Innovation:
The History of a Category

Benoît Godin

385 rue Sherbrooke Est
Montréal, Québec
Canada H2X 1E3
benoit.godin@ucs.inrs.ca

Project on the Intellectual History of Innovation
Working Paper No. 1
2008

Project on the Intellectual History of Innovation
385 rue Sherbrooke Est, Montreal, Quebec H2X 1E3
Telephone: (514) 499-4074 Facsimile: (514) 499-4065
www.csiic.ca

Abstract

Innovation is everywhere. In the world of goods (technology) certainly, but also in the realm of words. Innovation is discussed in scientific and technical literature, in social sciences such as history, sociology, management and economics, and in the humanities and arts. Innovation is also a central idea in the popular imaginary, in the media and in public policy. How has innovation acquired such a central place in our society?

This paper looks at innovation as category, and suggests an outline for a genealogical history. It identifies the concepts that have defined innovation through history, from its very first meaning as novelty in the Middle Ages to the most recent interpretations in sociology and economics. The paper suggests a genealogical history of innovation through the following three concepts: Imitation → Invention → Innovation.

We have a “violent Fondness for change, and greater Eagerness after Novelties”, B. Mandeville, *The Fable of the Bees*, 1732.

The analysis of the nature of creativity is one of the chief intellectual commitments of our age, L. White, *The Act of Invention*, 1962.

Introduction

Innovation is everywhere. In the world of goods (technology) certainly, but also in the realm of words: innovation is discussed in the scientific and technical literature, in social sciences like history, sociology, management and economics, and in the humanities and arts. Innovation is also a central idea in the popular imaginary, in the media and in public policy. Briefly stated, innovation has become the emblem of the modern society, a panacea for resolving many problems, and a phenomenon to be studied. As H. Nowotny defines our epoch: it is a fascination and quest for innovation (Nowotny, 2008; 2006).

This suggests three questions. First, **why** has innovation acquired such a central place in our society or, put differently, where precisely does the idea of innovation come from? To many, innovation is a relatively recent phenomenon, and its study more recent yet: innovation has acquired real importance in the twentieth century. In point of fact, however, innovation has always existed. The concept itself emerged centuries ago. This suggests a second question: why did innovation come to be defined as **technological innovation**? Most people spontaneously understand innovation to be technological innovation. The literature itself takes this for granted. More often than not, studies on technological innovation simply use the term innovation, although they are really concerned with technological innovation. However, etymologically and historically, the concept of innovation is much broader. How, when and by whom did its meaning come to be "restricted" to technology? Third, why is innovation generally understood, in many milieus, as **commercialized innovation**? It is hard today to imagine technology without thinking of the market. One frequently hears of innovations that are marketed by firms, but other types of innovation are either rapidly forgotten or rarely discussed. By contrast, every individual is to a certain extent innovative; artists are innovative, scientists are innovative, and so are organizations in their day-to-day operations.

To answer these three questions, this paper looks at innovation as a **category** and at its historical development. The paper is not a history of innovation itself, neither an internalist or externalist history. It looks rather at the representations of innovation and the discourses held in the name of innovation, namely since the term first appeared in the Middle Ages: how the public, innovators themselves, and academics, and particularly the theories of the latter, have understood innovation and talked about it.

This paper offers ideas toward a **genealogical history** of the category "innovation". It identifies the concepts that have defined innovation through history, and that have led to innovation as a central category of modern society. The paper is programmatic in the sense that it suggests a program of research or outline for such a genealogical history, a history that remains to be written. In the *Archeology of Scientific Reason*, M. Foucault asked "Comment se fait-il que tel concept soit apparu et nul autre à sa place?", (Foucault, 1969: 39-40) that is, under what conditions does a word come to mean what it signifies for us today? To Foucault, a genealogy is a study of descent rather than origins: the details and accidents, the forces and struggles that accompany every conceptual beginning and its further "solidification" (Foucault, 1984).

In a recently-launched project on the intellectual history of innovation, of which this paper is the first in a series, a genealogical study is framed through concepts, their uses and their context. As Q. Skinner suggested, words are markers of the social understanding of the world, and the emergence of new words is a marker of changes in society's values (Skinner, 1988). The genealogical study suggested here rests on six elements. It starts with the study of words (or terms), their genesis and transformation, and the network of concepts involved in speaking about innovation: invention, ingenuity, imagination, creativity, etc. Second, it looks at the meanings of the concepts developed. Such meaning usually goes from vagueness – firstly as a concept in construction where multiple terms are used, often interchangeably, and then with an implicit definition – to a relative

stabilization. Third, discourses held in the name of the concepts are identified. The discourses on innovation have been generally of three kinds: innovation as a factor for change in society, innovation as progress, [1] and innovation for its own sake, such as for personal recognition, prestige or professional identity. Fourth, the values on which innovation relies are analyzed, since they often involve an "essential tension" and lead to the development of dichotomies, such as tradition *versus* innovation (Kuhn, 1963). This part of the analysis calls on central categories of thought in Western history. Fifth, the theories and conceptual models developed to explain innovation are studied, from the very early "psychological" models to more recent sociological and economic ones. The sixth and final element in the genealogical history of innovation is the study of the context in which the category emerged: economy (trade), politics (the courts), and culture (expressiveness, awareness of history).

This paper advances three hypotheses in order to guide a genealogical history of innovation as category. The first hypothesis postulates that innovation is about **novelty**, as etymology, dictionaries and history suggest. As such, innovation is of any kind, not only material or technological. In this sense, innovation as category has a very long history. However, over time the conjunction of two factors gave preeminence to technological and commercialized innovation in representations: 1) the culture of things and its capitalistic corollary: industrial development through technology, 2) academics, the study of technology, and the conceptual frameworks that followed for policies in science and economic growth. In fact, there is a dialectics here between reality and language. Events and changes in the world gave rise to new categories; the latter in turn brought to light changes in the world and, in doing so, contributed to these changes.

The second hypothesis is that the history of innovation as category is that of three concepts (and their derivatives): **Imitation → Invention → Innovation**.

[1] In civilization (evolutionists, anthropology), in well-being (sociology), in growth (economics), in knowledge and the control of nature (philosophy).

Certainly, a lot has been written on imitation (literary theory and art theory), as well as invention (history, sociology, management and economics of technology). But no one has ever brought the two concepts together in a genealogical history, and neither has anyone looked at their contribution to the category innovation. Through Western history, imitation and invention have been contrasted, or are in tension. The dichotomy reaches its resolution with the idea of innovation in the twentieth century, particularly the idea of innovation as process: invention and imitation are two sequential steps in the process leading to innovation.

The third hypothesis is about innovation as a **break with the past**. Innovation and the discourses on innovation serve to make sense of modern practices and values. On the one hand, innovation represents continuity with the past. It is continuity in the sense that innovation is about novelty, an idea that was present in many forms before innovation took on a central place in representations, as we will see. It is also continuity in the sense that innovation is, to many, concerned with technological invention, which is a dominant understanding of what invention came to mean over time. However, on the other hand innovation is a break with the past in the sense that it suggests that invention *per se* is not enough. There has to be use and adoption of the invention, namely innovation, in order for benefits to accrue.

At this stage of the project, the first two parts of this paper (imitation, invention) are based on secondary sources. The third part (innovation) is composed entirely of original research and constitutes the core of the paper. It identifies the theories on innovation proper, and their emergence over the twentieth century. The period covered in this paper ends around 1970-90, which was when innovation developed its current understanding in representations, and when the literature on innovation exploded. [2]

Imitation

Imitation is a concept of Greek origin. McKeon (1936) has documented how Plato's philosophy is entirely concerned with imitation and its many senses and opposites: appearances (or images) – *versus* reality; falsity – *versus* truth. To Plato, even physical objects are imitations, compared to God and true nature. But it is through Aristotle that the concept of imitation got its main influence. To Aristotle, (practical) arts imitate nature (*mimesis*). Such an understanding of art gave rise to *imitatio* as the central problem of art, with pejorative overtones, then to imitation as inspiration (Abrams, 1953; Nahm, 1956). As M. H. Abrams has stated, the mimetic orientation was the most primitive aesthetic theory (Abrams, 1953: 8). Art imitates the world of appearance. The "artist" extracts the form of the natural world and imposes it upon an artificial medium (Abrams, 1953: 11). In fact, "wherever the Renaissance theorist turned, he usually found the concept of invention somehow subordinated to the imitation of nature" (Kushner, 1980: 144). [3]

However, according to most theories, imitation is only "instrumental toward producing effects" (Abrams, 1953: 14). In their quest for social status, artists debated for centuries on how to distance themselves from a conception of their work as mere copying. As E. T. Bannet suggested recently, imitation is a literary mechanism for the production of difference (Bannet, 2005). Until the mid-eighteenth century, imitation was presented as a positive practice, not one that was distrusted or pejorative. To rhetoricians, imitation is a method for teaching (Clark, 1951). To Renaissance artists, imitation certainly makes use of nature as

---

[2] The author wants to thank the following colleagues for comments on a first draft of this paper: Denise Lemieux, Carole Lévesque, Pierre Lucier, Reijo Miettinen, Helga Nowotny, Françoise-Romaine Ouellet, Jean-Jacques Salomon.

[3] On the different of meaning of imitation of nature in art, see Lovejoy (1927) and Lovejoy and Boas (1935). In history, the "naturalist presumption" is a widespread idea: what humans do, in literature, arts, crafts and science is a (continuation or) perfection of nature (Close, 1969). To many, above all philosophers, nature is generally considered as more primitive and more authentic. Nature functions as a cultural value and social norm. Nature has a moral authority (Bensaude-Vincent and Newman, 2007; Daston and Vidal, 2004).

model, or exemplar. However, it is not slavish or mechanical imitation, but selective borrowing and creative copying. Similarly, while humanist writers in the Renaissance make use of past authors (antiquity) as models, it is *aemulatio*, and the writer enriches the tradition. In fact, the artist, the poet and the writer in the Renaissance were not yet being judged for originality (Cole, 1995; Wittkover, 1965), but rather for interpretation. There was little sense of copyright – although accusations of plagiarism abounded (Hathaway, 1989; White, 1935).

And so it is with science and arts. To Francis Bacon, one comes closer to real knowledge of nature by imitating nature. Bacon's Salomon House is "an artificial world carefully fashioned and crafted in imitation of the natural world" (Eamon, 1994: 311). In the world of trade and goods, imitation is also positively appreciated. M. Berg and H. Clifford have documented how imitations served as substitutes for imported commodities in eighteenth-century Britain (Berg, 1999; Clifford, 1999). Imitation was a way to give access to luxury goods (decorative goods, clothing, household wares) to the people, through "semi-luxuries". In the case of the decorative arts over the same period, R. Benhamou has documented the contribution of imitation to lowering the costs of original products (Benhamou, 1991). Briefly stated, imitation is taken for granted and is a common practice. Imitation brings advantages to the people; it represents economic opportunity.

In more recent history, R. R. Nelson and S. G. Winter (1982), in a classic of the literature on technological innovation, suggested imitation as one of two strategies available to firms, the other being innovation. In fact, as early as 1966, T. Levitt from Harvard Business School suggested that "the greatest flow of newness is not innovation at all. Rather, it is imitation". He was referring to the fact that when "competitors in the same industry subsequently copy the innovator [a given firm or industry which has produced something that has never been seen before], even though it is something new for them, then it is not innovation, it is imitation" (Levitt, 1966: 63).

Not only, then, is imitation a good practice, but imitation has often been portrayed as being invention itself. The view in the Middle Ages of the work of artisans is that of art learned by imitating nature, but in so doing, the artisan changes nature, as claimed by the alchemists (Newman, 1989). Equally, in Renaissance literary theory and visual arts, one finds recurrent descriptions of imitation as rediscovery of the old, as something "new" to copy, as something never seen before. Here, "the charge of lies is turned to an argument for the truth of poetic imagination" (Rossky, 1958: 69). An argument frequently evoked here is that imitation requires work, experimentation, judgment and imagination. All these descriptions in literature, arts and crafts generally refer to an idea that has been very influential among many authors in defining invention, and subsequently innovation, as we will observe below: that of **combination**. Imitation is invention because, when combining elements from nature, it combines the best of them, and by so doing improves nature. Combination "creates a whole that is more perfect than nature"; it is as nature ought to be (Wittkower, 1965: 148). Equally, in combining previous schools of thought, the combination surpasses the work of past authors. *Compilatio*, a "wide literary activity which encompassed various genres in the Middle Ages" (and after), is combination of others' material into a new work, a *unio* (Hathaway, 1989: 41).

But let's continue with imitation as invention in other areas. In the sixteenth and seventeenth centuries, patents (and their precursors: letters and privileges) were granted not only to inventors, as they are today, but also to importers of existing inventions, as a way to develop the local economy (Macleod, 1988). In addition, premiums and prizes were awarded by societies of arts to imitations of existing foreign goods (Berg, 1999). Similarly, in consumer goods of eighteenth-century Britain, imitation was perceived as invention because it resulted in new commodities, introduced improvements in quality (design), and brought diversity and variety (Berg, 1999; 2002: Clifford, 1999; Benhamou, 1991). Due to a culture

of taste, the goods or commodities and their aesthetic qualities evoke the distinctive and the exotic, but also the latest technology and modernity.

Now, if we turn to the twentieth century, we clearly observe that imitation gave rise to, and was often used as a term for, diffusion. As I discuss below, contemporary theories on innovation now include diffusion as a step in the innovation process. In this process, diffusion is really imitation, and the word appears in early theories, from the French sociologist Gabriel Tarde in the 1890s to the economic literature on technological innovation in the 1980s. Equally, imitation gave rise to the idea of "adoption" as innovation itself: in recent theories on and measurements of technological innovation, adopting an existing technology is a behaviour considered just as innovative as inventing (OECD, 2005), and not as mere imitation, as Levitt has suggested. [4]

In summary, imitation has rarely been separated from invention. To many, imitation has close links to invention, and even constitutes invention itself. However, with time imitation came to be contrasted to invention. Starting from the mid-eighteenth century, imitation was regarded as mere copying, while originality became the criterion for real invention.

Invention

Invention is a term that comes from rhetoric. In classical rhetoric, invention was the first of five divisions of the rhetorical art. Invention is composed of guidelines to help speakers find and elaborate language. In *De Inventione*, Cicero (106-43 BC) defined invention as the "discovery of valid or seemingly valid arguments to render one's cause probable". However, in the history of rhetoric, invention as so conceived has been eclipsed by one or more of the four other divisions (arrangement, style, memory and delivery).

[4] See also the much cited concept "absorptive capacities": the capacity of a firm to assimilate and apply (imitate) other firms' innovations (Cohen and Levinthal, 1990).

Invention as a term in other domains really came to be used in the mid-fourteenth century as finding or discovery, namely with regard to knowledge (knowing). Then, it came to be applied to making as well, first in literature (poets), then in visual arts. In the sixteenth century, invention was used more and more to apply to newly-created things (artifacts).

From late medieval Europe, the idea of invention spread everywhere, to different degrees and under different terms. A whole network of words is used to name the new, as the list below indicates. Certainly, as M. Kemp has noted, in the Renaissance, there was "no unanimity in usage of *divino, ingegno, fantasia, immaginazione* and *invenzione*" (Kemp, 1977: 397). Equally, the term or terms associated with a specific field in the following list are not exclusive to that field, but are those that came to gain preeminence in that field (for a complete list of the vocabulary, see the Appendix). One thing is clear: the idea of novelty is everywhere:

- Philosophy: *praxis* [5]
- Literary theory and visual arts: imagination, originality, creation
- Arts and crafts (engineering): *ingenium*, invention
- (Natural Philosophy and) science: discovery, experiment, scientific change
- History: revolution, progress
- "Evolutionists": [6] growth, development, evolution, variation, mutation
- Anthropology: culture (or cultural) change
- Sociology: action, social change
- Psychology: creativity

[5] In philosophy, *praxis* has not really been theorized because of the emphasis on mind (Arendt, 1968; Lobkowic, 1957). It slowly begins to be become an issue, quite imperfectly according to many, with expressiveness (J. G. Herder), utilitarianism (free will), existentialism (life, will, consciousness), pragmatism (experience, inquiry), and the philosophy of action (Bernstein, 1971).
[6] Following Bowler (1983), I group together under evolutionists: early geology, early paleontology, natural history, and biology.

- Management and politics: organizational change
- Economics: entrepreneurship, technological change, innovation

Nowhere is the idea of novelty more present than in science. In the sixteenth and seventeenth centuries, science was frequently discussed as an active search or hunt (*venatio*), a very old metaphor (Eamon, 1994; Hadot, 2004). The scientific literature of the seventeenth century is full of the term "new", as L. Thorndike has documented (Thorndike, 1957), as well as the term "revolution" (Cohen, 1985). Equally, the idea of progress is a major one during the Renaissance, the Enlightenment and subsequently (Bury, 1932; Zilsel, 1945; Sarton, 1962; Rossi, 1970: 63-99; Crombie, 1975; Bock, 1978; Nisbet, 1980; Marx, 1987; Spadafora, 1990).

Change became a preoccupation of study in many emerging scientific disciplines, from sociology (A. Comte, H. Spencer) and history (A. Ferguson) to natural philosophy, or the sciences. Geologists, natural historians and biologists from the eighteenth century are the "men of science" who have taken change most seriously. Certainly, at that time, change as the natural process for the development of life on earth was seen as preordained, even through the nineteenth century: God is the designer of all things and their development; the linear chain of being is constructed as leading invariably to man (Lovejoy, 1936). But evolutionists, since before Darwin, have discussed change – as either linear, or cyclical or catastrophic (in the case of the earth formation), and as spontaneous generation and degeneration, then natural selection (in the case of biological species) (Bowler, 1983; 1993). The evolutionists also developed influential sequential theories of how life and societies evolve, based on the model of the embryo (birth, growth, maturity). Evolution, development, variation and mutation are only some of the key terms used here.

Whatever its name, the new is not without its opponents. The *Querelle* between the ancients and the moderns, in literature and philosophy but also in science and education, is that between imitating (and surpassing) the ancients *versus* a totally new enterprise (Jones, 1936). This is perhaps the first systematic debate in history about the new as opposed to tradition. In science, there is also the opposition with religion. An argument frequently evoked here is that of minimizing novelty, and portraying science as "new, but not so new": the purpose of scientific knowledge is to reveal the nature God has created; science talks about what is real, not magic or superstition. However, even among scientists themselves, scientific invention is resisted (Barber, 1961; Kuhn, 1962). As with imitation, invention is perceived in different ways. It is often distrusted and qualified as esoteric. Similarly, hypothesis, as coming from the imagination and as the major faculty behind scientific invention but a source of error for the rationalists, is said to be in need of control, namely a method, as Bacon suggests (Park, 1984). [7] Otherwise it leads to excesses, delusions and distortions, or to rhetoric and eloquence.

The defenders of invention often have an ideological aim: to distinguish oneself (identity) and to justify one's activities (image of scientists, inventors and writers), for purposes of patronage, among other things. Hence, the construction of oppositions portraying tradition and the like as static (transmission from generation to generation; irrational and arbitrary) versus invention and the like as cumulative and progressive. [8]

Over time, invention in science came to share the vocabulary of writers with the term **discovery**. In fact, for some time, invention meant finding as well as making, and was applied without qualification to both activities. Discovery also meant both. Later, a distinction was made between the two concepts: discovery

[7] On the role of hypothesis (imagination) in science, see Laudan (1981), Park, Daston and Galison (1984).

[8] Frequently heard oppositions are: Good *versus* bad imagination; imitation *versus* originality; science *versus* art; knowing *versus* imagining; objectivity *versus* subjectivity; books *versus* observation; hypotheses *versus* data; tradition *versus* modernity; good *versus* bad effects of technology (benefits *versus* disasters).

referred to facts, laws or things that already exist out there and that one finds out, while invention combines and makes new things, including scientific theories (Wyman, 1929; Kneale, 1955). However, since social constructivism (Hacking, 1999), the term "construction" seems to be the preferred term, applying to both scientific discoveries and technological inventions.

Literature and visual arts are other fields where the idea of novelty is widespread. In fact, literary theory and visual arts (painting, sculpture) in the Renaissance adapted invention from the literature on rhetoric (then from poetry) to a psychological process of *imagination* (Lee, 1940; Bundy, 1930; Spencer, 1957; Bond, 1935; 1937; Rossky, 1958; Engell, 1981). Although imagination was, as in science, portrayed for a time as in need of control, namely judgment and rules (Costa Lima, 1988), the real boundary work of the artist is against imitation: imitation (as combination) is stigmatized as *eclectici*. Real art is free imagination. The passive role (reproducing) of imagination in medieval usage (as opposed to *fantasy* which combines) turned into an active faculty with the Romantics. *Originality* came to define the artist (Cassirer, 1932: chapter 7; Mann, 1939; Mortier, 1982; Quint, 1983; McFarland, 1985), and the metaphor of **creation** – already present in Greek mythology (Prometheus) – entered the vocabulary (Nahm, 1947, 1956; Tigerstadt, 1968; Mason, 2003; 1988). Certainly, originality, as with imitation and invention, carries negative connotations as well. Until the nineteenth century, in social usage for example, an original person was bizarre, eccentric, ridiculed. [9] However, originality with the following two meanings gained credence over time. Originality means origin, or source (authorship), and this meaning would be influential, as discussed below, in the case of technological invention. It also means a distinctive quality of work, or novelty, unlike the imitation of the ancients, for example. As such, originality came to characterize the *genius*, an important figure in the Renaissance and to the Romantic authors (Zilsel, 1926; Murray, 1989). Genius as a concept has a long history. First defined

[9] On a very interesting sociological study of originality *versus* convention, see N. Elias on Wolfgang Amadeus Mozart (Elias, 1993).

as spirit (which gave inspiration), it came to mean innate talent or ability, then a person with superior creative powers, to which the Romantic conception has added the idea that genius defies rational analysis.

Ingenuity was also a key concept for the artisan from the Middle Ages onward. It gave rise to the figure of the inventor, a genius or hero who, as to scientists and artists, was not without opponents. As a matter of fact, it took time for inventors to be admitted to the pantheon of great men. Up to the end of the nineteenth century and the commercialization of technological inventions on a large scale, the inventor was anonymous. As C. MacLeod has discussed for Great Britain, the inventor was simply born at the right time and place, and was the last link in a causal chain (Macleod, 1996; 2006; 2007 Macleod and Tann, 2007; Macleod and Tuvolari, 2006).

However, while the idea of invention came to share its place with discovery in science (Branigan, 1981), and with creation in literature and visual arts (Mason, 2003), it gradually came to be identified primarily with **technological invention**, first of all in crafts and arts such as architecture, navigation, metallurgy and the military. Early in the Renaissance, the term invention was applied to *ingenious* things like "machines, artifices, devices, engines, methods", for which a whole literature developed – treatises, histories and encyclopedias (Rossi, 1970; Long, 2001) [10] – and for which the word *technology* subsequently became the category. [11] In the nineteenth century, engineering and works on bridges, tunnels and railways, then electrical systems add important inventions to the technological landscape (Chandler, 1977; 1990; Beniger, 1986; Hughes, 1983).

[10] On the contribution of magic and alchemy (and the books of secrets: receipts, formulas, instructions, experiments as tests, or trials) to the status of the arts and artisans, see White (1975), Newman (1989); Eamon (1994).
[11] On the history of the term technology, from *technique* to *artifact*, see: Morère (1966), Guillerme and Sebestik (1968), Salomon (1984), Frison (1992; 1993), Marx (1994; 1997), Schatzberg (2006).

This alignment of the term invention with technological invention was due firstly to the conventionalization, or institutionalization, of technological invention through patent laws from the seventeenth and eighteenth centuries onward. That invention as idea is itself an invention – a social invention – is now well admitted. A scientific theory is invention because a system for attributing authorship to an individual exists, namely the scientific publication. The scientific publication developed, in fact, as a mean to resolve priority disputes (Merton, 1957; 1961; Branigan, 1981; Gross, 1989; Iliffe, 1992; Biagioli and Galison, 2003). Similarly, the patent system is the institutional mechanism for deciding what a technological invention is (Rae, 1967; Macleod, 1988). As anthropologist O. T. Mason, curator at the US National Museum, put it in 1895: "The public recognition and reward of invention may itself be said to have been invented" (Mason, 1895: 15).

It is through the patent system that the criteria for a technological object's identity are negociated (Cooper, 1991; Cambrosio et al., 1990). And it is through the patent system that technological invention is defined: in fact, all technological inventions are defined here, whether it is patented or not. Ever since the early patent laws in the nineteenth century, three criteria have characterized technological invention (Lubar, 1990). First, originality as to quality of work, or novelty. Applications are examined for novelty before a patent is granted. Gone is the idea of imitation: transformations and improvements to existing goods are more and more difficult to patent. Originality is the norm. A technological invention, to qualify as such, has to be substantially new. With time, what constitutes novelty is increasingly settled through the judicial system, which arbitrates competing claims. The second criterion is originality as to origin, or priority. Here, patents institutionalized the then-emerging idea of intellectual property (authorship). Patent laws add property rights to inventions. [12] The third criteria suggested for the patented invention is utility, and this is crucial for understanding invention as technological invention.

[12] Copyright laws, or privileges, emerged before patent laws. However, these concerned printers, not authors. Rights to writers for original work developed after patent laws.

E. Zilsel, in his seminal study on the idea of genius, documented a shift in the idea of genius during the Renaissance. From being applied to the output of the artist, genius became something attributed to the artist as person, a subjectivization of the idea (Zilsel, 1926). However, in the larger context of innovation, as discussed in this paper, it is the opposite which is observed. As patents attest, the qualities previously attributed to the genius or artist (like originality) become those attributed to the commodity. Over time, technological invention obtained a "monopoly" in the vocabulary of invention because of the emerging **culture of things**, or material culture – and patents are witness to this phenomenon. From the Renaissance onward, due to commercial exchanges, exploration and travel (Cook, 2007; Smith and Findlen, 2002), natural and artificial objects have been what is valued in arts, science, and real life.

The culture of things owes its existence to many factors. One such factor is the "consumer revolution" (Berg and Clifford, 1999): the eighteenth century brought new consumer goods to the people. These new goods were a response to expressed needs for a better existence, an old motive, as L. Dresbeck (1979) and L. White (1971) have discussed with respect to the Middle Ages, but also in response to taste (a moral idea, then an aesthetic one), and its manifestation in luxuries and semi-luxuries as novelties (Berg, 1999). The emergence of economic thought in the eighteenth century, with its emphasis on gain, wealth and material prosperity, is witness to this phenomenon (Dumont, 1977). A second factor is what came to be called the "industrial revolution" and the use of technologies as industrial processes (Hudson, 1992). Then, a third "revolution", or innovation, occurred at the end of the nineteenth century and the beginning of the twentieth century: (large) firms began setting up research laboratories as a way to accelerate industrial development (US National Research Council, 1941; Noble, 1977). By 1920, there were approximately 300 industrial research laboratories in the United States alone, and twenty five years later industrial research accounted for more than two-thirds of national expenditures devoted to research and development

(R&D) in many countries. Along with the patent system discussed above, the development of industries based on the research laboratory and the commercialization of technological inventions on a large scale were major factors contributing to a conception of invention as technological invention.

Briefly stated, technological inventions got increased attention because they have **utilitarian** value (Long, 2001; Hilaire-Perez, 2000). They contribute to politics: technology and arts, such as painting, sculpture, and architecture, serve as political and military power, and as manifestations of power (displays of grandeur, wealth and magnificence). They also contribute to "social progress". From the medieval guilds (Epstein, 1988) to the mercantilists (Johnson, 1930), from the Enlightenment to the twentieth century, the literature is full of mentions of progress and utility from technological inventions with regard to contributing to character (virtue) of the individual, to social well-being, and to civilization. Finally, technological inventions as power over nature serve commerce, trade and manufacturing – activities seen positively at the time, as A. O. Hirshman (1977) has documented. From the nineteenth century onward, these beliefs led to narratives on modernity and technologies from everyone: from "ordinary people" to intellectuals (Marx, 1964; Kasson, 1976; Nye, 1997; 2003; Noble, 1998; Hard and Jamison, 1998; Rieger, 2005). However, at the same time, technological inventions have had opponents. The resistance to technology in history has been widely documented. From the industrial revolution in Great Britain to the debate on technological unemployment and displacement in the United States in the 1930s, many workers and their representatives questioned the benefits of machines, and refused, often violently, the introduction of new processes in industry (Stern, 1937; Berg, 1980; Bix, 2000).

Things and utility have a place in science too. First, the new sciences of the seventeenth century increasingly relied on the study of objects of nature. Observation, namely the collection of objects and the compilation of data, and measurement, with techniques or technologies as instruments, are the keywords

here. There is a rehabilitation of curiosity, which was a vice to Augustine (Eamon: 1994 58-66, 301-318), but which became a quality of the *virtuoso*, that is, the cultivated gentleman (Houghton, 1942), giving rise to one of the most central concepts of science, that of objectivity (Harrison, 2001; Daston, 1995). [13] Things like marvels, wonders, rarities and exotics (Daston and Park, 1998) also find a place in cabinets of curiosities, as precursors to museums (Findlen, 1994; Impey and MacGregor, 1985).

Second, there are also calls, for which F. Bacon is the main exponent, for more useful knowledge in science, namely for the mechanical arts and artificial objects. [14] As P. Zagorin put it, "Bacon is famed for his conviction that knowledge brings power and his insistence that the production of works of all kinds for the relief of the human condition is the proper end of knowledge" (Zagorin, 2001: 390). Bacon is followed by R. Boyle as one of the most serious defenders of his views, and by the scientific academies (Briggs, 1991; Ochs, 1985). [15] That machine technology benefits the public and industries becomes an argument for the promotion of science and for securing patronage (Keller, 1972; Stewart, 1998; 1992).

Innovation

Novation is a term that first appeared in law in the thirteenth century. It meant renewing an obligation by changing a contract for a new debtor. The term was rarely used in the various arts and sciences before the twentieth century – although "new" was, as mentioned above. Create and invent were preferred words for man's productive power and abilities. N. Machiavelli (*The Prince*, 1513) and F. Bacon (*Of Innovations*, 1625) are among the very few individuals having

[13] There is very good literature on the history of objectivity from L. Daston, P. Galison, S. Schaeffer and S. Shapin (see also Poovey, 1998; Shapiro, 2000). From this literature, one could develop a genealogical history of objectivity in three steps as follows: curiosity → matters of fact → objectivity.

[14] The fascination with machines entered science very early, via the mechanical philosophy. The metaphor of the clock for explaining different aspects of nature is one of the most well-known examples in the scientific literature.

[15] One should also include here the reformers of learning like S. Hartlib, J. Dury, W. Petty and J. Evelyn in England (Houghton, 1957; Jones, 1936).

devoted early analyses to innovation, using the term as such, and to the resistance of people to innovation. [16] In fact, as with imitation and invention, the term was pejorative for a while. Until the eighteenth century, a "novator" was still a suspicious person, one to be mistrusted. [17]

In this section, I document how innovation gradually came to resolve the tension between imitation and invention, at least at the theoretical level. Until innovation took on a central place in theories on social and economic change, imitation and invention (under different terms, as discussed above) were seen as opposites, as was the case in social practices. In the eighteenth century, for example, originality was contrasted to copying and plagiarism (imitation) in authorship (Woodmansee, 1984; Long, 2001). Equally, under patent laws, property (of the first inventor) gave rise to accusations of theft (imitation) (Macleod, 1988; Hilaire-Perez, 2000).

Similarly, the very first theories on innovation explicitly contrasted imitation to invention. While previous theories of invention were of a "psychological" kind and focused on inspiration, imagination and genius (Bundy, 1927), the end of the nineteenth century saw the emergence of new theories for explaining novelty, and these were of a social kind. The first such theories arose in anthropology.

Anthropology made very few uses of the term innovation. Innovation was nevertheless what anthropologists of the late eighteenth and early nineteenth century studied as **culture change**: changes in culture traits, but also inventions in agriculture, trade, social and political organizations (law, customs, religion, family) and technology. It is impossible to examine all of the voluminous literature produced on culture change in this paper; neither is it possible to analyze to what extent the theories that were produced really studied change as a

[16] On Machiavelli, see Pocock (1975); on Bacon, see Redlich (1954).
[17] See the works on projectors from of D. Defoe (An *Essay On Projects*, 1697) and T. Brugis (*The Discovery of a Projector*, 1641). Project and projectors (merchants) were early terms used for innovation and innovators in mechanics and trade. Complaints against projectors concerned financial schemes (manipulation), mechanical frauds (bad design), stolen or pirated methods, and mismanagement (Cummings and Stewart, 1991).

process. However, one debate deserves mention here. Many anthropologists framed the discussion in terms of invention versus diffusion (as imitation) to explain stages of civilization. This gave rise to what came to be called the diffusion controversy (Smith et al., 1927). On one side were evolutionists, to whom invention stems from multiple centers and occurs independently in different cultures. Parallel inventions, as they were called, reflect the psychic unity of human nature, and differences in culture reflect steps of the same process, or varying speeds of evolution. [18] Primitives were considered to be at an arrested stage of development. An associated discussion here was whether there was convergence between cultures, or divergence. [19]

At the opposite end were diffusionists, to whom man is essentially uninventive. [20] Culture emerges from one center, then diffuses through borrowings, migrations and invasions. [21] This gave rise to a whole literature on culture areas (culture circles in Germany), where diffusion is due to geographic contiguity (O. T. Mason, G. Holmes, A. L. Kroeber and C. Wissler).

Until about the mid-twentieth century, evolutionism was the framework anthropologists used to study culture change. Then acculturation, as the study of cultural change resulting from contacts between different cultures, developed (Redfield et al., 1936; Barnett et al., 1954). Anthropologists stopped looking at diffusion as mere imitation contrasted to invention: diffusion is inventive adaptation. Among anthropologists, one author stands apart: H. G. Barnett

---

[18] Precursors on parallel inventions are evolutionists in archeology (G. de Mortillet) and paleontology (multiple centers, discontinuous invention: R. Owen, G. S. Mivart, H. F. Osborn), historians (W. Robertson on parallel invention, but at different rates), and philologists.

[19] Convergence refers to things originally different that have become the same, and divergence to things originally the same that have become different. For the first discussion of the principle of limited possibilities of divergence, see Goldenweiser (1913).

[20] According to M. Harris (1968), diffusionists were responsible for the invention/diffusion dichotomy in anthropology, while evolutionists (like E. B. Tylor and L. H. Morgan) were said to admit both invention and diffusion. To J. Stewart, there are three dichotomies in the debate: unilinear/multilinear evolution, invention/diffusion, parallel invention/convergence (Stewart, 1955).

[21] Precursors to diffusionism are evolutionists in biogeography (one center, then migration: A. R. Wallace and J. D. Hooker), and biology (C. Darwin and the common ancestor to men).

(Godin, 2009a). Barnett developed a comprehensive theory of innovation, defined as "any thought, behavior, or thing that is new because it is qualitatively different from existing forms" (Barnett, 1953: 7). To Barnett, everyone is an innovator, but he could not find a precise and thoroughgoing analysis of how innovation occurs in the literature. Most studies, he said, concentrated on technological invention – and his use of the term innovation is motivated by the desire to eliminate this bias. From ethnological researches in ethnic groups and religious cults, he developed such a theory. However, Barnett had no followers among anthropologists. We have to turn to sociologists, and then economists, to find the systematic development of studies on innovation.

The first theory of innovation comes from the French sociologist Gabriel Tarde in the late nineteenth century (Tarde, 1890; 1895; 1898; 1902). Tarde's sociology distinguished statics from dynamics, [22] and was interested in explaining **social change** (or social evolution): grammar, language, religion, law, constitution, economic regime, industry and arts. Tarde made widespread use of the term innovation (and novation) as novelty, but with no explicit definition. In fact, he used a whole network of terms to discuss social changes: invention, ingenuity, novelty, creation, originality, imagination, discovery and initiative.

Tarde's theory of innovation was threefold: invention → opposition → imitation. [23] Inventions give rise to imitation – imitations of a limited number of inventions, because of the opposition or competition between the new and the old inventions. [24] The success of an invention (i.e.: imitation) depends on other inventions (or opposition between inventions) and social factors. To Tarde, invention is the combination of previous or elementary inventions (i.e.: imitation). Invention comes from individuals (not necessarily great men), and is socially influenced. To Tarde, invention is the driving force of society, but society is mainly imitative:

[22] With this distinction, Tarde foreshadowed J.A. Schumpeter in economics.
[23] The French sociologist A. Espinas (1897) and his praxeology was a source for Tarde's model of individual initiative followed by imitation in his discussion on animal societies (ants).
[24] On Tarde's theory of opposition, see Tarde (1897).

custom, fashion, sympathy, obedience and education. Imitation is to society what heredity is to biology, and vibration to electricity.

One had to wait for E. M. Rogers (1962) for other such broad theories of innovation in sociology. As to *praxis* in philosophy, and culture change in anthropology, the extent to which sociologists have really studied change is a matter of debate. Certainly, social change has been studied in sociology, from A. Comte, H. Spencer, P. Sorokin and their grand stages theories, then T. Parsons, [25] then studies like social movements as a source of social change, or the study of development in developing countries (Boskoff, 1957). However, to many critics over time sociologists have been concerned with imitation (as socialization) rather than with creative action (Hield, 1954; Joas, 1996). [26] The study of individual creativity was left to psychology. Be it as it may, one thing is sure: sociologists with an interest in technology, to whom we now turn, took change seriously.

What the subsequent theories of innovation have done is put an end to the contrast between imitation and invention. From the 1920s onward, invention came to be understood as a process (both diachronic and synchronic). Theories now combine invention and imitation in a sequence, that is, a linear "model": invention is followed by imitation. The first such theories came from sociologists (Godin, 2009d). The Americans W. F. Ogburn and S. C. Gilfillan were forerunners. Both positioned themselves against the views of anthropology and its theories of evolution by stages, because "the achievements have not been up to the high hopes" and have been disproved (Ogburn, 1922: 57), and against "great men" theories in philosophy and history. To Gilfillan, the great man or genius as hero is

[25] To Parsons, the social sciences may be all classified as "sciences of action".
[26] H. Joas argues that there has been no real theory of creativity in sociology. He is right. To many sociologists, action is rationality rather than creativity. "Creativity" is non-rational: a residual, a deviation But from a genealogical perspective, the authors and the theories Joas discusses (Durkheim, Weber, Tonnies, Simmel, Parsons) are steps or precursors, not "metaphors" as he called them, and should be studied in a genealogical history.

a mythology for historical origin "to increase the cohesion of the group and its loyalty to its living leaders" (Gilfillan, 1935: 77-78). [27]

Ogburn and Gilfillan started looking at inventions, above all technological inventions, as causes of cultural change or social change (social organizations and behaviours). [28] To Ogburn, "the use of material things is a very important part of the culture of any people" (Ogburn, 1922: 4). What he observed was the growth and acceleration of material culture, as would be documented quantitatively by American sociologist H. Hart from the 1930s to the 1960s (Hart, 1931; 1957; 1959), and its enormous consequences on society, or social change, a field he studied for over thirty years. Ogburn developed the concept of the cultural lag to account for this process. There is an increasing lag between the material culture (technology) and the rest of culture (adaptive culture) due to inertia and lack of social adaptation. Hence the need for control and adjustment, forecasting and planning.

To the sociologists, technological invention is a combination of prior art and ideas, and a complex of diverse elements: design, science, material, method, capital, skill and management (Gilfillan, 1935: 6). It is a social process rather than an individual one. Certainly "without the inventor there can be no inventions" (Gilfillan, 1935: 78), but "the inventors are not the only individuals responsible for invention" (Gilfillan, 1935: 81). Social forces like demographic (race) and geographic factors, and "cultural heritage" play a part. Secondly, technological invention is social in a second sense: it is cumulative (or evolutionary), namely the result of accumulation and accretion of minor details, modifications, perfectings, and minute additions over centuries, rather than a one-step creation

[27] The role of genius in civilization was an idea widely debated in philosophy (W. James *versus* G. Allen), in history (T. Carlyle *versus* the Spencerians, the Hegelians and the Marxists), in science (F. Galton on heredity *versus* A. de Candolle), and Tarde has previously positioned himself on the question. In anthropology, it was discussed in terms of great civilizations and the diffusion of culture to other parts of the world.

[28] To anthropologists, technology is rather an effect (a sign of civilization) to be explained.

(Gilfillan, 1935: 3). [29] Finally, technological invention is social in a third sense: it is more and more systematic. It comes from organized research laboratories specifically dedicated to this end. Recalling industrialists' discourses of the time, the sociologists observed a movement from the independent inventor to organized research in industrial laboratories (Gilfillan, 1935: 52-54, 63; Hart, 1931: 552-562).

What place does the term and category of innovation take in sociological theories? In studying the literature, one observes a move from multiple terms used interchangeably to innovation according to an implicit definition, then to explicit definitions. In the voluminous literature produced by Ogburn, the most frequent terms are the combined one invention/discovery and technology. There is no use of the term innovation until it appears occasionally in both a paper from 1941 (Ogburn, 1941: 3, 14, 18) and the 1950 edition of *Social Change* (Ogburn, 1950: 378), and then in the title of a chapter (plus p. 710) from the fourth edition of *Sociology* (Ogburn and Nimkoff, 1964). Gilfillan made no use of the term, but twice (Gilfillan, 1935: 59; Gilfillan, 1937: 20). In the meantime, however, the term began to appear among other sociologists, at first concurrently with other terms, like invention and technological change (Stern, 1927, 1937; Chapin, 1928; Davis, 1940). Then one finds more widespread use of the term (Hart, 1931; Nimkoff, 1957), and entire theories devoted to innovation (Rogers, 1962).

Innovation, in the hands of Ogburn and his contemporaries, meant many things. One was simply novelty. In this sense, the use of the term is rare, and is without real consequences for sociological theories. A second meaning is social change (Stern, 1927), and this meaning includes more than technological invention, that is, *social invention* as repeatedly suggested by Ogburn and some others (Bernard, 1923; Chapin, 1928; Weeks, 1932), [30] or *social experiments* (Chapin, 1917).

[29] In sociologists' hands, this idea became a *leitmotif*, although one had to wait until the 1980s and after for empirical studies of what came to be called technological "development". For an early discussion of technological development among sociologists, see Jewkes et al. (1958: chapter 8).
[30] See also the (short-lived) literature on "technicways": Odum (1937), Davis (1940).

However, with time, Ogburn and others focused more on technological invention. A third meaning is the use of (technological) inventions and their social effects (Stern, 1937). This gave rise to studies on diffusion and to a whole literature, often of a quantitative nature, with geometrical laws of diffusion (Chapin, 1928). This meaning of innovation as technological **invention used and adopted** is the common sociological understanding of innovation, although a fourth meaning would soon be used as well, following the economists' definition (see below): technological invention as commercialized by industry (Jewkes et al. 1958).

Despite this understanding, explicit definitions of innovation are rare among sociologists. The early few definitions that exist differ considerably. Certainly, they all refer to the idea of novelty, but they differ in the sense that some include the act itself (combination), others the impacts of innovation, still others the subjective perception of it:

- Hart (1931): making new working adjustments (combination) among material and socio-psychological culture
- Ogburn (1941): inventions that have served to transform the environment profoundly
- Rogers (1962): an idea, procedure or object perceived as new by its adopter

What characterizes the sociological literature is that innovation is described as an activity and as a process where both the production of an invention and its use are discussed rather than contrasted (Nimkoff, 1957). Invention and imitation (as adoption or diffusion) are steps in a linear sequence (see Table 1).

Innovation as process is also how economists understand the term. However, economists add their own stamp to the idea: innovation is the commercialization of (technological) invention. And unlike the definitions of sociologists, this

definition came with time to be accepted among economists, and by others, including the sociologists.

Table 1.
Sociologists' Sequential Theories of Innovation

Tarde (1890)	New ideas (oppositions), combination (unconscious, then conscious), imitation
Ogburn (1920)	Invention (and diffusion), maladjustment (lag)/adjustment
Bernard (1923)	Formula, blue print, machine [31]
Chapin (1928)	Invention, accumulation, selection, diffusion
Ogburn and Gilfillan (1933)	Idea, trial device (model or plan), demonstration, regular use, adoption
Gilfillan (1935)	Idea; sketch; drawing; model; full-size experimental invention; commercial practice
US National Resources Committee (1937)	Beginnings, development, diffusion, social influences
Ogburn (1941)	Idea, plan, tangible form, improvement, production, promotion, marketing, sales
Ogburn (1950)	Invention, accumulation, diffusion, adjustment
Rogers (1962)	**Innovation**, communication (or diffusion), consequences on the social system, and consequences over time
Rogers (1983)	Needs/problems, research, development, commercialization, diffusion and adoption, consequences

The study of change is not the traditional concern of economics. Historically, economics is concerned with equilibrium rather than dynamics (Veblen, 1898; Weintraub, 1991). Although the concepts of work (labour), production and growth held central place in early economic theories, the study of economic change is not a fundamental concept in economics, as culture change is in anthropology or as social change is in sociology. Change really got into economics with the study of technology as a cause of economic growth. Karl Marx was a forerunner here (Rosenberg, 1976a; Sweezy, 1968). To Marx,

[31] For social invention, the stages are: theory, rules, organizations and institutions.

changes in techniques of production gave rise to modern industry. Machines gave rise to 1) the capital-goods sector, and to 2) increases in productivity in other sectors of the economy. Machines were also a major factor in social change, through crisis, then through revolution.

However, it is to neo-classical economists that we owe the first interest in technological innovation, then called **technological change,** as the use of technological inventions in industrial processes. This literature is often minimized and contrasted to the later literature from evolutionary economists. However, from a genealogical point of view, this literature was a first step toward the study of technological innovation in economics. It was here that (some) interest in technology began among economists.

In the 1920s and 1930s, classifications of technologies as labour-saving, capital-saving or neutral appeared as part of larger discussions on economic theory (Pigou, 1924: 629-638; Hicks, 1932: 121-125; Robinson, 1938). The theoretical discussions of the time were very brief (with the exception of Cambridge economist J. Robinson), until resurrected in the 1960s under the name "induced innovation". In fact, the literature on induced innovation is probably the first to make extensive use of the term innovation in economics. In the meantime, and as the issue of technological unemployment gained importance in public discussions, the study of technology developed in the 1930s via the measurement of productivity: increases in productivity as an indicator of technology usage. Many quantitative studies were published by the US National Bureau of Economic Research (F.C. Mills, H. Jerome) and public organizations like the US Bureau of Labor Statistics and the US Work Projects Administration. Subsequently, formalization of the measurement developed through what was called the production function.

The production function is an equation suggested in the late 1920s that links the quantity produced of a good (output) to quantities of inputs (Cobb and Douglas,

1928; Douglas, 1948). There are at any given time, or so argue economists, inputs (labour, capital) available to the firm, and a large variety of techniques by which these inputs can be combined to yield the desired optimal output. The production function came to be interpreted as representing technological change, a precursor term to technological innovation in economics. Economists interpreted movements in the curve of the production function as technological change (the substitution of capital for labour), while others equated labour productivity with technology (technological change is likely to result, all other things being equal, in increased labour productivity), paving the way for R. Solow's influential paper which equated the residual in the production function with technology (Solow, 1957). Then economists started correlating R&D with productivity measures. Beginning in the late 1950s, a whole literature developed, analyzing the contribution of research to industrial development, and to performance and economic growth, first from neoclassical economists (US National Bureau of Economic Research, 1962), then evolutionary economists (Freeman, 1974; Dosi et al., 1988; Nelson and Winter, 1982).

The term technological change, already used by sociologist B. J. Stern in 1937, was popularized by economic historian W. R. Maclaurin from MIT in his pioneering program of research into the economics of technological change in the 1940s and 1950s (Godin, 2008b). Before Maclaurin, the term technological change appeared sporadically in the economic literature, together with technological (or technical) progress or advancement, and meant the substitution of capital for labor as factors in industrial production. In the late 1930s, the US Works Projects Administration, as part of a project on Reemployment Opportunities and Recent Change in Industrial Techniques, started using the term technological change regularly to discuss changes in employment due to technology. Then in the early 1940s, Maclaurin gave the term a new meaning concerned with the development and commercialization of new products, rather

than the use of technical processes in production. [32] By the early 1950s, Maclaurin was using both the term technological change and technological innovation. This would characterize the literature for the coming decades.

It is through evolutionary economics, among them J.A. Schumpeter, that innovation really got into economics. To Schumpeter, capitalism is creative destruction: disturbance of existing structures, and unceasing novelty and change (Schumpeter, 1928; 1942; 1947). In his view, innovations are responsible for this phenomenon. Schumpeter identified five types of innovation (Schumpeter, 1912: 66) – in fact, this classification comes from D. Ricardo: [33] 1) introduction of a new good; 2) introduction of a new method of production; 3) opening of a new market; 4) conquest of a new source of supply of raw materials or half-manufactured goods; and 5) implementation of a new form of organization.

Part of the explanation for the use of the term innovation in the economic literature has to do with a reaction against historians and against the term invention. Schumpeter distinguished innovation from invention. To Schumpeter, "innovation is possible without anything we should identify as invention and invention does not necessarily induce innovation" (Schumpeter, 1939: 84). Invention is an act of intellectual creativity and "is without importance to economic analysis" (Schumpeter, 1939: 85), while innovation is an economic decision: a firm applying an invention or adopting an invention. [34] However, it took time for the term to gain acceptance. In the early 1960s, the term was still not widely accepted. To economist F. Machlup, "we shall do better without the word innovation" (Machlup, 1962: 179). To others, the term is in need of a more rigorous definition, because it "has come to mean all things to all men" (Ames, 1961: 371). In the 1970s, the skepticism continued: the "use of the term

[32] Nevertheless, for many years most economists continued to focus on technological change as processes (used in production), rather than as products (for final consumption).
[33] On some of Schumpeter's borrowing from the German and Austrian economic literature, see Streissler (1994) and Reinert (2002).

innovation is counterproductive", claimed the authors of a survey conducted for the US National Science Foundation, because each individual has his or her interpretation (Roberts and Romine, 1974: 4). [35] For many years, the terms used in the economic literature were rather invention, technological change (and its variants: technical advance and technical progress) and sometimes automation.

Schumpeter is usually credited in the economic literature, particularly by evolutionary economists, as being the first theorist on **technological innovation**. This deserves qualifications. Certainly, Schumpeter did develop influential ideas on technological innovation as a source of business cycles, for example. However, Schumpeter did follow the literature on technological change and the production function for defining technological innovation as new combinations of means of production: innovation as change in the factors of production (input) to produce products (output) (Schumpeter, 1939: 87s; Lange, 1943). Second, as Maclaurin (1953) has stated, Schumpeter never developed a theory of technological innovation. To Schumpeter, the entrepreneur (and, in a next stage, the large firm) is responsible for technological innovation. But how?

The story of technological innovation in economics is rather the following. In the 1920s, industrialists put the research laboratory into public discourses: organized research, as contrasted to the individual inventor, was said to be the prime mover of industrial development, or evolution as many called it (Godin, 2008a). In their efforts to convince more firms to invest in research, the industrial pioneers were supported by industrial associations, governments and many organizations, among them the Department for Scientific and Industrial Research in Great Britain and the National Research Council in the United States. The rise of industrial research led to annual conferences for managers from the 1920s, and to the emergence of theories on the management of research (Mees, 1920). Economic study of

[34] Ten years earlier, the British economist and civil servant Josiah Stamp made a similar distinction (Stamp, 1929; 1934). For the distinction among German and Austrian economists prior to Schumpeter, like A.F. Riedel, see Streissler (1994).

industrial research and the commercialization of inventions had to wait for the economic historian Maclaurin, as the very first theorist on technological innovation (Godin, 2008b). Studying technological change in its economic dimensions was the task to which Maclaurin devoted himself entirely from the early 1940s onward. To Maclaurin, the study of technological change is concerned with factors responsible for the rate of technological development in industry, and for conditions that are more conducive to technological progress. From historical analyses of how the process of technological change takes place, Maclaurin broke down this process into distinct and sequential steps, from fundamental research to production engineering, and then to diffusion.

Over time, authors from business schools and economists developed theories or conceptual models of technological innovation as a process from invention to diffusion, similar to those of the sociologists (see Table 2). [36] In these theories, technological innovation was defined as a step (the ultimate step) of a process starting with invention – and defined as **commercialized innovation**. The formal definition of this comes from Maclaurin, originally as the first commercialization of a new or improved product or process (Maclaurin, 1953: 105) – then as the whole process, from invention to commercialization to diffusion.

[35] The same diversity of opinions characterizes the responses to current surveys of innovation from national statistical bureaus.

[36] The steps in the theories of Table 2 vary from psychological steps to organizational steps (development of new products) to economic steps (production and diffusion).

Table 2.

Management and Economists' Sequential Theories of Technological Innovation

Mees (1920)	Pure science, development, manufacturing
Epstein (1926)	Idea, sketch, drawing, test, use
Holland (1928)	Pure science research, applied research, invention, industrial research [development], industrial application, standardization, mass production
Usher (1929)	Elaboration of the concept, primary synthesis, critical revision [37]
Jewett (1932)	Plan (design), control (tests), preliminary small-scale operation, tool-made model, large scale production
Stevens (1941)	Fundamental research, applied research, test-tube or bench research, pilot plant, production (improvement, trouble-shooting, technical control of process and quality)
Bichowsky (1942)	Research, engineering (or development), factory (or production)
Furnas (1948)	Exploratory and fundamental research, applied research, development, production
Maclaurin (1949)	Fundamental research, applied research, engineering development, production engineering, service engineering
Mees and Leermakers (1950)	Research, development (establishment of small-scale use, pilot plant and models), adoption in manufacturing
Brozen (1951a)	Invention, **innovation**, imitation
Brozen (1951b)	Research, engineering development, production, service
Maclaurin (1953)	Pure science, invention, **innovation**, finance, acceptance
Usher (1954, 1955)	Perception of an unsatisfied need, setting of the stage, primary act of insight, critical revision and development
Ruttan (1959)	Invention, **innovation**, technological change
Ames (1961)	Research, invention, development, **innovation**
Scherer (1965)	Invention, entrepreneurship, investment, development
Schmookler (1966)	Research, development, invention
Mansfield (1968)	Invention, **innovation**, diffusion
Myers and Marquis (1969)	Problem solving, solution, utilization, diffusion
Utterback (1974)	Generation of an idea, problem-solving or development, implementation and diffusion

[37] This was only one of Usher's descriptions of the process. Others are: 1) technologies, consequences, adaptation; 2) discoveries and inventions, synthesis (concept, device), construction (design); 3) problem, setting of the stage, achievement (configuration).

In referring to diffusion, the term imitation continued to be used until the 1980s in the economic literature among its most serious students (Brozen, 1951; Mansfield, 1961; Schmookler, 1966; Rosenberg, 1976b; Nelson and Winter, 1982), while the term was no longer used by sociologists after Tarde, who turned to the term diffusion. However, to many economists, imitation or diffusion had a low status in the study of technological innovation. Then evolutionary economists got more and more interested in the diffusion of technology from the 1980s onward. A series of studies appeared suggesting that diffusion was as important to economic progress as invention itself, if not more so.

Theories combining both production (of goods) and distribution have a long history in economic thought, from Quesnay's *tableau économique* to A. Smith, D. Ricardo and K. Marx, then the System of National Accounts. Now, such theories are applied to technological innovation. The most popular and influential is what came to be called the "linear model of innovation" (Godin, 2006c). The theory suggests that technological innovation starts with basic research, then goes through applied research, then development, and then production and diffusion. Such an understanding of technological innovation has been very influential on science policy since 1945.

While innovation as technological innovation and as commercialized innovation came to dominate the economic literature, other conceptions of innovation developed elsewhere. One is that from psychologists, with the concept of **creativity**. A genealogy of the concept would have to look at genius, then talent (or ability), then intelligence, then creativity. As mentioned above, the very early studies on imagination from the Middle Ages to the Enlightenment were psychological in kind. However, it was only in the mid-1900s that psychologists themselves started studying creativity (Guilford, 1950). The word creativity itself emerged at about this time, although create and creation had existed for centuries, as the literature on poetry and art attests (Tatarkiewicz, 1980), and creativeness emerged in 1820.

To the psychologists, "eminent men", artists, inventors and scientists, were perfect representatives of creative individuals or geniuses. Here creativity was defined by way of measurement: measuring the attitudes of individuals and performances to test scores, but also, increasingly, counting the volume of output produced, or *productivity*. Beginning with H. Nelson's study, the period in which an individual is more productive (the "creative years" as it was called) became a serious topic of discussion (Nelson, 1928). The most active psychologists here were A. Roe, C. W. Taylor, M. I. Stein, H. C. Lehman and W. Dennis. Creativity as productivity gave rise to a whole literature on the counting of scientific papers produced by scientists (Godin, 2006a). In the 1950s and subsequently, sociologists also got into the study of scientific productivity and its relationship to recognition and the reward system (B. N. Meltzer, D. Crane, H. Zuckerman and R. K. Merton, S. Cole and J. S. Cole, P. D. Allison, J. S. Long, J. S. Scott). Then the field of bibliometrics developed.

Many of the psychologists' studies of innovation as creativity focused on the study of creativity of personnel in organizations. A favorite study group was scientists and engineers. [38] These studies were generally funded by government departments, for example the US Office of Naval Research, the Air Force, NASA, the US National Institute of Health, and by industries and their associations like the US Industrial Research Institute.

As another facet of innovation, management and business schools developed the study of **organizational innovation**. Following Schumpeter, entrepreneurial change became a topic of study for which whole programs of research developed, for example that of A. H. Cole's Research Center in Entrepreneurial History (1948-58) at Harvard University (Cole, 1959; Aitken, 1965). Second, the study of innovative behaviours of organizations developed, such as organizational

[38] The first "psychological" theories on technological inventors are from economic historian A. P. Usher (1929), and from US patent examiner J. Rossman (1931).

structure and management style, mainly following T. Burns and G. M. Stalker (Burns and Stalker, 1961; Hage and M. Aiken, 1970; Zaltman et al., 1973). Third, the management of research and technological activities gained increased attention because they contribute to firms' performance (productivity, profits, market share). In this context, innovation came to be understood as *efficiency*: value for money, or the output coming from investments in R&D. As with scientific productivity, technological productivity, or the volume of technological inventions coming from laboratories, became a subject of study in its own right.

Again, psychologists were among the firsts to get into this kind of study (Pelz and Andrew, 1966; Myers and Marquis, 1969). However, it is to the management of technology (previously called the management of scientific research), from accounting (Anthony and Day, 1952) to research evaluation (Rubenstein, 1957; Quinn, 1959; 1960; Hodge, 1963; Horowitz, 1963; Yovits et al., 1966; Lipetz, 1965; Seiler, 1965; Dean, 1968), that we owe the study of innovation as efficiency. Researchers began looking at the organizational climate and conditions most conductive to scientific and technological productivity, and at the incentives required to encourage creativity. [39] Creativity and productivity became one. In fact, in the 1960s creativity had become a buzzword, and came to be applied to many facets of industrial research (Steiner, 1965). [40]

What role did policy play in all this? A major one, indeed. Over the twentieth century, innovation was in fact a policy-driven concept. Psychologists, sociologists and researchers from management, business schools and economics acted as consultants to governments, and were concerned with offering policy recommendations for "social engineering" and economic growth based on their theories, the more recent ones being conceptual frameworks like the knowledge-based economy, the information economy, the new economy, and national innovation system (Godin, 2009b). Over the last sixty years, economists have

[39] On a very early survey of industrial incentives to invention, see Rossman (1935).

been the experts most solicited by governments. The first among the consulting experts were researchers from RAND (Hounshell, 2000), then the Science Policy Research Unit (SPRU) at Sussex University, Brighton, UK. In the 1990s, centers on innovation multiplied, such as the Maastricht Economic Research Institute on Innovation and Technology (MERIT) in the Netherlands.

Innovation is also a political concept in another sense. From its very beginning in the 1960s, science policy has been concerned with funding scientific research, with technological innovation as the expected *output* (Godin, 2009c; 2007b). Over time, the terms used came to reflect this very first goal. What was called science policy in the 1960s became science and technology policy in the 1970s, then innovation policy in the 1990s (Lundvall and Borras, 2005; Branscomb and Keller, 1998: chapters 5 and 18).

In this quest for technological innovation, statistics has been the best way to establish evidence. In the academic literature, technological innovation began to be measured via patents in the 1910s, culminating in the works of economist J. Schmookler in the 1950s (Schmookler, 1966). Then, it appeared to many that patent counts measure invention, not (commercialized) innovation. Then expenditures devoted to R&D came to be used as a proxy, thanks to the systematic data collected in the then recently-launched survey series from the US National Science Foundation. This practice then spread to other countries (Godin, 2005). This is not a bad proxy in reality, since two-thirds of R&D expenditures are devoted to the D (development of new technologies) (Godin, 2006b). Yet an official study concluded otherwise. In 1967, the US Department of Commerce published a study, known as the Charpie Report, which was the first governmental survey of technological innovation *per se* (US Department of Commerce, 1967). It showed that R&D does not constitute the main source of technological innovation. In light of the literature on technological innovation from the 1980s

[40] By the third edition of his book (1964), first published in 1931, J. Rossman added *Industrial Creativity* to the previous title *The Psychology of the Inventor*.

onward (Freeman, 1994), it appears that the study was correct. But at the time, it was criticized by economists and statisticians (Mansfield, 1971; Stead, 1976), among other things because the numbers on which it relied were "rule of thumb figures", so qualified by the authors of the study themselves. Nevertheless, the report was quite influential. It contributed to conventionalizing a definition of innovation as technological innovation and as a process leading to commercialized innovation. More than twenty years later, the OECD published the first edition of a methodological manual for measuring innovation, known as the Oslo Manual (OECD, 1991), which used essentially the same definition as that in the Charpie Report. The manual, now in its third edition, serves national statisticians in surveying firms and their innovation activities in a standardized manner.

Conclusion

In its history, innovation has been broadly conceived and defined. Innovation concerns any kind of novelty: artistic, scientific, technological, organizational, cultural, social or individual. As the American anthropologist O. T. Mason put it in 1895, "invention is finding out originally how to perform any specific action by some new implement, or improvement, or substance, or method (…). Every change in human activity, made designedly and systematically, appears to be an invention" (Mason, 1895: 13-14). To Mason, invention "consists in things and institutions, mental acts involved, rewards and benefits, powers and material of nature invoked" (Mason, 1895: 7; 15). It includes "not only things, but languages, institutions, aesthetic arts, philosophies, creeds, and cults" (Mason, 1895: 410).

Innovation, broadly defined, has given rise to many theories and has been recognized as a key characteristic of the artist (A. Shaftesbury, W. Wordsworth, S.T. Coleridge), the scientist (C. S. Pierce), the inventor (A. P. Usher), the entrepreneur and the firm (J.A. Schumpeter). Innovation has also to a certain extent been recognized as a key characteristic of the individual – in psychology, if

not in philosophy and sociology. Some biologists even attribute innovation to animals (Reader and Laland, 2003), as H. Bergon attributed it to nature in *L'Évolution créatrice*, published one hundred years ago (1907).

Over this same history, innovation came to be defined as **useful** innovation. According to the sociologist, when used and adopted, an invention becomes an innovation; to the economist, invention is innovation when commercialized. Here, the focus of both sociologists' and economists' theories was technological innovation. In the collective imaginary, in public representations and in policy, innovation came spontaneously to be identified with technological innovation. Many factors contributed to this move: the political and economic context, the industrial and consumer revolutions, the impacts of technologies on individuals and societies, technology as a source of economic growth and productivity and, above all, the institutionalization of technological invention via patent laws, and industrial development through R&D laboratories. To many, innovation thus became an industrial and economic affair. The innovation surveys conducted by governments, of which the OECD Oslo Manual is the emblem, are witness to this orientation: the measurement of innovation concerns innovation in firms only.

Evolving Conception of Innovation

1. Imitation
2. Invention
3. Discovery
4. Ingenuity
5. Creation
6. Cultural Change
7. Social Change
8. Creativity
9. Organizational Change
10. Technological Change
11. Technological Innovation
12. Commercialized Innovation

One observes a dialectics here between reality and language. Novelties, events and changes in the world give rise to new categories. For example, the material culture contributed to a representation of innovation as technological and commercialized invention. In turn, categories, as part of representations, discourses, laws and policies, theories and statistics make events visible, bring to light novelties and changes in the world, and contribute to these changes: the category innovation contributed to convincing more firms to invest in research and governments to fund research activities.

Innovation as a (widely-used) category during the twentieth century is witness to a certain context or era - capitalism - and to changes in political values. As J. Farr put it, "to understand conceptual change is in large part to understand political changes" (Farr, 1989: 25). Until early in the twentieth century, invention, ingenuity and imagination were discussed as symbols of civilization and as attributes of geniuses, and their contribution to the progress of the race. Then, the growing role of organizations in the twentieth century led to changes in values. If there was to be increasing economic efficiency, there had to be innovation - through organizations and the mobilization of their employees' creative abilities. [41] Such were the discourses of managers as well as policy-makers. Theorists from many disciplines started studying innovation in terms of the effects of technological innovation on the economy and society. To sociologists, gone was the lonely inventor as a hero or genius. It was a myth created by past authors. Innovation is rather a social process. To economists, gone was invention without market value. It is a subject for the historian. To the policy-maker, gone was (or should be) research with no application. The golden age between the state and the funding of the basic scientist, although short-lived, is finished. Innovation as a category in the twentieth century expresses precisely these political changes: a demarcation with past understandings, values and practices. The category's previous meanings or predecessors (invention, ingenuity, imagination, etc.) came to be subsumed under "innovation", and the creative abilities of an individual

[41] For a similar shift in context and its impact on statistics on science, see Godin (2007a).

placed in the service of organizations, industrial development and economic growth.

Innovation is the last of a series of terms imagined to give meaning to modern practices. Certainly, innovation is, to a certain extent, continuity with the past, in the sense that more often than not it refers to technological invention. However, it is also a break with the past: invention *per se* is not enough. In fact, many ideas and inventions fail, according to the history of technology. There has to be use of the invention, namely innovation, in order for benefits to accrue. This is the first aspect of the break. Another concerns the production of invention. While it was the individual, or genius, who was the source of invention in previous representations, innovation places emphasis on the firm. And there is a third aspect of the break: benefits deriving from invention concern economics, not culture or civilization.

There are now many people trying to broaden the understanding of innovation as technological innovation. One now hears discourses on "social innovation", meaning either major advances in the social sciences (Deutsch et al., 1971; 1986), or policy/organizational reforms for the betterment of society, or solutions to social problems coming from the community sectors (Mulgan et al., 2007; Goldenberg, 2004). [42] Calls for "open innovation" and for "democratizing innovation" are in the same vein: technological innovation comes from many sources, not only the research laboratory, but also users (Chesbrough, 2003; Hippel, 2005). One also hears discourses on the "creative class", which includes the "bohemians" such as artists and designers (Florida, 2002), and the "creative industries", as a category in need of statistical, economic and policy recognition (Bakhshi et al., 2008). The OECD Oslo Manual itself, in its latest edition, has broadened the definition of innovation to include organizational and marketing innovation, although this is limited to firms.

[42] Recently, R. R. Nelson has re-labeled "institutions" as "social technologies" (Nelson, 2008; Nelson and Sampat, 2001). Nelson's "rhetorical move" is motivated (to my mind) by his

Whether these ideas will have an impact on the current understanding of innovation remains to be seen. For the moment, they certainly contribute to extending the discourses on, and the fascination with, innovation to more spheres of society, and mobilizing more people in the name of innovation.

---

insistence on trying to persuade economists to better integrate the role of institutions in economic theories. The term "technology" may convince economists more than "institution" does.

Appendix.

The Vocabulary of Innovation

(ACT)	(SOURCE)	(EFFECTS)
Imitation	Inspiration	Culture
Invention	Ingenuity	Civilization
Discovery	Curiosity	Evolution
Experiment/Investigation	Imagination	Modernity/Progress
Initiative	Reason (logic)	Advancement
Praxis/action		Improvement
Change	Associated terms: originality, freedom, expression	Development
Creation/Creativity		Revolution
Novation/Innovation		Novelty

(TECHNOLOGICAL OBJECTS)		
Art/craft	Craftsman	Useful
Artificial	Artisan	Practical
Project	Projector	Improvement
Mechanics	Merchant	Growth/Productivity
Machine/Machinery	Technician	Performance
Tool/Instrument/	Engineer	Competitiveness
Device/Engine	Entrepreneur	Leadership
Technique	Business/Industrious	Benefits
Technology	Laboratories	Gain
Automation/Mechanization		Output
Capital/Equipment		Efficiency/
Production		Effectiveness
Product/Process		Power/safety/
Methods		Comfort
Fabricating/Making		Prosperity
Constructing/Manufacturing		Well-being/
Applications		Wealth
		Returns
		Employment
		Savings
		Standards (or conditions) of living
		Leisure

References

Abrams, M. H. (1953), *The Mirror and the Lamp: Romantic Theory and the Critical Tradition*, Oxford: Oxford University Press.

Aitken, H. G. J. (1965), *Explorations in Enterprise*, Cambridge (Mass.): Harvard University Press.

Ames, E. (1961), Research, Invention, Development and Innovation, *American Economic Review*, 51 (3), pp. 370-381.

Anthony, R. N., and J. S. Day (1952), *Management Controls in Industrial Research Organizations*, Boston: Harvard University

Arendt, H. (1958), *Condition de l'homme moderne*, Paris: Calmann-Lévy, 1983.

Arendt, H. (1963), *On Revolution*, Bungay, Suffolk: Penguin Books, 1965.

Bakhshi, H., E. McVittie and J. Simmie (2008), *Creating Innovation: Do the Creative Industries Support Innovation in the Wider Economy?*, London: National Endowment for Science, Technology and the Arts (NESTA).

Bannet, E. (2007), Quixotes, Imitations, and Transatlantic Genres, *Eighteenth-Century Studies*, 40 (4), pp. 553-569.

Barber, B. (1961), Resistance by Scientists to Scientific Discovery, *Science*, 134 (3479), September 1, pp. 596-602.

Barnett, H.G., L. Broom, B.J. Siegel, E.Z. Vogt and J.B. Watson (1954), Acculturation: An Exploratory Formulation, *American Anthropologist*, 56 (6), pp. 973-1000.

Barnett, H.G. (1953), *Innovation: the Basis of Cultural Change*, New York: McGraw Hill.

Benhamou, R. (1991), Imitation in the Decorative Arts of the Eighteenth Century, *Journal of Design History*, 4 (1), pp. 1-13.

Beniger, J.R. (1986), *The Control Revolution: Technological and Economic Origins of the Information Society*, Cambridge (Mass.): Harvard University Press.

Bensaude-Vincent, B., and W. R. Newman (2007), *The Artificial and the Natural: An Evolving Polarity*, Cambridge (Mass.): MIT Press.

Berg, M. (2002), From Imitation to Invention: Creating Commodities in Eighteenth-Century Britain, *Economic History Review*, LV (1), pp. 1-30.

Berg, M. (1999), New Commodities, Luxuries and their Consumers in Eighteenth-Century England, in M. Berg and H. Clifford (eds.), *Consumers and Luxury: Consumer Culture in Europe, 1650-1850*, Manchester: Manchester University Press, pp. 63-85.

Berg, M. (1980), *The Machinery Question and the Making of Political Economy, 1815-1848*, Cambridge: Cambridge University Press.

Berg, M., and H. Clifford (eds.) (1999), *Consumers and Luxury: Consumer Culture in Europe, 1650-1850*, Manchester: Manchester University Press.

Bergson, H (1907), *Creative Evolution*, New York: Dover, 1998.

Bernard, L. (1923), Invention and Social Progress, *American Journal of Sociology*, 29 (1), pp. 1-33.

Bernstein, R. (1971), *Praxis and Action: Contemporary Philosophies of Human Activity*, Philadelphia: University of Pennsylvania Press.

Biagioli, M., and P. Galison (eds.) (2003), *Scientific Authorship: Credit and Intellectual Property in Science*, New York: Routledge.

Bichowsky, F. R. (1942), *Industrial Research*, New York: Chemical Publishing.

Bix, A. S. (2000), *Inventing Ourselves Out of Jobs? America's Debate Over Technological Unemployment, 1929-1981*, Baltimore: Johns Hopkins University Press.

Bock, K. (1978), Theories of Progress, Development, Evolution, in T. Bottomore and R. Nisbet (eds.), *A History of Sociological Analysis*, New York: Basic Books, pp. 39-79.

Bond, D. F. (1937), The Neo-Classical Psychology of the Imagination, *English Literary History*, 4 (4), pp. 245-264.

Bond, D. F. (1935), Distrust of Imagination in English Neo-Classicism, *Philological Quarterly*, 14 (1), pp. 54-69.

Boskoff, A. (1957), Social Change: Major Problems in the Emergence of Theoretical and Research Foci, in H. Becker and A. Boskoff (eds.), *Modern Sociological Theory*, New York: Holt, Rinehart and Winston, pp. 260-302.

Bowler, P. J. (1983), *Evolution: the History of an Idea*, Berkeley (Calif.): University of California Press.

Bowler, P. J. (1989), *The Invention of Progress*, Oxford: Basil Blackwell.

Bowler, P. J. (1993), *Biology and Social Thought, 1850-1914*, Office for History of Science and Technology, Berkeley: University of California.

Branigan, A. (1981), *The Social Basis of Scientific Discoveries*, New York: Cambridge University Press.

Branscomb, L. M., and J. H. Keller (eds.) (1998), *Investing in Innovation: Creating Research and Innovation Policy that Works*, Cambridge (Mass.): MIT Press.

Briggs, R. (1991), The Académie Royale des Sciences and the Pursuit of Utility, *Past and Present*, 131, pp. 38-88.

Brozen, Y. (1951a), Invention, Innovation, and Imitation, *American Economic Journal*, May, pp. 239-257.

Brozen, Y. (1951b), Research, Technology and Productivity, in L. R. Tripp (ed.), *Industrial Productivity*, Industrial Relations Research Association, Champaign, Illinois: 25-49.

Bundy, M. W. (1930), Invention and Imagination in the Renaissance, *Journal of English and German Philology*, 29, pp. 535-545.

Bundy, M. W. (1927), *The Theory of Imagination in Classical and Medieval Thought*, University of Illinois Studies in Language and Literature, 12, Urbana: Illinois.

Burns, T., and G. M. Stalker (1961), *The Management of Innovation*, London: Tavistock Publication.

Bury, J.B. (1932), *The Idea of Progress*, New York: Macmillan.

Cambrosio, A., P. Keating and M. Mackenzie (1990), Scientific Practice in the Courtroom: The Construction of Sociotechnical Identities in a Biotechnology Patent Dispute, *Social Problems*, 37 (3), pp. 293.

Cassirer, E. (1932), *The Philosophy of the Enlightenment*, Princeton: Princeton University Press, 1951.

Chandler, A.D. (1977), *The Visible Hand: The Managerial Revolution in American Business*, Cambridge (Mass.); Harvard University Press.

Chandler, A.D. (1990), *Scale and Scope: The Dynamics of Industrial Capitalism*, Cambridge (Mass.): Harvard University Press.

Chapin, F. S. (1928), *Cultural Change*, New York: The Century Co.

Chapin, F. S. (1917), The Experimental Method and Sociology, *The Scientific Monthly*, pp. 133-144 and 238-247.

Chesbrough, H. (2003), *Open Innovation: the New Imperative for Creating and Profiting from Technology*, Boston: Harvard Business School Press.

Clark, D. L. (1951), Imitation: Theory and Practice in Roman Rhetoric, *Quarterly Journal of Speech*, 37 (12), pp. 11-22.

Clifford, H. (1999), Concepts of Invention, Identity and Imitation in the London and Provincial Metal-Working Trades, 1750-1800, *Journal of Design History*, 12 (3), pp. 241-255.

Close, A.J. (1969), Commonplace Theories of Art and Nature in Classical Antiquity and in the Renaissance, *Journal of the History of Ideas*, 30 (4), pp. 467-486.

Cobb, C. W., and P. H. Douglas (1928), A Theory of Production, *American Economic Review*, 18, March, pp. 139-165.

Cohen, I. B. (1985), *Revolution in Science*, Cambridge (Mass.): Belknap Press.

Cohen, W.M., and D.A. Levinthal (1990), Absorptive Capacity: A New Perspective on Learning and Innovation, *Administrative Science Quarterly*, 35, pp. 128-152.

Cole, A. H. (1959), *Business Enterprise in its Social Setting*, Cambridge (Mass.): Harvard University Press.

Cole B. (1995), Titan and the Idea of Originality in the Renaissance, in A. Ladis (ed.), *Craft of Art*, Athens: University of Georgia Press

Cook, H. J. (2007), *Matters of Exchange: Commerce, Medicine, and Science in the Dutch Golden Age*, New Haven: Yale University Press.

Cooper, C.C. (1991), Social Construction of Invention through Patent Management: Thomas Blanchard's Woodworking Machinery, *Technology and Culture*, 32 (4), pp. 960-998.

Costa-Lima, L. (1988), *Control of the Imaginary: Reason and Imagination in Modern Times*, Minneapolis: University of Minnesota Press.

Crombie, A.C. (1975), Some Attitudes to Scientific Progress: Ancient, Medieval and Early Modern, *History of Science*, 13, pp. 213-230.

Cummings, A.J.G., and L. Stewart (1991), The Case of the Eighteenth-Century Projector: Entrepreneurs, Engineers, and Legitimacy at the Hanoverian Court in Britain, in B.T. Moran (ed.), *Patronage and Institutions: Science, technology, and Medicine at the European Court, 1500-1750*, Suffolk: Boydell Press, pp. 235-261.

Daston, L. (1995), Curiosity in Early Modern Science, *Word & Image*, 11 (4), pp. 391-404.

Daston, L., and K. Park (1998), *Wonders and the Order of Nature, 1150-1750*, New York: Zone Books.

Daston, L., and F. Vidal (2004), *The Moral Authority of Nature*, Chicago: University of Chicago Press.
Davis, A. (1940), Technicways in American Civilization: Notes on a Method of Measuring Their Point of Origin, *Social Forces*, 18 (3), pp. 317-330.
Dean, B.V. (1968), *Evaluating, Selecting, and Controlling R&D Projects*, New York: American Management Association.
Deutsch, K.W., A.S. Markovits and J. Platt (1986), *Advances in the Social Sciences, 1900-1980: What, Who, Where, How*, Cambridge (Mass.): Abt Books.
Deutsch, K.W., J. Platt and D. Senghaas (1971), Conditions Favoring Major Advances in Social Science, *Science*, 171 (3970), February 5, pp. 450-459.
Dresbeck, L. (1979), Techne, Labor and Natura: Ideas and Active Life in the Medieval Winter, *Studies in Medieval and Renaissance History*, 2, pp. 83-119.
Dosi, G., et al. (1988), *Technical Change and Economic Theory*, London: Pinter Publishers.
Douglas, P. H. (1948), Are There Laws of Production?, *American Economic Review*, 38, March, pp. 1-41.
Dumont, L. (1977), *From Mandeville to Marx: the Genesis and Triumph of Economic Ideology*, Chicago: University of Chicago Press.
Eamon, W. (1994), *Science and the Secrets of Nature: Books of Secrets in Medieval and Early Modern Culture*, Princeton: Princeton University Press.
Eamon, W. (1983), Technology as Magic in the Late Middle Ages and the Renaissance, *Janus*, 70, pp. 171-212.
Elias, N. (1993), *Mozart: Portrait of a Genius*, Cambridge: Polity Press.
Engell, J. (1981), *The Creative Imagination: Enlightenment to Romanticism*, Cambridge (Mass.): Harvard University Press.
Epstein, R. C. (1926), Industrial Invention: Heroic, or Systematic?, *The Quarterly Journal of Economics*, 40 (2), pp. 232-272.
Epstein, S. R. (1998), Craft Guilds, Apprenticeship, and Technological Change in Preindustrial Europe, *Journal of Economic History*, 58, pp. 684-713.
Espinas, A. (1897), Des sociétés animales: étude de psychologie comparée, New York: G. E. Stechert & Co., 1924.
Farr, J. (1989), Understanding Conceptual Change Politically, in T. Ball, J. Farr and R. L. Hanson (eds.), *Political Innovation and Conceptual Change*, Cambridge: Cambridge University Press, pp. 24-49.
Findlen, P. (1994), *Possessing Nature: Museums, Collecting, and Scientific Culture in Early Modern Italy*, Berkeley: University of California Press.
Florida, R. (2002), *The Rise of the Creative Class*, New York: Basic Books.
Foucault, M. (1969), *L'Archéologie du savoir*, Paris: Gallimard.
Foucault, M. (1984), Nietzsche, Genealogy, History, in P. Rabinow (ed.), *The Foucault Reader*, 1984, pp. 76-100.
Freeman, C. (1994), The Economics of Technical Change, *Cambridge Journal of Economics*, 18, pp. 463-514.
Freeman, C. (1974), *The Economics of Industrial Innovation*, London: Penguin.

Frison, G. (1993), Linnaeus, Beckmann, Marx and the Foundation of Technology, *History and Technology*, 10, pp. 139-160 and 161-173.

Frison, G. (1992), Smith, Marx and Beckmann: Division of Labour, Technology and Innovation, in H.-P. Muller and U. Troitzsch (eds.), *Technologie: Zwischen Fortschritt und Tradition, Beitrage zum Internationalen Johan Beckmann-Symposium*, Frankfurt: Am Main P. Lang, pp., 17-40.

Furnas, C. C. (ed.) (1948), *Research in Industry: Its Organization and Management*, Princeton: D. Van Nostrand.

Gilfillan, S. C. (1952), The Prediction of Technical Change, *Review of Economics and Statistics*, 34 (4), pp. 368-385.

Gilfillan, S.C. (1937), The Prediction of Inventions, in US National Resources Committee (1937), *Technological Trends and National Policy*, Subcommittee on Technology, Washington, pp. 15-23.

Gilfillan, S. C. (1935), *The Sociology of Invention*, Cambridge (Mass.): MIT Press.

Gilfillan, S. C. (1927), Who Invented It?, *Scientific Monthly*, 25, pp. 529-534.

Godin, B. (2009a), *Homer G. Barnett and Culture Change: A Student of Innovation among the Anthropologists*, Project on the Intellectual History of Innovation, INRS: Montreal, Forthcoming.

Godin, B. (2009b), *Making Science, Technology and Innovation Policy: Conceptual Frameworks as Narratives, 1945-2005*, Edward Elgar, Forthcoming.

Godin, B. (2009c), National Innovation System: The System Approach in Historical Perspective, *Science, Technology and Human Values*, Forthcoming.

Godin, B. (2009d), *The Invention of Innovation: William F. Ogburn and the Social Use of Technology*, Project on the Intellectual History of Innovation, INRS: Montreal, Forthcoming.

Godin, B. (2008a), *Industrial Science: the Research Cycle and the Revolution by Research*, Project on the Intellectual History of Innovation, INRS: Montreal, Forthcoming.

Godin, B. (2008b), In the Shadow of Schumpeter: W. Rupert Maclaurin and the Study of Technological Innovation, *Minerva*, 46 (3), Forthcoming.

Godin, B. (2007a), From Eugenics to Scientometrics: Galton, Cattell and Men of Science, *Social Studies of Science*, 37 (5), pp. 691-728

Godin, B. (2007b), Science, Accounting and Statistics: the Input-Output Framework, *Research Policy*, 36 (9), pp. 1388-1403.

Godin, B. (2006a), On the Origins of Bibliometrics, *Scientometrics*, 68 (1), pp. 109-133.

Godin, B. (2006b), Research and Development: How the "D" got into R&D, *Science and Public Policy*, 33 (1), pp. 59-76.

Godin, B. (2006c), The Linear Model of Innovation: The Historical Construction of an Analytical Framework, *Science, Technology, and Human Values*, 31 (6), pp. 639-667.

Godin, B. (2005), *Measurement and Statistics on Science and Technology: 1920 to the Present*, London: Routledge.

Goldenberg, M. (2004), *Social Innovation in Canada*, Canadian Policy Research Network, Report no. 25, Ottawa.

Goldenweiser, A. A. (1913), The Principle of Limited Possibilities in the Development of Culture, *The Journal of American Folklore*, 26 (101), pp. 259-290.

Gross, A. G. (1989), The Rhetorical Invention of Scientific Invention: the Emergence and Transformation of a Social Norm, in H. W. Simons (ed.), *Rhetoric in the Human Sciences*, London: Sage, pp. 89-108.

Guilford, J. P. (1950), Creativity, *American Psychologist*, 5, pp. 444-454.

Guillerme, J., and J. Sebestik (1968), Les commencements de la technologie, *Thalès*, 12, pp. 1-72.

Hacking, I. (1999), *The Social Construction of What?*, Cambridge (Mass.): Harvard University Press.

Hadot, P. (2004), *Le voile d'Isis: essai sur l'idée de nature*, Paris: Gallimard.

Hage, J., and M. Aiken (1970), *Social Change in Complex Organizations*, New York: Random House.

Harris, M. (1968), *The Rise of Anthropological Theory: a History of Theories of Culture*, Walnut Creek (California): Altamira Press.

Harrison, P. (2001), Curiosity, Forbidden Knowledge and the Reformation of Natural Philosophy in Early Modern England, *Isis*, 92, pp. 265-290.

Hard, M., and A. Jamison (1998), *The Intellectual Appropriation of Technology: Discourses on Modernity, 1900-1939*, Cambridge (Mass.): MIT Press.

Hart, H. (1931), *The Technique of Social Progress*, New York: Henry Holt and Co.

Hart, H. (1957), Acceleration in Social Change, in F. R. Allen (ed.), *Technology and Social Change*, New York: Appleton, pp. 27-55.

Hart, H. (1959), Social Theory and Social Change, in L. Gross (ed.) (1959), *Symposium on Sociological Theory*, New York: Harper and Row, pp. 196-238.

Hathaway, N. (1989), *Compilatio*: From Plagiarism to Compiling, *Viator*, 20, pp. 19-44.

Hicks, J. R. (1932), *The Theory of Wages*, London: Macmillan.

Hield, W. (1954), The Study of Change in Social Science, *The British Journal of Sociology*, 5 (1), pp. 1-11.

Hilaire-Pérez, L. (2000), *L'invention technique au siècle des Lumières*, Paris: Albin Michel.

Hirshman, A. O. (1982), Rival Interpretations of Market Society: Civilizing, Destructive, or Feeble?, *Journal of Economic Literature*, 20, pp. 1463-1484.

Hirshman, A. O. (1977), *The Passions and their Interest: Political Arguments for Capitalism Before its Triumph*, Princeton: Princeton University Press.

Hodge, M.H. (1963), Rate Your Company's Research Productivity, *Harvard Business Review*, November, pp. 109-122.

Holland, M. (1928), Research, Science and Invention, in F. W. Wile (ed.), *A Century of Industrial Progress*, American Institute of the City of New York, New York: Doubleday, Doran and Co., pp. 312-334.

Horowitz, I. (1963), Evaluation of the Results of Research and Development: Where We Stand, *IEEE Transactions on Engineering Management*, 10, June, pp. 42-51.

Houghton, W. E. (1957), The History of Trades: its Relation to Seventeenth-Century Thought, in P. P. Wiener and A. Noland (eds.), *Roots of Scientific Thought: A Cultural Perspective*, New York: Basic Books, pp. 354-381.

Houghton, W. E. (1942), The English Virtuoso in the Seventeenth Century: Part I, *Journal of the History of Ideas*, 3 (1), pp. 51-73.

Hounshell, D. A. (2000), The Medium is the Message, or How Context Matters: the RAND Corporation Builds an Economics of Innovation, 1946-1962, in A. C. Hughes and T. P. Hughes (eds.), (2000), *Systems, Experts, and Computers: the System Approach in Management and Engineering, World War II and After*, Cambridge (Mass.): MIT Press, pp. 255-310

Hudson, P. (1992), *The Industrial Revolution*, London: Edward Arnold.

Hughes, T.P. (1983), *Networks of Power: Electrification in Western Society, 1880-1930*, Baltimore: Johns Hopkins University Press.

Iliffe, R. (1992), "In the Warehouse": Privacy, Property and Priority in the Early Royal Society, *History of Science*, 30, pp. 29-68.

Impey, O., and A. MacGregor (eds.) (1985), *The Origins of Museums: the Cabinet of Curiosities in Sixteenth- and Seventeenth-Century Europe*, North Yorkshire: House of Startus.

Jewett, F.B. (1932), The Philosophy and Practical Application of Industrial Research, in M. Ross (ed.), *Profitable Practice in Industrial Research*, New York: Harper, pp. 1-39.

Jewkes, J., D. Sawers and R. Stillerman (1958), *The Sources of Invention*, London: Macmillan.

Joas, H. (1996), *The Creativity of Action*, Chicago: University of Chicago Press.

Johnson, E. A. J. (1930), The Mercantilist Concept of Art and Ingenious Labour, *Economic History*, 2, pp. 234-253.

Jones, R. F. (1936), *Ancients and Moderns: A Study of the Rise of the Scientific Movement in Seventeenth-Century England*, New York: Dover, 1961.

Kasson, J. F. (1976), *Civilizing the Machine: Technology and Republican Values in America, 1776-1900*, New York: Viking Press.

Keller, A. (1972), Mathematical Technologies and the Growth of the Idea of Technical Progress in the Sixteenth Century, in W. Pagel (ed.), *Science, Medicine, and Society in the Renaissance: Essays to Honor Walter Pagel*, New York: Science History Publications, pp. 11-27.

Kemp, M. (1977), From Mimesis to Fantasia: the Quattrocento Vocabulary of Creation, Inspiration and Genius in the Visual Arts, *Viator*, 8, pp. 347-398.

Kneale, W. C. (1955), The Idea of Invention, *Proceedings of the British Academy*, 41, pp. 85-208.

Kuhn, T. S. (1962), *The Structure of Scientific Revolution*, Chicago: University of Chicago Press.

Kuhn, T. S. (1963), The Essential Tension: Tradition and Innovation in Scientific Research, in C. W. Taylor and F. Barron (eds.), *Scientific Creativity: Its Recognition and Development*, New York: John Wiley, pp. 341-354.

Kushner, E. (1980), The Concept of Invention and its Role in Renaissance Literary Theory, *Neohelicon*, 8 (1), pp. 135-146.

Lange, O. (1943), A Note on Innovations, *The Review of Economic Statistics*, 25 (1), pp. 19-25.

Laudan, L. (1981), *Science and Hypothesis: Historical Essays on Scientific Methodology*, Dordrecht: Reidel Publishing Co.

Lee, R. W. (1940), *Ut Pictura Poesis*: the Humanistic Theory of Painting, *The Art Bulletin*, 22 (4), pp. 197-269.

Levitt, T. (1966), Innovative Imitation, *Harvard Business Review*, September, pp. 63-70.

Lipetz, B.-A. (1965), *The Meausrement of Efficiency of Scientific Research*, Carlisle (Mass.): Intermedia.

Lobkowicz, N. (1967), *Theory and Practice: History of a Concept from Aristotle to Marx*, London: University of Notre Dame.

Long, P. (2001), *Openness, Secrecy, Authorship: Technical Arts and the Culture of Knowledge from Antiquity to the Renaissance*, Baltimore: Johns Hopkins University Press.

Lovejoy, A.O (1936), *The Great Chain of Being*, Cambridge (Mass.): Harvard University Press, 1964.

Lovejoy, A.O. (1927), Nature as Aesthetic Norm, *Modern Language Notes*, 42 (7), pp. 444-450.

Lovejoy, A.O., and G. Boas (1935), *Primitivism ands Related Ideas in Antiquity*, Baltimore: Johns Hopkins University Press.

Lubar, S. (1990), New, Useful, and Nonobvious, *Invention and Technology*, Summer, pp. 9-16.

Lundvall, B.-A., and S. Borras (2005), Science, Technology and Innovation Policy, in J. Fagerberg, D. C. Mowery and R. R. Nelson (eds.), *The Oxford Handbook of Innovation*, Oxford: Oxford University Press, pp. 598-631.

Machlup, F. (1962), *The Production and Distribution of Knowledge in the United States*, Princeton: Princeton University Press.

Maclaurin, W. R. (1949), *Invention and Innovation in the Radio Industry*, New York: Macmillan.

Maclaurin, W. R. (1953), The Sequence from Invention to Innovation and its Relation to Economic Growth, *Quarterly Journal of Economics* 67 (1), pp. 97-111.

Macleod, C. (2007), *Heroes of Invention: Technology, Liberalism and British Identity, 1750-1914*, Cambridge: Cambridge University Press.

Macleod, C. (1996), Concepts of Invention and the Patent Controversy in Victorian Britain, in R. Fox (ed.), *Technological Change: Methods and Themes in the History of Technology*, London: Harwood Academic, pp. 137-153.

Macleod, C. (1988), *Inventing the Industrial Revolution: the English Patent System, 1660-1800*, Cambridge: Cambridge University Press.

Macleod, C., and A. Nuvolari (2006), The Pitfalls of Prosopography: Inventors in the Dictionary of National Biography, *Technology and Culture*, 47, pp. 257-276.

Macleod, C., and J. Tann (2007), From Engineer to Scientist: Reinventing Invention in the Watt and Faraday Centenaries, 1919-1931, *British Journal for the History of Science*, 40 (3), pp. 389-411.

Mann, E. L. (1939), The Problem of Originality in English Literary Criticism, 1750-1800, *Philological Quarterly*, 28 (2), pp. 97-118.

Mansfield, E. et al. (1971), *Research and Innovation in the Modern Corporation*, New York: Norton.

Mansfield, E. (1961), Technical Change and the Rate of Imitation, *Econometrica*, 29 (4), pp. 741-765.

Mansfield, E. (1968), *The Economics of Technological Change*, New York: W. E. Norton.

Mason, O. T. (1895), *The Origins of Invention: A Study of Industry Among Primitive People*, Cambridge (Mass.): MIT Press.

Mason, J. H. (2003), *The Value of Creativity: the Origins and Emergence of a Modern Belief*, Aldershot (Hampshire): Ashgate.

Mason, J. H. (1988), The Character of Creativity: Two Traditions, *History of European Ideas*, 9 (6), pp. 697-715.

Marx, L. (1997), Technology: The Emergence of a Hazardous Concept, *Social Research*, 64 (3), pp. 965-988.

Marx, L. (1994), The Idea of Technology and Postmodern Pessimism, in M. R. Smith and L. Marx (eds.), *Does Technology Drive History?: The Dilemma of Technological Determinism*, Cambridge (Mass.): MIT Press, pp. 237-257.

Marx, L. (1987), Does Improved Technology Mean Progress?, *Technology Review*, January, pp. 33-42.

Marx, L. (1964), *The Machine and the Garden: Technology and the Pastoral Ideal in America*, New York: Oxford University Press.

McFarland, T. (1985), *Originality and Imagination*, Baltimore: Johns Hopkins University Press.

McKeon, R. (1936), Literary Criticism and the Concept of Imitation in Antiquity, *Modern Philology*, 34 (1), pp. 1-35.

Mees, C. E. K. (1920), *The Organization of Industrial Scientific Research*, New York: McGraw Hill.

Mees, C. E. K., and J. A. Leermakers (1950), *The Organization of Industrial Scientific Research*, New York: McGraw-Hill.

Merton , R. K. (1957), Priorities in Scientific Discovery, *American Sociological Review*, 22 (6), pp. 635-659.

Merton, R. K. (1961), Singletons and Multiples in Science, *Proceedings of the American Psychological Society*, 105 (5), pp. 470-486.

Morère, J.-E. (1966), Les vicissitudes du sens de technologie au début du dix-neuvième siècle, *Thalès*, 12 (12), pp. 73-84.

Mortier, R. (1982), *L'originalité : une nouvelle catégorie esthétique au siècle des lumières*, Genève : Droz.

Mulgan, G. et al. (2007), *In and Out of Sync: the Challenge of Growing Social Innovations*, London: National Endowment for Science, Technology and the Arts (NESTA).

Mumford, L. (1934), *Technics and Civilization*, San Diego: Hartcourt Brace and Co., 1963.

Murray, P. (1989), *Genius: the History of an Idea*, Oxford: Basil Blackwell.

Myers, S. and D. G. Marquis (1969), *Successful Industrial Innovations: A Study of Factors Underlying Innovation in Selected Firms*, NSF 69-17, Washington: National Science Foundation.

Nahm, M. C. (1956), *The Artist as Creator: an Essay of Human Freedom*, Baltimore: Johns Hopkins University Press.

Nahm, M. C. (1947), The Theological Background of the Theory of the Artist as Creator, *Journal of the History of Ideas*, 8 (3), pp. 363-372.

Nelson, H. (1928), The Creative Years, *American Journal of Psychology*, 40, pp. 303-311.

Nelson, R. R. (2008), What Enables Rapid Economic Progress: What Are the Needed Institutions?, *Research Policy*, 37, pp. 1-11.

Nelson, R. R., and B. N. Sampat (2001), Making Sense of Institutions as a Factor Shaping Economic Performance, *Journal of Economic Behavior and Organization*, 44, pp. 31-54.

Nelson, R. R., and S. G. Winter (1982), *An Evolutionary Theory of Economic Change*, Cambridge (Mass.): Belknap Press.

Newman, W. (1989), Technology and Alchemical Debate in the Late Middle Ages, *Isis*, 80 (3), pp. 423-445.

Nimkoff, M. F. (1957), Obstacles to Innovation, in F. R. Allen et al. (eds.), *Technology and Social Change*, New York: Appelton-Century Crofts, pp. 56-71.

Nisbet, R. (1980), *History of the Idea of Progress*, New York: Basic Books.

Noble, D. F. (1997), *The Religion of Technology: the Divinity of Man and the Spirit of Invention*, New York: Alfred D. Knopf.

Noble, D.F. (1977), *America by Design: Science, Technology, and the Rise of Corporate Capitalism*, Oxford: Oxford University Press.

Nowotny, H. (2008), *Insatiable Curiosity: Innovation in a Fragile Future*, Cambridge (Mass.): MIT Press.

Nowotny, H. (2006), The Quest for Innovation and Cultures of Technology, in H. Nowotny (ed.), *Cultures of Technology and the Quest for Innovation*, New York: Berghan Books, pp. 1-38.

Nye, D. E. (2003), *America as Second Creation: Technology and Narratives of New Beginnings*, Cambridge (Mass.): MIT Press.

Nye, D. E. (1997), *Narratives and Space: Technology and the Construction of American Culture*, New York: Columbia University Press.

Ochs, K.H. (1985), The Royal Society of London's History of Trades Programme: An Early Episode in Applied Science, *Notes and Records of the Royal Society of London*, 39 (2), pp. 129-158.

Odum, H.W. (1937), Notes on the Technicways in Contemporary Society, *American Sociological Review*, 2 (3), pp. 336-346.

OECD (2005), *Oslo Manual: Guidelines for Collecting and Interpreting Innovation Data*, Third Edition, Paris: OECD.

OECD (1991), *OECD Proposed Guidelines for Collecting and Interpreting Innovation Data* (Oslo Manual), DSTI/STII/IND/STP (91) 3.

Ogburn, W. F. (1950), *Social Change with Respect to Culture and Original Nature*, Second edition, New York: The Viking Press.

Ogburn, W. F. (1941), National Policy and Technology, in S. M. Rosen and L. Rosen (eds.), *Technology and Society: the Influences of Machines in the United States*, New York: Macmillan Co., pp. 3-29.

Ogburn, W. F. (1922), *Social Change with Respect to Culture and Original Nature*, New York: The Viking Press.

Ogburn, W. F. and S. C. Gilfillan (1933), The Influence of Invention and Discovery, in *Recent Social Trends in the United States*, Report of the US President's Research Committee on Social Trends, New York: McGraw-Hill, Volume 1.

Ogburn, W. F., and M. F. Nimkoff (1964), *Sociology*, Fourth edition, New York: Houghton Mifflin Co.

Park, K. (1984), Bacon's Enchanted Glass, *Isis*, 75, pp. 290-302.

Park, K., L. J. Daston and P. Galison (1984), Bacon, Galileo and Descartes on Imagination and Analogy, *Isis*, 75, pp. 287-326.

Pelz, D. C. and F. M. Andrews (1966), *Scientists in Organizations: Productive Climate for Research and Development*, New York: John Wiley.

Pigou, A. C. (1924), *The Economics of Welfare*, Second edition, London: Macmillan.

Pocock, J.G.A. (1975), *The Machiavellian Moment: Florentine Political Thought and the Atlantic Republican Tradition*, Princeton: Princeton University Press.

Poovey, M. (1998), *A History of the Modern Fact: Problems of Knowledge in the Sciences of Wealth and Society*, Chicago: University of Chicago Press.

Quinn, J.B. (1959), *Yardsticks for Industrial Research: The Evaluation of Research and Development Output*, New York: Ronald Press Co.

Quinn, J.B. (1960), How to Evaluate Research Output?, *Harvard Business Review*, 38, March-April, pp. 69-80.

Quint, D. (1983), *Origin and Originality in Renaissance Literature: Versions of the Source*, New Haven: Yale University Press.

Rae, J. B. (1967), The Invention of Invention, in M. Kranzberg and C. W. Pursell (eds.), *Technology in Western Civilization*, vol. 1, London: Oxford University Press, pp. 325-337.

Reader, S. M., and K. N. Laland (2003), *Animal Innovation*, Oxford: Oxford University Press.

Redfield, R., R. Linton and M.J. Herskovits (1936), Memorandum for the Study of Acculturation, *American Anthropologist*, 38 (1), pp. 149-152.

Redlich, F. (1954), The Role of Innovation in a Quasi-Static World: Francis Bacon and His Successors, *Explorations in Entrepreneurial History*, 7 (1), pp. 12-25.

Reinert, E.S. (2002), Schumpeter in the Context of Two Canons of Economic Thought, *Industry and Innovation*, 9 (1-2), pp. 23-39.

Rieger, B. (2005), *Technology and the Culture of Modernity in Britain and Germany, 1890-1945*, Cambridge: Cambridge University Press.

Roberts, R. E., and C. A. Romine (1974), *Investment in Innovation*, Report produced for the US National Science Foundation, Midwest Research Institute, Kansas City.

Robinson, J. (1938), The Classification of Inventions, *Review of Economic Studies*, February, pp. 139-142.

Rogers, E. M. (1983), *Diffusion of Innovation*, New York: The Free Press.

Rogers, E. M. (1962), *Diffusion of Innovations*, New York: The Free Press.

Rosenberg, N. (1976a), Marx as a Student of Technology, *Monthly Review*, July-August, pp. 56-77.

Rosenberg, N. (1976b), Problems in the Economist's Conceptualization of Technological Innovation, in *Perspectives on Technology*, Cambridge: Cambridge University Press, pp. 61-84.

Rossi, P. (1962), *Philosophy, Technology, and the Arts in the Early Modern Era*, New York: Harper and Row, 1970.

Rossky, W. (1958), Imagination in the English Renaissance: Psychology and Poetic, *Studies in the Renaissance*, 5, pp. 49-73.

Rossman, J. (1935), Stimulating Employees to Invent, *Industrial and Engineering Chemistry*, 27 (11), pp. 1380-1386, and 27 (12), pp. 1510-1515.

Rossman, J. (1931), *The Psychology of the Inventor*, Washington: The Inventors Publishing Co.

Rubenstein, A.H. (1957), Looking Around, *Harvard Business Review*, 35 (3), pp. 133-145.

Ruttan, V. W. (1959), Usher and Schumpeter on Invention, Innovation, and Technological Change, *Quarterly Journal of Economics*, 73, pp. 596-606.

Salomon, J.-J. (1984), What is Technology? The Issue of its Origins and Definitions, *History and Technology*, 1, pp. 113-156.

Sarton, G. (1962), The Quest for Truth: Scientific Progress During the Renaissance, in W.F. Ferguson et al., *Six Essays: The Renaissance*, New York: Harper, pp. 55-76.

Schatzberg, E. (2006), *Technik* Comes to America: Changing Meanings of Technology Before 1930, *Technology and Culture*, 47, pp. 486-512.

Scherer, F. M. (1965), Invention and Innovation in the Watt-Boulton Steam Engine Venture, *Technology and Culture*, 6, pp. 165-187.

Schmookler, J. (1966), *Invention and Economic Growth*, Cambridge (Mass.): Harvard University Press.

Schumpeter, J.A. (1912), *The Theory of Economic Development: An Inquiry into Profits, Capital, Credit, Interest, and the Business Cycle*, Cambridge: Harvard University Press, 1934.

Schumpeter, J.A. (1928), The Instability of Capitalism, *The Economic Journal*, September, pp. 361-386.

Schumpeter, J.A. (1939), *Business Cycles: A Theoretical, Historical, and Statistical Analysis of the Capitalist Process*. New York: McGraw-Hill.

Schumpeter, J.A. (1942), The Process of Creative Destruction, in *Capitalism, Socialism and Democracy*, Chapter 7, New York: Harper, 1962.

Schumpeter, J.A. (1947), The Creative Response in Economic History, *Journal of Economic History*, November, pp. 149-159.

Seiler, R.E. (1965), *Improving the Effectiveness of Research and Development*, New York: McGraw Hill.

Shapiro, B. J. (2000), *A Culture of Fact: England, 1550-1720*, Ithaca: Cornell University Press.

Skinner, Q. (1988), Language and Social Change, in J. Tully (ed.), *Meaning and Context*, Princeton: Princeton University Press, pp. 119-132.

Smith, G. E. et al. (1927), *Culture: The Diffusion Controversy*, New York: Norton and Co.

Smith, P.H., and P. Findlen (2002), *Merchants and Marvels: Commerce, Science and Arts in Early Modern Europe*, London: Routledge.

Solow, R. M. (1957), Technical Change and the Aggregate Production Function, *Review of Economics and Statistics*, 39 (August), pp. 312-320.

Spadafora, D. (1990), *The Idea of Progress in Eighteenth-Century Britain*, New Haven: Yale University Press.

Spencer, J. R. (1957), Ut Rhetorica Pictura, *Journal of the Warburg and Courtauld Institutes*, 20, pp. 26-44.

Stamp, J. (1933-34), Must Science Ruin Economic Progress?, *The Hibbert Journal*, 32, 383-399.

Stamp, J. (1929), Invention, in *Some Economic Factors in Modern Life*, London: P.S. King, pp. 89-121.

Stead, H. (1976), The Costs of Technological Innovation, *Research Policy*, 5, pp. 2-9.

Steiner, G.A. (ed.) (1965), *The Creative Organization*, Chicago: University of Chicago Press.

Stern, B. J. (1937), Resistance to the Adoption of Technological Innovations, in US National Resources Committee, *Technological Trends and National Policy*, Subcommittee on Technology, Washington: USGPO.

Stern, B. J. (1927), *Social Factors in Medical Progress*, New York: Columbia University Press.

Stevens, R. (1941), A Report on Industrial Research as a National Resource: Introduction, in National Research Council, *Research: A National Resource (II): Industrial Research*, Washington: National Resources Planning Board.

Stewart, J. H. (1955), *Theory of Culture Change*, Urbana: University of Illinois Press.

Stewart, L. (1992), *The Rise of Public Science: Rhetoric, Technology and Natural Philosophy in Newtonian Britain, 1660-1750*, Cambridge: Cambridge University Press.

Stewart, L. (1998), A Meaning for Machines: Modernity, Utility, and Eighteenth-Century Britain, *The Journal of Modern History*, 70 (2), pp. 259-294.

Streissler, E.W. (1994), The Influence of Garman and Austrian Economics on Joseph A. Schumpeter, in Y. Shionoya and M. Perlman (eds.), *Schumpeter in the History of Ideas*, Ann Arbor : University of Michigan Press, pp. 13-38.

Sweezy, P.M. (1968), Karl Marx and the Industrial Revolution, in R.V. Eagly (ed.), *Events, Ideology and Economic Theory*, Detroit: Wayne State University Press, pp. 107-126.

Tarde, G. (1902), L'invention, moteur de l'évolution sociale, *Revue internationale de sociologie*, juin, pp. 561-574.

Tarde, G. (1898), *Les lois sociales: esquisse d'une sociologie*, Le Plessis-Robinson: Institut Synthélabo, 1999.

Tarde, G. (1897), *L'opposition universelle: essai d'une théorie des contraires*, Le Plessis-Robinson: Institut Synthélabo, 1999.

Tarde, G. (1895), *La logique sociale*, Le Plessis-Robinson: Institut Synthélabo, 1999.

Tarde, G. (1890), *Les lois de l'imitation*, Paris: Seuil, 2001.

Tararkiewicz, W. (1980), Creativity: History of the Concept, in W. Tararkiewicz (ed.), *A History of Six Ideas: An Essay in Aesthetics*, Boston: Kluwer, pp. 244-265.

Thorndike, L. (1957), Newness and Novelty in Seventeenth-Century Science and Medicine, in P. P. Wiener and A. Naland (eds.), *Roots of Scientific Thought: A Cultural Perspective*, New York: Basic Books, pp. 443-457.

Tigerstedt, E. N. (1968), The Poet as Creator: Origins of a Metaphor, *Comparative Literature Studies*, 5, pp. 455-488.

Usher, A. P. (1929), *A History of Mechanical Inventions*, New York: Dover, 1988.

Usher, A. P. (1954), *A History of Mechanical Inventions*, Revised edition, New York: McGraw Hill.

Usher, A. P. (1955), Technical Change and Capital Formation, in National Bureau of Economic Research, *Capital Formation and Economic Growth*, Princeton: Princeton University Pres, pp. 523-550.

US Department of Commerce (1967), *Technological Innovation: its Environment and Management*, Washington: USGPO.

US National Bureau of Economic Research (1962), *The Rate and Direction of Inventive Activity: Economic and Social Factors*, Princeton: Princeton University Press.

US National Research Council (1941), *Research: A National Resource (II): Industrial Research*, National Resources Planning Board, Washington: USGPO.

US National Resources Committee (1937), *Technological Trends and National Policy*, Subcommittee on Technology, Washington.

Utterback, J. M. (1974), Innovation in Industry and the Diffusion of Technology, *Science*, 183 (4125), pp. 620-626.

Utterback, J. M. and W. J. Abernathy (1975), A Dynamic Model of Process and Product Innovation, *Omega*, 3 (6), pp. 639-656.

Veblen, T. (1898), Why is Economics not an Evolutionary Science?, *The Quarterly Journal of Economics*, 12 (4), pp. 373-397.

Von Hippel, E. (2005), *Democratizing Innovation*, Cambridge (Mass.): MIT Press.

Weeks, A. D. (1932), Will There Be an Age of Social Invention?, *The Scientific Monthly*, 35 (4), pp. 366-370.

Weintraub, E. R. (1991), *Stabilizing Dynamics: Constructing Economic Knowledge*, Cambridge: Cambridge University Press.

White, H. O. (1935), *Plagiarism and Imitation during the English Renaissance*, Cambridge (Mass.): Cambridge University Press.

White, L. (1975), Medieval Engineering and the Sociology of Knowledge, *Pacific Historical Review*, 44, pp. 21.

White, L. (1971), Cultural Climates and Technological Advance in the Middle Ages, *Viator*, 2, pp. 171-201.

White, L. (1962), The Act of Invention: Causes, Contexts, Continuities and Consequences, *Technology and Culture*, 3 (4), pp. 486-500.

Wittkower (1965), Imitation, Eclecticism, and Genius, in E. R. Wasserman (ed.), *Aspects of the Eighteenth Century*, Baltimore (Maryland): Johns Hopkins University Press.

Wyman, W.I. (1929), Patents for Scientific Discoveries, *Journal of the Patent Office Society*, 11, pp. 533-557.

Yovits, M.C. et al. (1966), *Research Program Effectiveness*, Proceedings of the Conference Sponsored by the US Office of Naval Research, Washington, July 27-29, 1965, New York: Gordon and Breach.

Zagorin, P. (2001), Francis Bacon's Concept of Objectivity and the Idols of the Mind, *British Journal for the History of Science*, 34, pp. 379-393.

Zaltman, G., R. Duncan and J. Holbek (1973), *Innovations and Organizations*, New York: John Wiley.

Zilsel, E. (1945), The Genesis of the Concept of Scientific Progress, *Journal of the History of Ideas*, 6 (3), pp. 325-349.

Zilsel, E. (1926), *The Origin of the Genius Concept*, Tubingen, Germany.