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Normativity and Innovation

An Approach to Concepts of Innovation from the Perspective of Philosophy of Technology

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Abstract – **The aim of this short paper is to sketch an analytic approach to *innovation* from the perspective of philosophy of technology. Until now, philosophers have been reluctant to address issues of innovation—even though both innovation research and philosophy of technology share the same object of study: the intersection of science, technology, and society. In this paper I will reveal normative assumptions in innovation research. I identify normativity in four areas: (1) theory of society and innovation, (2) objects of innovation (artifacts, processes, knowledge, problems), (3) process of innovation, and (4) ethics and innovation. This paper presents an outline for a research program and a catalog of questions—and not a net argumentation or final answers. The aim is to attract philosophical interest and to stimulate interdisciplinary collaboration between social scientists and philosophers.**

A POLITICAL TERM ...

Buzzwords determine science, technology, and innovation politics: they shape the future trajectories of research and development. Most dominant are terms such as "interdisciplinarity" and "innovation". In this paper I focus on the latter. My thesis is that "innovation" should be characterized as an eminently *political term*. The term can be regarded as a cognitive boundary object located in a transfer zone between academia (different types of natural, engineering and social sciences) and politics (at the federal, state, regional or local level or of firms/corporations)—a minefield of different interests, claims and considerations. That makes a mere descriptive approach impossible. What innovation *is* cannot be separated from what it *should* be. The term is descriptive and normative at the same time.

In spite of its prevalence, normativity is rarely explicitly considered by innovation researchers. Most empirical researchers in the field of innovation (and of sciences and technology studies, STS) regard their approaches mainly as descriptive, quantitative and explanatory. This is, indeed, a shortcoming. Normativity has not always received the scholarly attention it deserves.

Normativity is and has always been present in research of the intersection of science, technology and society. We cannot abandon normative assumptions, hidden convictions and implicit goals but—by means of critical argumentation and rational justification—we can contribute to societal discourses in order to find adequate goals for shaping innovation processes towards our common future. If we do not make normativity (normative assumptions, implicit goals) explicit it can easily convert to metaphysics and ideology. The aim of this paper is to advocate *critical* and *reflexive* innovation research in order to assess, to reflect on and to revise goals, ends, and objective. Such a kind of a renewed innovation research shares many well-known procedures with prospective *technology assessment* (PTA). Bridging the gap between empirical research and reflection on/revision of normativity will also be beneficial for engineering ethics.

In order to stimulate *critical* and *reflexive* innovation research I will address the underlying normative assumptions of "innovation". I find normativity in four areas: (1) innovation and theory of society, (2) objects of innovation (artifacts, processes, knowledge, problems), (3) process of innovation, and (4) innovation and ethics. I argue in favor of the priority of normative reflection.

1. SOCIETY

How should one understand innovation *in* society? Innovation theories—this is my thesis—are always interlaced with theories of society. If we argue for this thesis, we are faced with a problem. It is hard to identify the exact origin and the core content of innovation theories. The date and place of birth of innovation theories depend quite considerably on what underlies one's understanding of innovation. The medium-range history of innovation theories traces back to Joseph Schumpeter in the 1930s / 1940s—in particular to his "Theory of Economic Development" and "Capitalism, Socialism and Democracy" in which he explicitly focuses on "creative destruction" as a source of innovation. From a short-range historical perspective the initial point of innovation research is no doubt Christopher Freeman's work on "The Economics of Industrial Innovation" and the foundation of the Science Policy Research Unit at the University of Sussex, UK. Early contributions are sometimes identified in the works of Francis Bacon, Adam Smith and Karl Marx.

The unifying arch is that innovation is regarded as the central source and driving force for the further development of mod ern (and late-modern) societies. Although some differences to classical modernization theories can be found, all (late-modern) concepts of innovation (still) associate technological advancement with societal progress: without innovation, no progress![i] For instance, according to Jan Fagerberg, "innovation is as old as mankind itself. There seems to be something inherently 'human' about the tendency to think about new and better ways of doing things and to try them out in practice. Without it, the world in which we live would look very, very different. Try for a moment to think of a world without airplanes, automobiles, telecommunications, and refrigerators, just to mention a few of the more important innovations from the not-too-distant past. Or—from an even longer perspective—where would we be without such fundamental innovations as agriculture, the wheel, or printing?" [1]

After the debates in the 1960s, 1970s and 1980s on side effects, long-term impacts, and risks caused by technological development (*Silent Spring*, Hole in the Ozone Layer, Three Mile Island, Chernobyl), Fagerberg's one-sided positive interpretation is surprising. However, most innovation researchers share Fagerberg's technoscientific optimism for society. Innovation means an "improvement" and a "progress" for society in general (and further, an "enhancement of human performance" [2]). "Innovation is crucial for long-term economic growth." [3] In addition, many innovation theorists proceed to regard market mechanisms, consumer demands and customer desires as the driving forces behind "new" and "better" products and processes. According to Afuah, "innovation is the use of new knowledge to offer a new product or service that customers want. It is invention and commercialization." [4] The market, and in particular the customer or the state (by regulating market mechanisms), seems to determine what innovation is. This view is not only close to the classic linear chain-based pull theory of innovation. It fits well with both a liberal/neo-liberal (Adam Smith, Milton Friedman) and, with slight modifications, an interventionist approach (John M. Keynes). Innovation—encompassing the whole field of science, technology, and society (STS)—is defined and determined mainly from an economic perspective.

This perspective is in sharp contrast to the pessimistic doctrine of technological determinism. Jacques Ellul (1964) has exemplified the deterministic position in his "Technological Society" [5]. According to Ellul's analysis technological development is an autonomous process, governed by its own internal rules which cannot be altered by politicians or by the market. The process cannot be modified and shaped by anyone's intentional actions.

The skepticism and pessimism of Ellul, however, is not in line with the optimism of innovation researchers ("principle of hope" according to the philosopher Ernst Bloch). Two optimistic versions advocated by innovation researchers can be distinguished. A *weak version* assumes that innovations can (just) be fostered, stimulated, and supported (*stimulating assumption*). This characteristic fits well into the scope of neo-liberal or neo-classical approaches. In the *strong version* of this position innovations seem to be open to planning and controlling throughout the whole process (*planning assumption*). This thesis is in accordance with the planning optimism of the 1960s and with Keynes' interventionalism. Today, the terms "planning" and "controlling" have been replaced by others such as "shaping": e.g. "shaping technology, building society". Sometimes this understanding of innovation is said to advocate a Marxist's understanding of sociotechnological development within the late historical phases (socialism, communism): technology planned and controlled by the working class can be viewed as being instrumental to fostering social and human progress.

However, the foregoing two positions—the weak and the strong position—highlight the fact that underlying theories of society are very crucial for understanding innovation. To summarize, innovation research is intermingled with the following normative assumptions:

1. *Term and its connotation:* The term "innovation" is viewed positively. Normativity here means that innovation researchers rarely judge any innovation negatively. Innovation, Fagerberg states, "is crucial for long-term economic growth." [6] Whether a negative innovation is an "innovation" remains an open question. Is the atom bomb an innovation? What would a negative assessment imply: fostering or, more than that, shaping and controlling innovation processes? Which actors decide what is considered an "innovation"?

2. *Progress and advancement:* Innovation researchers share a technological optimism. The phenomenon of innovation (not just the term) is regarded as a central element of progress and prosperity. Even creative destruction, a well-known term coined by Schumpeter, is positively highly valued as the condition for the possibility of novelty. Fagerberg mentions very generally "the desirable consequences" of innovation [7].

3. *Power and relevance:* Innovation is regarded as *the* driving force and most influential factor of the historic and future development of modern societies. "Without innovation, the world in which we live would look very, very different. " [8] This is a normative statement rather than a descriptive proposition. It is not based on proper investigations of the history of the "world"; clearly defined terms are missing as are empirical falsifiable hypotheses. Therefore, the thesis that innovation is the driving for is either normative or—if innovation just means change—is trivial.

4. *Stimulating and shaping:* Innovation can be stimulated and shaped. "Because of the desirable consequences, policy makers and business leaders alike are concerned with ways in which to foster innovation." [9] There is no superstructure or abstract system that prevents us from fostering and controlling innovation processes. Innovations are open to shaping procedures by actors such as

political decision makers, consumers, corporation managers, and others. Technological determinism is rejected.

5. *Market and economy:* Innovation is defined by successful diffusion into the market and by consumer demands. Market mechanism and commercialization determine the innovation process. In a market system, innovations are often private property such as patents.

The preceding is an open list that encompasses normative assumptions most prevalent across the society/technology boundary. This kind of normativity is not always considered and reflected in the framework of innovation theories. However, innovation theories are interlaced with theories of late-modern technoscientific society—in particular with visions for societal future. A *philosophical* research program on innovation should address these broader issues; they should be integrated into empirical innovation research.

2. OBJECT

What does innovation mean? What is the "object" or "phenomenon" that shows novel properties? What is the object being innovated? What is included in *and* what is excluded from the term "innovation"? Definitions of terms—here: "innovation"—are not harmless and innocent. Normativity is embodied in the term's extension (mirroring inversely the term's intension). The term's extension is not given by itself, rather it is based on normative decisions. Is a broader or narrower extension of the term adequate? What definition is preferable—for what purpose?

It is common to distinguish between product and process innovation. A highly acknowledged distinction is also that between material goods and new intangible services, and between technological and organizational innovations [10]. Let us proceed from a narrower to a broader definition of "innovation".

1. The *ontological type* of innovation focuses on products, artifacts, material systems, objects, and entities (technoobject innovation = "ontological dimension"). Keith Pavitt, for example, stresses the "translation of knowledge into working artifacts" as the central element of innovation [11]. For Pavitt innovation always has something to do with "technological artifacts" and with "matching working artifacts with users' requirement" (ibid.). Jan Fagerberg's examples of innovations encompass technical artifacts such as "airplanes, automobiles, telecommunications, and refrigerators, just to mention a few of the more important innovations from the not-too-distant past." In addition, there is "the wheel" or "printing press" [12]. Charles Edquist mentions "product innovation" and also refers to "material goods" [13]. In line with this, Keith Smith stresses "new product characteristics" such as "new lift/drag aspects of an aircraft wing [...] or improved fuel efficiency of an engine." [14] The foregoing shows a strong (techno)object-oriented understanding of innovation.
2. The *process, production or method type* of innovation refers to procedures, actions, and practices (*process innovation* = "methodological dimension"). The term "process innovation" has been used to characterize improvements in the ways of producing goods and services [15]. It differs from product innovation that focuses on the occurrence of new or improved goods. Good examples illustrating the process and method type of innovation in the realm of nanotechnology are the scanning tunneling microscope (STM) and the atomic force microscope (AFM), which stem from technological inventions in the early 1980's. Process innovations may be technological, organizational, or both [16]. Alice Lam, for instance, endorses "organizational innovation" [17]; by this she means the creation of an idea and behavior new to processes and procedures of the organization. Thus, processes of innovation can encompass technological and organizational elements.
3. The *knowledge or conceptual type* of innovation refers to knowledge, theories, and concepts (knowledge innovation = "theoretical dimension"). This type of innovation does not primarily focus on material objects and artifacts, nor does it refer mainly to processes and methods. Charles Edquist highlights the non-material side of innovation when he writes about "intangible kinds of innovation" [18]. Keith Smith argues that "more generally, innovation involves multidimensional novelty in aspects of learning or knowledge organization" [19]. He regards "knowledge creation" as the core character of innovation [20]: Innovation means innovation of knowledge, of concepts and theories. By advocating a non-artifactual and non-methodological understanding of innovation Edquist and Smith criticize that "traditionally" there has "been a tendency to focus much on the process innovations and goods". In order to widen the perspective and to broaden the concept of innovation Gernot Böhme and Nico Stehr coined the term "knowledge societies" [21] —a new field of political activity ("knowledge politics") is emerging in late-modern societies. In line with this Nelson and Winter introduced the notion of the "organizational memory" as a major element that determines innovation. Patents are an example of the knowledge type of innovation. Other examples are specific skills and practices such as how to handle a machine, how to program a computer, or how to use the internet. Characterizing nanotechnology as a sciences-based "enabling technology" highlights the knowledge type of innovation.
4. In addition to these three types, we can identify and specify a very different type of innovation (although whether this type exists might be a contentious issue). This type of innovation is concerned with the initial

points, the goals, problems and purposes—in other words, it is the problem framing, problem setting and problem perception type (*problem-oriented and goal-setting innovation*). Problem-oriented innovation refers to progress in problem perception ("realism") or problem construction ("constructivism"). Erich Jantsch, for instance, argues in favor of a "*purposive* innovation system" [22]: an explicit reflection on and revision of purposes could be regarded as the highest level of innovation. Jürgen Habermas also draws attention to the critical reflection on purposes of research and innovation processes [23]. Problem seeing and research agenda setting and the aim, volition and intention to obtain a certain knowledge precede product-, process- and knowledge innovation. However, this first and foundational step of innovation is externalized by the other three foregoing types of innovation. – Innovation might, on this broad understanding, allow us to refer to, reflect on, and revise societal goals and purposes. From this perspective it does not seem appropriate that Jan Fagerberg insists we should "leave definitions aside" and instead address the "fundamental question for innovation research [... namely] to explain how innovation occurs" [24]. Normativity, as the term is used here, refers to the guiding ideas, goals, objectives and purposes. Innovation is linked to a reflexive questioning of what is given in order to improve goals and objectives. Reflecting normativity means posing questions such as: what for and for what? What is the purpose and the goal? Is the purpose "innovative"?—Required is knowing-what and knowing-where-to (*quo vadis*), instead of (just) knowing-why. This is, indeed, a broad perspective on innovation that is close to well-known procedures of *prospective technology assessment* (PTA).

The extension of the term "innovation" is not given (by itself or by any empirical approach). Rather, it is based on normative decisions about what objects/phenomena should be included: term definitions and word understandings are always crucial for the constitution (and construction) of research fields. A broader definition encompasses knowledge and problem innovation, a narrower perspective exclusively refers to material artifacts and processes.

3. PROCESS

How can we describe the innovation process? An immediate normative issue is that innovation is, by definition, based on novelty. Innovation is the creation of something qualitatively new. A fundamental definitional issue concerns what is meant by "novelty". We know from self-organization theory in physics that novelty is hard to define—it is a matter of ongoing dispute. Normative criteria to qualify and quantify novelty are indispensable; problems of comparability and incomparability, of commensurability and incommensurability emerge. In addition, novelty seems to be a multidimensional property and a (time-dependent) process phenomenon. According to Keith Smith, "as with 'research', innovation is a multidimensional process, with nothing clearly measurable about many aspects of the underlying process." [25][ii]

In spite of the lack of a unified theory of innovation we can at least identify common conceptual elements in most of the models of innovation, e.g., the (modified) pull-push models, the evolutionary models, and the actor-network models. According to Keith Pavitt, the innovation process consists of three (in fact of six detailed) subprocesses which are non-linear interacting, non-deterministic, time-dependent, and non-disjunct overlapping [26]. By taking feedback loops on different time scales into account Pavitt modifies the classic causal-chain model of innovation that was highly disputed [27]. Pavitt argues that although innovation processes in different sectors differ strongly, we can observe a common structure. Based on Pavitt's analytic distinctions we can identify in any subprocess normative elements: in fact, normative criteria specify and qualify these subprocesses. Normativity is indispensable for the development of any concept of innovation.

1. *The production of scientific-technological knowledge:* This process encompasses basic scientific research and, based on this, technological inventions. Normative criteria such as "truth" for characterizing scientific discoveries and "novelty" for specifying technological inventions are involved. In particular, invention means the first occurrence of an idea for a new product or process. However, novelty is not given by itself but is an outer ascription. Normative criteria have to be formulated: an idea is considered to be "new" in comparison to others. – For this subprocess the contributions of natural and engineering science are of major importance. Most scientists argue that innovation is equivalent to, or at least mainly based on, scientific-technological knowledge. This position is well known as the science and technology push view of innovation. Scientific knowledge seems to determine downstream the whole process of innovation. However, whether or not the term "innovation" does, or should, refer primarily to scientific discoveries and inventions is highly disputed. Many scholars contend that

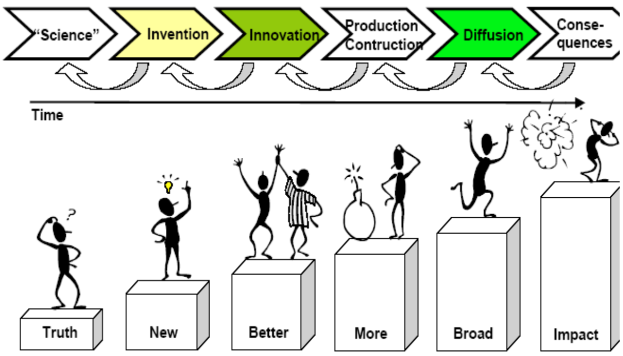

Fig. 1. The modified chain-model of innovation.
Normative criteria specify different subprocesses

we should draw a clear line between (scientific-technological) invention and (societal/economic/public acceptable) innovation [28].

2. *The translation and transformation processes of technoscientific knowledge into working artifacts:* Most innovation researchers stress a general knowledge-transformation process. Therefore, "truth" and "novelty" are necessary, but not sufficient as adequate normative criteria for innovation. Most important are others, such as "better" and "more". Therefore, innovation is mainly considered to be a transformative process: innovation (in a more restricted understanding: "better"), and manufacturing / construction / production ("more"). This transformation process is truly very interdisciplinary as it involves engineering sciences as well as certain social sciences such as economics.

3. *The response to and influence by market demands and societal needs:* Traditionally, this process was called diffusion, distribution, consumption, or use. Normative criteria to specify this process are "broad acceptance", "societal impact", "economic success", and "ethical acceptability". The process does not only encompass consumers' responses, but also the influence and power of the market mechanism on technological development (upstream, pull view). This is the domain of social scientists, in particular of sociologists and economists. Christopher Freeman, for instance, talks about the "economics of industrial innovation" and he highlights the relevance of an approach from economics [29]. "Innovation and diffusion" and "diffusion of innovations" is a major topic of innovation research in the social sciences.

Without the normative criteria (truth, novelty, better, more, ...) a concept/theory of innovation is impossible. While the normative criteria themselves are not open to empirical investigations, they form an indispensable prerequisite for any empirical analysis. In order to justify the criteria, analytic clarification and rational argumentation are necessary.

Not only do the normative criteria within the three subprocesses of innovation differ, but *disciplinary* scholars also highlight different subprocesses. From the perspective of different disciplines, different aspects of innovation are considered more or less important. (a) Natural and engineering scientists tend to stress the first subprocess—the production of scientific-technological knowledge—and (b) social scientists mainly highlight the last point—the diffusion, the response to and influence by market demands and societal needs. Thus, any assessment of the relevance of the subprocesses of innovation seems to depend essentially on disciplinary preferences. Disciplinary norms determine any understanding of innovation. So natural and engineering scientists tend to assume that the innovation process is based on a *science (technology) push*, whereas social scientists frequently endorse a societal *demand pull* ("finalization"). Interdisciplinarity is hard to achieve.[iii]

It is interesting to note that the field today is dominated by social scientists—and by a social constructivist view of innovation / technology. We find a devaluation of the science push view and, interlaced with this, (a) a disregard for the theoretical advancements and the explanatory power of sciences as well as the internal structure of technology and (b) a devaluation of any critical materialist position. Of course, the science push view is naive in that it overestimates the relevance of basic research for society. In addition, it is an expertocratic mode of problem solving. It is not open to public decision making and participatory governance. – The deficits of the science push view are obvious. However, the crucial question is whether today's dominant view, which is pull oriented and interlaced with evolutionary-, actor-network- and/or case study approaches, will permit us to reflect on the real and problematic power of (natural and engineering) sciences and of (technoscience-based) material artifacts *in* society. Innovation researchers seem hesitant to open Pandora's box of the dynamics of science and technology, and of material entities.

Let us look at an example illustrating the disregard of innovation researchers for the theoretical advancements of (natural and engineering) sciences. Jan Fagerberg misinterprets the history of science when he writes: "Although Leonardo da Vinci is reported to have had some quite advanced ideas for a flying machine, these were impossible to carry out in practice due to a lack of adequate materials, production skills, and—above all—a power source." [30] Fagerberg's statement is misleading because not only were adequate materials and production skills not present at that time, but, more importantly, Leonardo's concept was erroneous. Leonardo's flying machine would never have been constructed. The theories of physics in the 19th century were necessary, in particular aero- and hydrodynamics, fluid mechanics, and in addition the boundary layer theory that Prantl developed in 1904 (as part of the new engineering sciences). This example shows that in order to understand innovation processes, just focussing on the social sphere (and considering the social construction of technology) is not sufficient. A in-depth knowledge of science and technology is necessary.

An influential paper that reveals (at least implicitly) how normativity and strategic arguments are linked with innovation concepts was presented by Stephen Kline and Nathan Rosenberg in 1986. Kline and Rosenberg argue against what they call "the linear model of innovation" [31]. Although the linear model was a widely accepted interpretation of innovation at that time, Kline and Rosenberg show convincingly that this is an erroneous view: according to them, the objective of the model was not to describe the innovation process but to provide arguments for the relevance of basic research and natural science. Its objective was to defend the interests of researchers, scientists, and engineers. The linear model assumes misleadingly (1) that innovation is a kind of applied science. Sciences and scientific inventions were considered to be the important bottleneck. (2) Further, the linear model is based on an assumption of causality and could easily be used as an argument in favor of technological determinism. Technological determinism seems to be erroneous, too. This position is not open to public deliberation processes. (3) The linear model fails to reflect economic and societal demands—in particular the driving power of economy. (4) Temporal effects, different sectoral time scales and nonlinear feedback are not considered.[iv] – An important implicit finding from the paper of Kline and Rosenberg is that innovation concepts are often linked to disciplinary convictions and claims. Innovation concepts can be used and misused as strategic arguments in order to pursue particulate interests of disciplines.

The preceding ideas were articulated by referring to Richard Nelson's and Sidney Winter's "Theory of economic change" [32]. This book was tremendously important for innovation research and for the concept of evolutionary models. Nelson and Winter share the Schumpeterian view of "capitalism as an engine of change." However, today we may ask whether innovation theorists really perceive and reflect on (?) the real power of material artifacts or not. This specific point was highlighted in the epoch-making critique "Do Artifacts have Politics?" raised by Langdon Winner: "Technological innovations are similar to legislative acts or political foundings that establish a framework for public order that will endure over many generations." [33] In general, terms such as "knowledge-based firms", "technological regime", "industrial dynamics", and "organizational memory" coined by Nelson and Winter seem to be far too week to reflect on and to revise the sociotechnical power of material artifacts.[v] Friedrich Engels wrote in his essay "On Authority" in 1872: "The automatic machinery of a big factory is much more despotic than the small capitalists who employ workers ever have been." [34] Lewis Mumford identified two traditions of technology – one authoritarian, the other democratic [35]. Material artifacts have embodied power. This is not (just) a *social construction* but a material-artifactual *real construction*!

Langdon Winner criticizes his colleagues stating that "we immediately reduce everything to the interplay of social forces." [36] Most innovation researchers do not regard innovation processes from the materialist's but from the constructivist's perspective. From this perspective, the process of innovation seems to be widely open to shaping procedures. Openness to shaping is, indeed, a normative assumption and *not* an empirical result. This *optimistic* viewpoint underestimates the real power of materialized (or institutionalized) innovations: "the normative power of the factual existing" (Horkheimer/Adorno [37]). An initial point for a prospective critical assessment of innovation processes is to acknowledge the shaping problems and the (innovation-internal) resistance against shaping attempts.[vi] Thus, some analytic ideas of critical theory (encompassing a critique of *political economy*) seem to be indispensable for present-day *prospective*-oriented and *reflexive* innovation research.

4. ETHICS

Innovation theories are relevant for ethics, in particular for engineering ethics. Nonetheless, neither ethicists nor innovation researchers have perceived and acknowledged that innovation theories are indispensable to localize, to reflect on, and to revise engineering action in society.

Engineering ethics refers to engineer's practice; it is contextualistic rather than universalistic. It is not solely concerned with universal principles, rational argumentation, and intersubjective justification (theory of ethics, argumentation theory). The conceptual challenge is that engineering ethics is context dependent in the sense that the analysis and diagnosis of the situation determines the decision making and the action taking. So, from a philosophical perspective, engineering ethics is based on action theory. – Action theory, however, should be interlaced with innovation theories in order to be in touch with the societal situation and the problem that is at stake. *Implicitly*, most textbooks on engineering ethics acknowledge that action theory and innovation theory play an important role. However, all this is not reflected explicitly—in particular, an integration of innovation theory is missing.

Referring to innovation theory, at least four positions concerning the "innovation-engineering-ethics intersection" can be distinguished:

(a) If we presuppose technological determinism, ethics does not have a chance impact on the innovation process.

(b) If we argue for a push view of innovation, science ethics is most important.

(c) On the other hand, if we assume a demand pull understanding of innovation, social and political ethics are most relevant.

(d) In between we may find *engineering ethics.* It has to explicitly reflect on and mediate between the other extreme positions in order to find a realistic approach to engineering action.

If we apply the dominant view of innovation researchers (demand pull view), it follows that scientists and research engineers are not generally responsible for their action in society. Engineering actions seem to be just one minor factor in the whole innovation process. Most important are the market dynamics, the manager's action, the organizational structures, the customer's behavior, the public governance. Hence, innovation theory has consequences for applied ethics.

Besides the various versions of the pull-push models of innovation, other models such as evolutionary or actor-network models can also serve as a reference frame for localizing ethical action. When considering an evolutionary approach we can say that a kind of nomological law-like machine seems to govern this kind of innovation process—a machine that operates very similarly to processes of self-organization in natural sciences. Evolutionary approaches are—similar to technological determinism—not open to ethical considerations. In addition, actor-network models are of some interest. On the one hand, responsibility might be dissolved within the structures of the net and on the other hand, everybody has—because of global interactions and various "butterfly effects"—a tremendous impact on the whole.

Innovation theories can serve as an excellent guideline to identify and localize engineering responsibility. Insofar as ethics is a *normative* subdiscipline, innovation theories are interlaced with ethical-normative consequences as well as with prerequisites. Taking this into account, we should stress that engineering ethics (as a theoretical discipline) encompasses not only theory of ethics/moral and argumentation theory, but in addition: action theory and innovation theory.

SUMMARY

Four types of normativity can be identified in innovation concepts: normativity with regard (a) to society/theories of society, (b) to objects of innovation, (c) to the process of innovation, and (d) to ethics. – Innovation can be characterized as an eminently political term. The term is a cognitive boundary object located in a transfer zone between academia and politics. What "innovation" *is* cannot be separated from what it *should* be. The term "innovation" is descriptive and normative at the same time. In order to shape innovation processes towards our common future it seems worthwhile to consider, to reflect on and to revise the normativity of innovation.

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[i] Such identification was doubted from the 1960’s until the middle of the 1990’s, but evidently just for this short episode. In the 1990’s, concepts of innovation replaced more reflexive and critical considerations, as brought to light in works such as *The Silent Spring*, *The Limits of Growth*, *The World Risk Society*, and *Normal Accidents*. Late-modern problem orientation was repressed by the revived classical-modern technology orientation. The technological optimism of the Baconian Project seems to be back.

[ii] However, there are indicators that try to quantify some aspects of the innovation process: (1) R&D data, (2) data on patents, patent applications and grants, (3) bibliometric data. In addition to these well-established measurements there are others (Smith 2005, 152): (4) technometric indicators, (5) synthetic indictors (parallel to consultant indicators), (6) specific indicators (such as firm databases, ...). Of course, the indicators specify some important aspects of innovation. However, we have to guard against believing that one of them is *the* basic indicator characterizing *the* innovation. The major difference between innovation measurement on the one hand and measurements in the realm of classical Newtonian mechanics on the other hand still remains ...

[iii] We find, more or less, a “science war” concerning the appropriate understanding of innovation. This kind of science war differs, of course, from that between constructivists and realists.

[iv] Contrary to the linear model, innovation is regarded as a learning process involving multiple inputs on various scales. Kline and Rosenberg advocated what is called the chain-link model of innovation (Smith 2005, 150).

[v] In a similar vein one can mention the expression “national system of innovation” (NSI) that was highlighted by Freeman (1987). Freeman defined it as “the network of institutions in public or private sectors whose activities and interactions initiate, import, and diffuse new technologies.” (Freeman 1987, 1) Two other important books on the national systems of innovation are by Lundvall (1992) and Nelson (1993). Whereas Nelson’s approach is case study oriented, Lundvall emphasizes the need for a theoretical approach. He seeks to develop an alternative to the neo-classical tradition in economics by placing innovation at the center of the analysis: innovation cannot only be fostered, but in addition it can be shaped deliberately. The systems-of-innovation approach adopts a holistic, non-linear, and—as many authors stress—“interdisciplinary perspective.” (Edquist 2005, 185) The systems approach primarily emphasizes common learning processes.—Edquist describes the “systems of innovation” by focusing on organizations and institutions (Edquist 2005, 182). The systems of innovation are the main determinants of innovation processes. According to Edquist the determinants encompass “all important economic, social, political, organizational, institutional, and other factors that influence the development, diffusion, and use of innovation.” (ibid.) In line with this, Keith Smith, referring to Rosenberg and Kline, argues in favor of “the importance of non-R&D inputs to innovation.” He mentions “training”, “design activities” and the “exploration of markets for new products” (Smith 2005, 150).

[vi] The real power of innovations (artifacts, processes, and knowledge) in society and the closeness to (public policy) shaping of many innovation processes has to be noticed to enable a critique—this is different from just being aware of the path dependency of technological development.