoar, 1982; Rothwell, 1984, Rothwell & Zegveld, 1985]
1980-s
- **empirical studies on innovation process**s [Cooper, 1980]; - innovation avenues model [Sahal, 1981], - **comprehensive theories of innovation diffusion** and imitation in the view of evolutionary theory in economics [Mansfield et al., 1981; Nelson and Winter, 1982] - one of the first **comprehensive research on social innovation** [Chambon and Devevey, 1982]; - **black box innovatio**n model [Rosenberg, 1982] - **technological paradigms** model [Dosi, 1982, 1988]; - further theoretical developments on the concept of innovation as the first commercialization of new product in evolutionary models (process) [Nelson and Winter, 1982]; - emergence the **concept of financial innovation** [Myers and Nicholas, 1984; Miller and Merton, 1986; Franklin and Gale, 1988; Ross, 1989]; - iterative (circular) process of innovation model [Kline & Rosenberg, 1986]; - emergence of the concept of **user innovation** [von Hippel, 1986; Fleck, 1988]; - real development of the **lead user concept** in the framework of user innovation concept [Von Hippel, 1986; Urban and Von Hippel,, 1988]; - technoeconomic paradigms [Freeman & Perez, 1988; Perez, 1983]; - **strategic networks** model (alliances) [Jarillo, 1988] - **technological innovation system** and **national innovation system** concept emergence [Lundvall, 1985; Dosi et al, 1988, Freeman, 1988]

Note: milestones in development of innovation studies were identified on the basis of analysis of Rothwell (1994), Marinova and Phillimore (2003) and Godin (2008) papers, as well as on the basis of material of Web of Science, Scopus and Google Scholar databases.

Table A.1 – Development of innovation concepts and models in its historical developments, continuation (1990-s)

1990-s
- **innovation complexes** model [Gann, 1991, 2000]; - **innovation milieu** model [Camagni, 1991]; - **national systems of innovation** model development [Freeman, 1991, 1995; Lundvall, 1992, 1993; Nelson, 1993]; - development of **technological innovation system model** [Carlsson and Stankiewicz, 1991; Van Lente, 1993, 1998]; - problem of **"bounded rationality"** in application to **innovation studies** [Dosi & Egibi, 1991]; - **innovation chains** model [Marceau, 1992; Dodgson, 1993]; - **technological trajectories** model [e.g. Biondi & Galli, 1992; Pavitt et al., 1989], - **first edition of a methodological manual for measuring innovation** Oslo Manual [OECD, 1992]; - **regional network** model [Dodgson, 1993]; - **strategic networks** model (alliances) [Sako, 1992]; - **technological opportunities** and established decision-making rules as dynamic **self-organized systems** [Dosi & Orsenigo, 1994]; - further development of **social innovation concept** among French theoreticians [Laville, 1994] - theories of growth of regional clusters of innovation and high technology [Feldman, 1994]; - **first edition of methodological manual for patent statistics** OECD Patent Manual (Data on Patents and Their Utilization as Science and Technology Indicators) *[OECD, 1994]* - imperfections as drivers for technical change concept [Metcalfe, 1995]; - development of the **financial innovation concept** [Duffe and Rohit, 1995; Persons and Warther, 1997]; - emergence of **innovation intermediary** concept [Bessant and Rush, 1995; Stankiewicz, 1995; Hargadon, 1998]; - learning regions model [Florida, 1995; Kirat & Lung, 1999; Macleod, 1996] - first edition of methodological manual for technology balance of paymants statistics – OECT TBP Manual (Proposed Standard Practice for the Collection and Interpretation of Data on the Technological Balance of Payments) [OECD, 1995]; - emphasis on innovation product diversity [Dowrick, 1995]; - theory of successful and failure innovations [Tisdell, 1995]; - "technological gap" studies [Dodgson & Bessant, 1996]; - **first edition of methodological manual for Human Resources in R**&D – Canberra Manual (*Manual on the Measurement of Human Resources in Science and Technology*) [OECD, 1996] - concept of the **result and process equivalence** in R&D [OECD, 1996]; - emergence of **eco-innovation concept** [Fussler, and James, 1996; James 1997]; - innovation in the context of territorial organization (Bramanti & Ratti, 1997); - regional system of innovations model [Cooke, 1998]; - emergence of **innovation intermediary concept** [Bessant and Rush, 1995; Stankiewicz, 1995; Hargadon, 1998]; - innovation clusters model [OECD, 1999]

Note: milestones in development of innovation studies were identified on the basis of analysis of Rothwell (1994), Marinova and Phillimore (2003) and Godin (2008) papers, as well as on the basis of material of Web of Science, Scopus and Google Scholar databases.

Table A.1 – Development of innovation concepts and models in its historical developments, continuation (2000-s)

2000-s
- further development of **financial innovation concept** [Friedman, 2000; Goodhart, 2000; Woodfor, 2000; Tufano, 2003; Fernando, Lippi, 2009] - further development of the **eco-innovation concept** [Jones and Harrison, 2000; Rennings, 2000; Jones et al. 2001; Nuij, 2001; Smith, 2001; Rai and Allada, 2005; Beveridge and Guy, 2005; Pujari, 2006; Carrillo-Hermosilla del Río and Könnölä, 2009]; - further development of the **lead user concept** in the framework of user innovation concept [Luthje, 2000; Lilien, et al. 2002; Intrachooto, 2004; Luthje and Herstatt, 2004; Skiba and Herstatt, 2009; Skiba, 2010, Oliveira and Von Hippel, 2011] - **national systems of innovation** mode (in theoretical as well as empirical direction) further development [Chudnovsky Niosi and Bercovich, 2000; Etzkowitz and Leydesdorff, 2000; Nasierowski and Arcelus, 2000, 2003; Nelson, 2000; Edquist, 2001, 2004; Lundvall, 2002; Lundvall et al., 2002, Lundvall, 2007; Niosi, 2002; Monttobio, 2008, Pan, Hung, Lu, 2010]; - theories of growth of **regional clusters of innovation** and high technology [Keeble & Wilkinson, 2000]; - emergence of the **toolkits for user innovation concept** in the framework of user innovation concept [von Hippel, 2001; von Hippel and Katz, 2002; von Hippel and]; - further **development of methodology for the international and national R&D statistics and STI policy measurement** [Gokhberg, Gaslikova and Sokolov, 2000; Boekholt et al., 2001; ESCWA, 2003; Katz, 2006; Tijssen and Hollanders, 2006; Gokhberg L. and Boegh-Nielsen, 2007; OECD, 2007; Gokhberg, Kuznetsova and Roud, 2012] - establishment of the theory of **social innovation** in academic literature [Mumford, 2002; Moulaert and Sekia, 2003; Westley, Zimmerman and Patton M. 2006; Kohli and Mulgan 2007; Mulgan Ali and Tucker 2007; Nichols, 2007; James, Deiglmeier and Dale, 2008; Nambisan, 2008, 2009; MacCallum, Moulaert, Hillier and Vicari, 2009; Goldsmith, 2010; Howaldt and Schwarz 2010; Murray, Caulier- Grice and Mulgan, 2010; Gill, 2012] - further development of **innovation intermediary concept** [Wolpert, 2002; Stewart and Hyysalo, 2008; Sieg, Wallin and von Krogh, 2010] - further development of **technological innovation system** concept [Bergek, 2002; Smits, 2002; Hekkert et al., 2007; Negro, 2007; Bergeck et al, 2008; Suurs, 2009]; - further development of **open innovation concept** [Chesbrough 2003; Vemuri and Bertone, 2004; Zhao and Deek, 2004; Chesbrough, Vanhaverbeke and West, 2008; von Hippel, 2011; Penin, Hussler and Burger-Helmchen, 2011; Pearce, 2012]; - emergence of the **collaborative innovation network concept** in the framework of open innovation concept [Gloor, 2005; Gloor and Cooper, 2007; Silvestre and Dalcol, 2009]; - further development of **user innovation concept** [von Hippel, 2005; Braun, 2007; Bilgram, Brem, Voigt, 2008; Nambisan and Nambisan, 2008; Bogers, Afuah, Bastian, 2010];

Note: milestones in development of innovation studies were identified on the basis of analysis of Rothwell (1994), Marinova and Phillimore (2003) and Godin (2008) papers, as well as on the basis of material of Web of Science, Scopus and Google Scholar databases.

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