The Changing Identity of Research: A Cultural and Conceptual History [1]

Benoît Godin and Désirée Schauz

Abstract

Science as a body of *knowledge* (natural and/or social) and as a *method* (experimental and hermeneutic) have been discussed and debated for centuries among philosophers and 'men of science' (scientists). This **paper** looks at *research*, the latest element added to the discourse on science. Science as research (an activity or practice), conducted at the level of organizations, got increased attention in the public discourses of the twentieth century on what science is.

The **article** documents how different actors enlarged the meaning of research from solely academic to industry and government as well, and from research to research and development (R&D), then restricted it to laboratory research, and marginalized the role of research in explaining economic progress. It is suggested that these changes are witness to a shift in the society's cultural values, from (basic) research to (industrial) development to (technological) innovation.

[1] Special thanks to David Kaldewey, Lissa Roberts and two anonymous reviewers for commenting on a first draft of this paper.

> The special characteristic of modern scientific research is that it is developing in institutions which are no longer confined to the university environment (OCDE, 1972).

> Research and development (R&D) comprise creative and systematic work undertaken in order to increase the stock of knowledge – including knowledge of humankind, culture and society – and to device new applications of available knowledge (OECD, *Frascati Manual*, 2015).

Whereas science as a body of *knowledge* (natural and/or social) and as a *method* (experimental and hermeneutic) have been discussed for centuries among philosophers and 'men of science' (scientists), it was not before the twentieth century that *research* as a scientific activity or practice, conducted at the level of organizations, also became an object of debates, particularly in the public discourses.

Today research is much talked about while science gets comparatively less attention. Science policy traditionally restricted to universities or academies of science made way for research and technology policy, or, more recently, research and innovation policy.[2] The increasing role research plays in public debates stands in stark contrast to the little attention scholars have paved to the concept of research so far. In the last five years a few scholars began conducting conceptual analyses of *basic research* and *applied research* and trace the origins and meanings of these concepts (e.g.: Clarke, 2010; Pielke, 2012; Schauz, 2014). These studies dealing with the emergence of the new semantics already indicate that in the early 20th century the public and political discourse had developed an interest in research activities beyond the enclosed sphere of academic science. Yet, the concept of research *per se* remains unexplored.

STS debates on structural changes of the modern research landscape and shifting perspectives on the science-technology relationship, held under the label of technoscience, mode 2 or triple helix (e.g.: Latour 1993; Gibbons et al., 1994; Grandin et al. 2004; Forman 2007), already brought about the want to historicize the categories science and technology or related terms such as natural science, pure and applied science or popular science (e.g.: Hounshell 1980; Kline 1995; Dear 2005; Schatzberg 2006; Topham 2009; Marx 2010; Philipps 2012; Bud 2012, Lucier 2012, Gooday 2012; Nikiforova 2015). [3] Moreover, history of science has broadened its perspective and showed interests in non-academic science and the identity of industrial researchers (e.g. most prominently Shapin 2008).

---

[2] Today many ministries or administrative unites in charge of research policy define their fields of responsibility as "research and innovation". The EU commission, for example, has established a Directorate-General for Research and Innovation (formerly DG Research):. EU member states have meanwhile adopted the label "research and innovation" for funding programs and directives.

[3] A lot has been written on *pure science* and *applied science*, as sources or factors of economic growth, but also as discursive categories for professional identity and epistemic norms, autonomy/liberty and boundary work. Yet, pure science and applied science are different from basic research and applied research. The first two refer to science as an outcome; the other two refer to science as an activity or practice. Moreover, the difference between pure/applied science and basic/applied research becomes even clearer when one takes into account that the latter emerged exactly when research activities started to spread out across academia.

What if we discuss these issues in the light of the conceptual history of research? In a short, programmatic essay from 1998, Bruno Latour demurred "very little has been done to illuminate research". He stated a "transition from the culture of 'science' to the culture of 'research'" alluding to a dichotomy between science as an institutionally authorized body of knowledge and the detached activity of research as a complex, socially mixed world of knowledge production (Latour, 1998: 208). While Latour and many other scholars who followed the practical turn have been interested in concrete research practices and not in their delusive conceptual representation, this article focuses on the discursive use of the term research. Which expectations, claims, characteristics or institutional arrangements did actors communicate by deploying the word research? The article intends to show how research became an issue of societal and political negotiations and conflicting interests and how it turned into an institutional category like science had been before. Although it is not possible here to discuss at length how the public discourse on research reflected the perceived science-technology or the science-research relationship, we aim at demonstrating how research became a category of its own right as a first step of further studying the STI discourse.

According to the Oxford Dictionary, the term research has French origins and appeared in the sixteenth century. [4] Research has its roots in the term *search*, invented in the fourteenth century, and is defined as "examine thoroughly". Research meant an "act of searching closely and carefully", or "intensive searching". The term was first applied to 'science' in 1639 defined as "scientific inquiry" (Cohen, 1948: 56), but rarely used in that context in early modern era, at least in the Anglo-Saxon world. *Investigation* and *enquiry* were the keywords. It was not before the academic professionalization during the nineteenth century that the concept was more exclusively linked to science by denoting its professional activity. When the advancement of knowledge turned into a professional criterion for scientists and scholars next to the teaching of established theories, "diligent", "patient" or "accurate research" became a proof of scientific proficiency and a reference to a methodological approach in all academic disciplines.[5] Only a few decades later, the concept started to spread beyond the academic sphere.

The article studies how, over the twentieth century, different actors expanded the meaning of research beyond the academic sphere to industry and government as well. At the very beginning of that century, research was a concept still associated mainly with universities, according to scholars' representation (but evidently practice was already different). In 1906, James McKeen Cattell, editor of *Science*, published the first edition of a directory of researchers in the United States. It included 4,000 biographies of "men who have carried out research work". No researchers from industry were included in the directory. To Cattell, research meant university research, above all "pure" research in the natural, medical and psychological sciences (Cattell, 1906). As the century progressed, a

[4] *Oxford Dictionary of English Etymology*, C. T. Onions (ed.), Oxford: Clarendon Press, 1966; *The Shorter Oxford English Dictionary*, W. Little, H. M. Fowler, J. Coulson, Oxford: Clarendon Press, 1959.

[5] In review journals or commented bibliographies of the 19th century such as The Lancet, The Annual Review or The Library of Useful Knowledge "research" became a marker for individual contributions to the advancement of scientific knowledge and the applied methodology.

diversity of actors appropriated the term research and changed its then-current meaning. The university is not the sole province of research, so it was said. Industry conducts research too, with specific divisions devoted to this activity. Governments do so as well, and the term was soon incorporated into the names of public institutions like the Department of Scientific and Industrial *Research* (Britain – 1916) and the National *Research* Council (USA –1916; Canada – 1917).

This article is concerned solely with the concept of research as an *institutional* category: research conducted in institutional settings or institutions (university, government and industry). We document the contribution of industry and industrial issues to the changing meaning of research. Industrialists were most likely the first to propose a conception of research that is broader than the academic conception. Together with other actors – policy-makers, statisticians, engineers and scholars from the social sciences – they succeeded in changing the meaning of research, a meaning that we still use today.

The article is in four parts, corresponding to four moments in the history of the concept in the twentieth century. Two of these moments enlarged the meaning of research (from solely academia to industry and government as well; from research to research and development), while a third restricted it (to laboratory research), and a fourth marginalized the role of research in explaining economic progress (to one of many factors leading to technological innovation). These changes are witness to a shift in the society's cultural values, from (basic) research to (industrial) development to (technological) innovation. Over the period studied, the concept of research shifted from having a central place in culture, particularly policy culture, to a peripheral one:

1. Research includes more than just academic research. Research is a *whole*, as industrialists called it, encompassing: academic, industrial, government research activities.
2. Research is *organized* research (laboratories with a division of labor, not independent inventors), as industrialists but also sociologists and historians put it.
3. Research is *research and development* (R&D) (to policy-makers, statisticians).
4. Research is one step or stage only (often not even necessary) in the *process* leading to marketable products or technological innovation (to engineers, management schools, governments and international organizations, students of technological innovation).

The article focuses on the United States, but not exclusively. It was in the United States that new public discourses on research developed most fully in the first half of the twentieth century. Indeed, Europeans made repeated references to the United States – as Americans made references to Europe –, as both a source of ideas on what research is and as a model to emulate. A broader comparative perspective including e.g. France or Germany, would mean not only to deal with the semantic or linguistic differences but also with divergent institutional scientific infrastructures and policy traditions. [6]

[6] We intend to deal with the German expression *Forschung* and French *recherche* in a forthcoming paper.

A Research Whole

The experience of World War I led to mobilization of the totality of scientific resources on a nationwide basis, what the American historian Hunter Dupree called the "great estates" of science in the country, and to the demand to link universities (science) with industry (applications) (Dupree, 1957). In Great Britain, this started with efforts by the Board of Education (1915) to strengthen and redirect educational resources toward industry's needs. The belief in shortages of scientifically trained researchers, particularly ones with expertise in both pure and applied science, and specifically industrial scientists, gave rise to the Department of Scientific and Industrial Research) (DSIR) (Macleod and Andrews, 1970; Varcoe, 1979; Hull, 1999). While the British DSIR became an active supporter of cooperative organizations, the United States developed a different approach. In 1916, the National Academy of Science offered to bring into cooperation government, education, industry and other organizations for the war effort. A National Research Council was to serve as the vehicle to this end. It would rely primarily on private sources, among them the great foundations (Kevles, 1971).

From that time on, there were regular speeches by the Council's leaders, industrialists and members of government on what Dupree describes as "the beginning of a realization that the nation's scientific program was a single interrelated *whole*" [our italics] (Dupree, 1957: 340). The Council and its initiatives were "a pioneer effort to deal with the *whole* [our italics] pattern of science as a single unit … [and] the beginning of a recognition that the estates of science – government, universities, foundations and industry – were closely interrelated" (Dupree, 1957: 343).

The emergence of large-scale industrial research was a key factor in the rise of a 'whole' or holistic approach to research: universities were not alone in conducting research; there was a more complex whole composed of universities, government, industry (and what was called "benevolence", namely private philanthropy). By the Second World War, this was admitted publicly. The US President's Scientific Research Board called for a more "balanced" program of research. "Each of the three segments of the research triangle [a precursor term to the much popular "triple helix" used today] is especially adapted to the performance of a particular type of research and each can make a unique contribution to our total research and development effort … The general emphasis in the universities is upon basic research while that of industrial research laboratories is overwhelmingly on development. The Government laboratories stand somewhat between the two …" (US President's Scientific Research Board, 1947: 27). Within a few decades the discourse on a research 'whole' turned into a discourse on a research 'system'.

In the first half of the twentieth century, many universities had little interest in a holistic approach to research. According to scientists, all progress starts with discoveries in the basic sciences. To them, university research constitutes the whole, and is the only research deserving of the name. In the first decades of the twentieth century, universities were still struggling for research funding. The entry or recognition of a new research player on the scene would only make it harder for university research to get support from the government, which would have to distribute funding based on other criteria than science alone. However, to industry it was another matter. A holistic approach to research would put industry on the map, and contribute to public recognition of research conducted in industry. It would also help make a case for universities contributing to industries' needs, and for industries benefiting from government's research efforts.

That research is not the exclusive province of the university was a leitmotif of many industrialists during and after World War I. Industry also does research, or at least firms were strongly urged to do so. As documented in this section, a research whole encompasses different kinds of research *agencies* (Arthur D. Little) or *institutions* (Kenneth Mees) or *classes*/*branches* (Charles Skinner) or *types* of research (Perley Nutting) or *spheres* (Desmond Bernal), serving the *nation* as a whole (Herbert Hoover), with complementary tasks. Such were the terms used at the time to discuss the research whole. In the addresses of industrialists, a national perspective is often adopted as rationale: such a diversity, or research whole, is a source of national strength, or "greatness" and progress.

Such a view began to emerge shortly before World War I. In many of his discourses, Arthur D. Little, the chemist who gave his name to a well-known firm of consultants, compared the United States to Europe, as many scientists did at this time. For example, in 1913, he discussed how "Germany has long been recognized as preeminently the country of organized research", namely the use of science in industry. However, in the United States there is a "disdain of scientific teaching" (Arthur D. Little, 1913: 643). Little then discussed recent advances in agriculture, the telephone, the automobile, chemistry, iron and oil, and how these discoveries depended upon what he called different kinds of research *agencies*: government, where the research "results are immediately made available to the whole people" (such as agriculture, roads, forestry, fisheries, geology, mining and standards); industry, representing at least 50 laboratories each with over $300,000 in research expenditures per year; and universities. In the latter case, however, "our own institutions of learning have, speaking generally, failed to seize or realize the great opportunity confronting them. They have, almost universally, neglected to provide adequate equipment for industrial research and … have rarely acquired that close touch with industry essential for familiarity and appreciation of its immediate and pressing needs", with a few exceptions like MIT (Arthur D. Little, 1913: 651). To Little, the issue is not better university funding in recognition of their central place in the research whole, but the need for more university research relevant to the common good and to industry in particular.

Kenneth Mees, director of the research laboratory at Eastman Kodak and author of a classic book on the management of research (Mees, 1920), is also critical of universities. "It is generally assumed that research is the proper home of the university. However, very few universities devote a large portion of their energies to research work. In fact, history shows that "so far as research work has been associated with *institutions* [our italics], it has always been because those institutions required the results of research for the effective performance of their own essential duties". Mees referred first to ecclesiastics using knowledge to support religious belief, then to teachers using research results in their teaching (Mees, 1914: 618).

To Mees, with the growing specialization and complexity of science, there was an increasing distance between teaching and research. “Our energies should, therefore, be directed towards the development of [new forms of] institutions which will prosecute scientific research … because it is of use to them … It is to the industrial research laboratories that we must look in the future for progress in all branches of science” (Mees, 1914: 619). And the research required in industry “is not merely an improvement in processes or a cheapening in the costs of manufacture, but fundamental development … The work of the research laboratory must be directed primarily toward the fundamental theory of the subject”, because “it is almost impossible to name any class of physical or chemical scientific work, from the physics of the atom to structural organic chemistry, which may not sooner or later have a direct application and importance for the industries” (Mees, 1920: 9, 11).

Apart from the university and industry, there is a third type of institution involved. According to Mees, special provision must be made for “non-paying” branches of science, including government and private philanthropy, where research benefits accrue to the welfare of the people as a whole. Although private philanthropy has been acknowledged as a key source of funding for individual researchers for some time (Kohler, 1991), Mees, like most US industrialists, was skeptical of government support for industrial research, such as that provided by the British DSIR. He felt that government support generally degenerates into a control mechanism.

From industrialists like Little and Mees, we can see that a whole approach to research was slowly taking form in industrialists’ minds. Still more explicit statements are to be found among other industrialists, and classifications of research developed. To Charles Skinner of Westinghouse (Research Division), research covers an extremely wide field of activities. Both pure science and applied research are “so closely interlinked that it is impossible to say where the one ends and the other begins” (Skinner, 1917: 871). Skinner suggests dividing research into four *classes* or *branches*, depending on the agencies involved and the purposes for which the work is done. Although “no sharp lines can be drawn between these classes”, states Skinner, the classification is based on the primary function of each class and their distinctive fields. Skinner suggests we also look at the relationships among the classes:

- Universities, where the primary function is pure science and the training of “research men”.
- Industry, with its own laboratories and men familiar with all phases of research, but where closer relationships with universities are needed for better training.
- Government, where research results are directly available to all people, but where there is a “desirability of increased cooperation between all the forces having to do with research, both at home and abroad” (Skinner, 1917: 877).
- Private research foundations.

Similarly, in an address delivered to the Associated Engineering Societies of Worcester (England) in 1917, Perley Nutting (1917) from Eastman Kodak suggested that different types of research make up the scientific landscape. He starts by adopting a national perspective: “A nation is great according to its resources and according to its development of these resources. And the development of those resources may be accomplished only through *organized* [our italics] knowledge”. To Nutting, “a nation will advance to leadership in which the increase in *organized* [our italics] knowledge and the application of that knowledge are greatest … For this reason, interest in research should be as wide as the nation and should cover the whole gamut of problems from administration to agriculture, from medicine to manufacture” (Nutting, 1917: 247-248).

To Nutting, there are “three distinct *types* [our italics] of research organizations”: government or national (for the “solution of such problems as concern the national as a *whole* [our italics]”), universities (devoted to the “advancement of the various sciences as such”), and industry (focused on “practical commercial application”). [7] In the latter case, he says “we need more teaching and instructors in closer touch with industrial problems” (Nutting, 1917: 251). To Nutting, “another great need is cooperation among the various *branches* [our italics] of research: university, national and industrial. There should be a free interchange of men between such laboratories, and each should be thoroughly familiar with the needs and problems of the other” (Nutting, 1917: 251).

The whole approach to research reached the national planning agenda in the hands of Herbert Hoover, then US Secretary of Commerce. According to Hoover, pure scientific research is the most precious asset of the country. “It is in the soil of pure science that are found the origins of all our modern industry and commerce. In fact, our civilization and our large populations are wholly builded upon our scientific discoveries” (Hoover, 1927: 27). However, Hoover calculated that the *nation* was not spending enough on this kind of research, in contrast to applied research, a fact stressed again by Vanevar Bush in his blueprint for science policy in 1945. To Hoover, “there is no price that the world could not afford to pay these men” (Hoover, 1927: 27): “The wealth of the country has multiplied far faster than the funds we have given for those purposes. And the funds administered in the nation today for it are but a triviality compared to the vast amount that a single discovery places in our hands. We spend more on cosmetics than we do upon safeguarding this mainspring of our future progress” (Hoover, 1927: 29).

“How are we to secure the much wider and more liberal support to pure science research” (Hoover, 1927: 28)? Hoover considered that this support should be in three directions: government (more pure research in national laboratories), industry (entrust the National Academy of Sciences with a fund to support research), and philanthropy. “A *nation* with an output of fifty billion [dollars] annually in commodities which could not be produced but for the discoveries of pure science could well afford, it would seem, to put back a hundredth of one percent as an assurance of further progress” (Hoover, 1927: 28).

[7] To these Nutting adds the following, but without discussion: privately endowed research organizations and private cooperative research laboratories.

From that time on, the national organization of research as a whole, would be increasingly well understood as being carried out in three main "administrative *spheres* [8] – not independent of one another", and contrasted to an era (the nineteenth century) in which independent scientists depended on sporadic benefactors (Bernal, 1939: 35). It would not take long for a "*national* science budget" to be constructed for policy purposes, representing the sum of expenditures devoted to research by government, universities, industry and philanthropy.

A holistic approach to research evolved gradually. At the very beginning, there was only one component in the research whole, or rather there was no whole at all. University research was said to be the basis of all progress, and pure science was contrasted with applied science, which was supposed to derive from pure science. The interest of academics here was to preserve a division of labour. This understanding was shared also among non-scientists very early on. As Willis Whitney from General Electric put it in 1934, the "principle of discovery first and utilization after is the oldest thing in man's history" (Whitney, 1934: 74).

Then industrialists added their voice to a national view of research, first suggested by governments due to the need to mobilize the scientific "estates" of the nation for the war. The research whole has obvious and necessary relationships between its components. The interest of industrialists was manifold. One was convincing more firms to invest in research and thus accelerate industrial progress. Another was to get support from universities and to participate in and benefit from the government effort during the war and subsequently.

The controversies over how to organize research as a whole have preoccupied research policy since then. The views have varied not only within the group of industrialists or between industry and academia but also between political parties. The debates that followed dealt with planning versus scientific freedom, or more basically with issues of who finance or should finance what kind of research and who benefit or should benefit from research funding. This was exactly the time when new concepts such as basic and applied research entered the public arena. The different groups of actors have become aware of the problem of research as a whole.

Organized Research

That research is conducted in many different types of settings is only one shift in the conceptualization of research over the twentieth century. This conceptualization went hand in hand with another change in meaning. Research is *organized* research, as Nutting put it. The terms organization and *organized* were on every manager's lips between 1915 and 1935: *The Organization of Industrial Scientific Research* (C. E. K. Mees, Kodak), *The Organization of Scientific Research in Industry* (F. B. Jewett, ATT), *Organized*

[8] Philanthropy, or non-profit, is more often than not a residual in "modern" versions of the whole approach.

Industrial Research (C. D. Coolidge, General Electric), *Organized Knowledge and National Welfare* (P. G. Nutting, Westinghouse) are only some of the numerous titles published.

What did organized research at this time mean? To industrialists, *organized* had three connotations. First, it referred to research conducted in organizations. Second, the concept stressed laboratory research. Third, the scientific method was a key characteristic of organized research, and was called *systematic* research. Let's look at the three criteria in turn.

First of all, organized research referred primarily to industrial organizations, in contrast to individual scientists (funded by philanthropists). The contrast is usually put into a narrative or story in two phases. "Until the twentieth century, industrial research remained largely a matter of the unorganized effort of individuals. Early in the 1900's a few companies *organized* [our italics] separate research departments and began a *systematic* [our italics] search not only for the solution of immediate problems of development and production, but also for new knowledge that would point the way to the future" (Bartlett, 1941: 19). This is how the National Research Council and historian Howard Bartlett from MIT narrated the evolution of research conducted in industry in a voluminous study on industrial research published in 1941 by the National Resources Planning Board. This was a shared understanding at the time. In 1940, the Works Progress Administration conducted a survey of industrial laboratories, using National Research Council directories, to assess the scope of research conducted in industry in the United States. The authors contrasted colonial times when research was random, haphazard and unorganized because it was realized by independent individuals (Perazich and Field, 1940: 46-47) with modern times when, between 1927 and 1938 for example, "the number of organizations reporting research laboratories has grown from about 900 to more than 1,700 affording employment to nearly 50,000 workers" (Perazich and Field, 1940: 40).

Such stories or narratives were legion at the time, one of the first to put it as such being Kenneth Mees:

> "In the early days of the technical industries the development of new processes and methods was often dependent upon some one man, who frequently became the owner of the firm which exploited his discoveries. But with the increasing complexity of industry and the parallel increase in the amount of technical and scientific information necessitating increasing specialization, the work of investigation and development which used to be performed by an individual has been delegated to special departments of the organization, one example of which is the modern industrial research laboratory." (Mees 1916: 764; see also Jewett 1932: 5)

The stories went hand in hand with a literature on the cumulative nature of discovery and invention, as opposed to genius, as anthropologists, sociologists and historians studied it in the 1920-30s (e.g. William Ogburn, Colum Gilfillan, Robert Merton, Abbott Usher).

Second, as the National Research Council survey stated, organized research refers to the laboratory, with specialization and division of work. “Industry can no longer rely on random discoveries, and it became necessary to organize the *systematic* [our italics] accumulation and flow of new knowledge. This prerequisite for the rise of industrial research to its present proportions was being met by the formation of large corporations with ample funds available for investment in research” (Perazich and Field, 1940: 41). “The facilities available in these laboratories make it possible for the scientist to devote his time *exclusively* [our italics] to work of a professional caliber. He is not required to perform routine tasks of testing and experimentation but is provided with clerical and laboratory assistants who carry on this work” (Perazich and Field, 1940: 43). Research is not a part-time or *ad hoc* activity, as it is in university (e.g.: Kenneth Mees, Oliver Buckley), but an activity conducted in a continuous fashion. Thanks to the laboratory, research can be planned and directed.

Third, organized research means research conducted according to the scientific method, rather than by rule of thumb, namely *systematic* research. Whether one looks at twentieth century dictionaries, definitions of research always contain the idea of ‘systematicness’. The 1939 edition of the Webster’s dictionary, for example, defined research as “*diligent* inquiry or examination in seeking facts or principles”, [9] while more recent definitions often specify “diligent *and systematic*”. One historical use of the concept is from Francis Bacon on the method of induction, as opposed to discovery by accident (*Novum Organum*, 1620). Bacon’s term for systematic is *ordine*.

In the discourses of industrialists, *systematic* is a concept often used concurrently with that of *organized*. The National Research Council survey began with the following fact: “The *systematic* [our italics] application of scientific knowledge and methods to research in the production problems of industry has in the last two decades assumed major proportions” (Perazich and Field, 1940: xi). Maurice Holland, Director of the Engineering and Industrial Research Division of the National Research Council**,** thought similarly**:** “There was a time in the history of mankind”, Holland stated, “when new products or processes were discovered by accident, rather than deliberately invented … Industrial research properly *organized* [our italics] , properly equipped with a selected personnel, making proper use of new fundamental knowledge, and properly coordinated with all other functions” has now replaced the rule of thumb … Scientific research has made of invention a *systematic* [our italics], highly efficient process” (Holland and Spraragen, 1933: 12-13).

These are only some examples of the rhetoric of the time. In 1932, for example, the National Research Council organized a conference in which industrialists, among them Willis Whitney, talked of *science as systematized knowledge and research as systematized search*, and urged that “America must be foremost in *systematic, organized* research [our italics], or we shall be distanced by other countries” (Whitney and Hawkins, 1932: 245, 253). Here, the understanding of systematic oscillated between the meaning of generic facts and principles, discovered by experiments on the one hand; on

[9] *Webster’s 20th Century Dictionary of the English Language*, New York: Guild Inc., 1939.

the other, that of a whole, mainly the European model of free men devoting their entire time to research with the assistance of students (Whitney and Hawkins, 1932: 245-249). Others talked simply of *scientific spirit* and *scientific principles*, which had replaced the mere rules of thumb (Nutting, 1917: 250; Jewett, 1918: 2).

Despite the use and diffusion of the concept or phrase *organized research* in the 1930-40s, the idea that the organization has ousted the individual in terms of research activities remained contested in the following decades. “The doctrine is now promulgated”, stated John Jewkes and his colleagues in 1958, “that industrial society can get along without individual independence and generate its necessary innovations by mass effort” (Jewkes, Sawers and Stillerman 1958: 179-80). This was not only the view of industrialists. Joseph Schumpeter defended the idea in the early 1940s (as did John Galbraith later), [10] and many scholars continued to do so in the following decades when narrating the history of research conducted in the first half of the twentieth century (e.g.: Schmookler, 1957; 1960; Hughes, 2004). [11] But to Jewkes, “the individual inventor is still important” (Jewkes, Sawers and Stillerman 1958: 182). Jewkes was right. The doctrine is in fact a “common misperception that result[s] from tendentious rhetoric and sophisticated public relations”, as historian Erick Hintz puts it (Hintz, 2011: 6). “It is only after about 1955 that we start to see a sharp divergence and the dominance of corporate patenting” (Hintz, 2011: 4).

Research and Development

While the experience of WW1 was an important impetus to a changing conceptualization of research, the experience of WW2 changed this conception further. Research came to be talked of in terms of *research and development*, or *R&D* (see Figure 1). If industry is part of the research whole, as many industrialists assumed, the concept of research has to reflect this fact. Hence the concept or phrase R&D. The concept has two main purposes. The first is organizational. It corresponds to the type of research conducted in industry, to research divisions in firms, and to entire organizations that defined themselves according to both research and development. The second purpose is analytical and statistical. Policy-makers, consultants, statisticians and scholars developed taxonomies identifying development as a separate and decisive category of research and a step in the process of economic growth. [12]

We turn in this section to a totally different set of actors than the industrialists. Yet it is the model of industrial research that these actors adopted and adapted.

[10] “The perfectly bureaucratized giant industrial unit … ousts the entrepreneur” (Schumpeter, 1942: 134).
[11] True, to Schmookler “independent invention has declined. But it has not vanished … [The independent inventor is just] no longer the major source of the economy’s dynamism” (Schmookler, 1960: 145-46).
[12] A third purpose, not discussed here, is political: 1. Prestige: adding development to research to show larger expenditures; 2. Public funding: including development in research expenditures to get a greater amount of money from public funds (e.g.: tax credits). See Godin (2006b).

An Organizational Category

In his classic book from 1920, Kenneth Mees described the development laboratory as a small-scale manufacturing department devoted to developing “a new process or product to the stage where it is ready for manufacture on a large scale”. The work of this department was portrayed as a sequential process: development work is “founded upon pure research done in the scientific department, which undertakes the necessary practical research on new products or processes as long as they are on the laboratory scale, and then transfers the work to special *development* [our italics] departments which form an intermediate stage between the laboratory and the manufacturing department” (Mees, 1920: 79).

Figure 1.
Research and Development: Frequencies
(Google Ngram)

While research was originally an academic category, *development* is an industrial category. It is composed of those activities which are devoted to developing prototypes of new goods and services: engineering, design, testing, scaling-up and pilot plants. Development as a concept comes from biology and social evolutionism in the second half of the nineteenth century, and started to be used in industry in the late nineteenth-early as the evolution of industry which could be accomplished through research. The term was also used somewhat ambiguously to mean both a new thing and the latter stage of a project.

Development gave its name to firms’ divisions, previously called (experimental or technical) laboratories, which later got separated into research (applied research) and development (developing new products) divisions. Development got still more attention from the 1920s onward when many started talking of a spectrum (and a sequence) from basic research to applied research then to development – rather than the dichotomy basic *versus* applied. Such was the case in management (Mees, 1920), in Maurice Holland’s “research cycle” (Holland, 1928), and in economic historian Rupert Maclaurin’s linear model of innovation – not named as such at the time (Maclaurin, 1949).

True, the early public discourses of the National Research Council and its industrial members, since they were aimed at persuading firms to get involved in research, mainly talked of research or science, ignoring development. But within firms, the reality was different: there was little basic research, some applied research and a lot of development. To industrialists, research was entirely aimed at developing new products for commercialization, and development was an integral part of (applied) research. The organization of research in firms reflected this interpretation: until the 1920s, there were very few separate departments for research on the one hand, or development on the other. Both activities were carried out in the same department, usually called the experimental laboratory (Bell), technical laboratory (Bayer) or, increasingly, development laboratory (Du Pont). It was also the same kind of people (engineers, chemists) who carried out both types of tasks (Wise, 1980; Reich, 1983). All in all, most of the laboratories "were, in fact, testing or engineering labs, where scientists and engineers labored to assure consistency and efficiency in production" (Reich, 1985: 2), a fact admitted by most industrialists and analysts of the time, [13] but obscured by the increased use in the 1920s of both terms "research and development" together. The two activities first split when a few companies began to do "fundamental" research. Several large laboratories began to develop separate divisions for the two functions – research and (product) development. By 1945, most large companies conducting research had these two types of laboratories or divisions.

R&D as an acronym came to be widely used in the mid-1940s. It is to the US Office of Scientific Research and Development (OSRD), created in 1941 to contribute to the war research efforts, that we owe the wide diffusion of the acronym in public discourse. At the OSRD, development activities were coupled to those of research, above all in the organization's name, for two reasons. First, there were problems during the war getting technological innovations rapidly into production (Purcell, 1979: 363). As Irvin Stewart noted (Stewart, 1948: 35):

> Between the completion of research and the initiation of a procurement program there was a substantial gap which the armed services were slow to fill. It was becoming increasingly apparent that for the research sponsored by NDRC [the National Defense Research Committee, OSRD's predecessor] to become most effective, it was essential that the research group carry its projects through the intermediate phase represented by engineering *development* [our italics].

In fact, firms experienced a lot of problems with production, and universities were often called on to help with development (pilot plants, large-scale testing) (Owens, 1994). In 1943, the OSRD created the Office of Field Service to bring research closer to its military users. "Military dissatisfaction with the performance of new weapons in combat, although it might result from improper use in the hands of personnel without technical

[13] "The term research is frequently applied to work which is nothing else than *development* [our italics] of industrial processes, methods, equipments, production or by-products" (US National Research Council, 1920: 1-2). There is a "difficulty of distinguishing between scientists and technicians in industrial service. Many mechanical engineers, and still more electrical and chemical engineers, are necessarily in part scientists, but their work on the whole cannot be classified as scientific research as it mostly consists of translating into practical and economic terms already established scientific results" (Bernal, 1939: 55).

knowledge, could delay an entire program of research and development" (Stewart, 1948: 128). The services rendered by the Office of Field Service were, among other things, "analysis of the performance of new weapons and devices under field combat condition, which might result in modifications back to the laboratories; assistance in promoting the flow of technical information between laboratories and production plants and the field users" (Stewart, 1948: 131).

With the OSRD, Vannevar Bush as Director succeeded in obtaining greater responsibilities than he had with its predecessor, the National Defense Research Committee, namely responsibilities for development, procurement and liaison with the Army, in addition to research activities (Owens, 1994: 527), without getting involved in production *per se*, i.e.: with respect for the frontiers between research and production. Thanks to the OSRD, among others, the "R&D" acronym spread to other public organizations, first among them the Department of Defense: the *Research and Development* Board (1946), the RAND project (1948) which gave the current organization its name, [14] the Air Force *R&D* Command (1950), and the position of Assistant Secretary of Defense for *R&D* (1953). In the private sector, firms like American *R&D* (a venture capital firm) and Evans *R&D* (a consulting firm) were set up after the war.

An Analytical and Statistical Category

R&D crystallized in discourse, due to the invention of precise categories intended to measure the whole or national scope of research. If development represents the bulk of research activities in industry, national statistics had to reflect that. From the 1930s onward taxonomies of research appeared with development as a subcategory, and the first numbers on development were collected beginning in the late 1940s. We can identify three stages in the construction of *development* as one of these categories. First, at the beginning development was only a series or list of activities without a label, but identified for definition purposes and for inclusion in questionnaire responses. Although it had been measured since the early 1920s, the question "what is research?" was originally left to the questionnaire respondent to decide. The first edition of the US National Research Council directory of industrial research laboratories reported using a "liberal interpretation" that let each firm decide which activities counted as research: "all laboratories have been included which have supplied information and which by a liberal interpretation do any research work" (National Research Council, 1920: 45). And the National Research Council's report admitted that "research is frequently applied to work which is nothing else than *development* [our italics]". Again in 1941, in its study on research in industry conducted for the US National Resources Planning Board, the National Research Council used a similar practice: the task of defining the scope of activities to be included under research was left to the respondent (National Research Council, 1941: 173).

Second, development came to be identified as such by way of creating a subcategory of research, alongside basic and applied research. The categories were used

[14] RAND means R and D.

for measurement. We owe to British and left-wing scientist Julian Huxley the introduction of new terms and the first formal taxonomy of research, if we except the dichotomy basic research/applied research. The taxonomy had four categories: background, basic, ad hoc and development. The first two categories defined pure research: background research is research "with no practical objective consciously in view", while basic research is "quite fundamental, but has some distant practical objective … Those two categories make up what is usually called pure science" (Huxley, 1934: 253). To Huxley, ad hoc meant applied research, and development meant more or less what we still mean by the term today: "work needed to translate laboratory findings into full-scale commercial practice".

Despite having these definitions in mind, however, Huxley did not conduct any measurements. We owe to the Canadian Department of Reconstruction and Supply the first measurement of development *per s*e (Department of Reconstruction and Supply (1947). Development was defined as "all work required, after the initial research on the laboratory (or comparable) level has been completed, in order to develop new methods and products to the point of practical application or commercial production". The inclusion of development was (probably) motivated by the importance of military procurement in the government's budget on science (contracts to industry for developing war technologies). Indeed, most of the data were broken down into military and non-military expenditures. Overall, the Department estimated that 40% of the $34 million spent on federal scientific activities went to research, 48% to development, and 12% into analysis and testing.

Although innovative with regard to the measurement of development (in government research), Canada would not repeat such a measurement before the advent of the OECD recommendations contained in the Frascati manual published in 1962. It is, in fact, to Robert Anthony from the Harvard Business School and to the Bureau of Labor Statistics, that we owe the first measurement of all of the terms in the taxonomy, with precise definitions (Anthony, 1952; Dearborn, Kneznek and Anthony, 1953). The surveys revealed that industry spent 8% of its research budget on basic (or uncommitted) research, 42% on new products (applied research) and 50% on product improvement (development). Then, the National Science Foundation followed with yearly measurements, and extended the definitions to all sectors of the economy: university, government, industry and non-profit organizations (US National Science Foundation, 1953; 1957). By that time, the taxonomy was reduced to three terms, as it continues to this day: basic research, applied research, and development (see Apendix 1).

As a third step, development became a category on its own, alongside research. After 1945, development shifted from being a subcategory of research (together with basic and applied research) to a separate category. It gave us the acronym we now know and use: R&D. Officials coined the acronym and measured the combination of the two activities as one and the same concept. R&D no longer applies only to industry, but also to all sectors of the economy.

Like organized research, development is a contested category. To some, research is said to exclude development. As economist Simon Kuznets put it, development "is a job of adjustment"; "it is not original invention". [15] Similarly, to economist Jacob Schmookler, development "does not demand the creative faculty which the term invention implies" (NBER, 1962: 45). To others, like David Novick from RAND: "we should stop talking about research and development ["a fashionable phrase"] as though they were an entity and examine research on its own and development as a separate and distinct activity" (Novick, 1965b: 13; see also Novick, 1960; 1965a). Over time, the economists lost their argument: the "D" got into R&D (Godin, 2006a; 2006b), and scholars began to devote specific studies to development *per se* (e.g.: Furnas, 1948; Jewkes et al., 1958; Scherer, 1965; Hughes, 1976). "Development is simply an extension of research", claimed Clifford Furnas in 1948, "but it is so different … that it requires separate considerations" (Furnas, 1948: 21).

The Marginalization of Research

The phrase R&D and the categories basic research, applied research and development spread to the official (conventionalized) definition of and statistics on research from the 1950-60s onward, beginning with the NSF (1953, 1957), then by the OECD (1962, 1970) and UNESCO (1968, 1977) (see Appendix 2). Research and development is "creative work undertaken on a *systematic* basis [our italics] to increase the stock of scientific and technical knowledge and to use this stock of knowledge to devise new applications" (OECD, 1970 31). [16]

The concept of *organized* and *systematic* research is a key feature of this definition. Gradually, systematic shifted from having a scientific connotation (method) [17] to an institutional connotation (organizations with dedicated laboratories). [18] Official

[15] "I do not mean to disparage development work when I exclude it from inventive activity; it certainly makes demands upon ingenuity, technical knowledge, and ability. But it is a job of adjustment within given patterns of the production process; it is not original invention" (NBER, 1962: 34-35).

[16] The first edition of the OECD Frascati manual (1962) has no such definition. Research and development is defined by way of categories.

[17] "With the growth of modern scientific methods … which proceed by observation and experiment, and by the *systematizing* of the resulting facts and relationships into truth and laws, the search for new knowledge, especially in the scientific and technical fields has become more and more institutionalized and professionalized" (Canadian Department of Reconstruction and Supply, 1947: 5); "An activity can be said to be scientific, in fact, when it is based on a network of logical relationships, which make it possible to obtain reproducible and measurable results. The methods used to obtain these results may be considered as techniques when the skills they employ are also *systematic*, when these skills are based on numerical measurements, and when the results which these measurements give are reliable" (UNESCO, 1974:1); scientific research is "the use of scientific methods, or work in a systematic way" (UNESCO, 1977b: 81).

[18] "In the past, inventions have come mainly from individual free-lance inventors, or have merged almost accidently as by-product of scientific discoveries … But most inventions, particularly in industries based on advanced technology, are now sought *systematically*, by providing adequate facilities and arranging an appropriate environment of encouragement for the people who do the work, as part of planned programmes of innovation and marketing" (British Central Advisory Council for Science and Technology, 1968: 1); "An activity to be considered at the international level of science statistics must be properly structured, i.e.: it must meet the minimum requirements of a *sytematic* activity such as: the person(s) exercising this activity must work during a significant number of hours per year; there must exist a programme of work; a

surveys measure research conducted in organizations (industry, university and government as units of observation) and research performed on a continuous basis (thus minimizing SME's *ad hoc* research activities). [19] The numbers are then aggregated to produce a national statistic on the research whole, what Desmond Bernal called a "national research budget", and what statisticians call GERD today (Gross Expenditures on R&D).

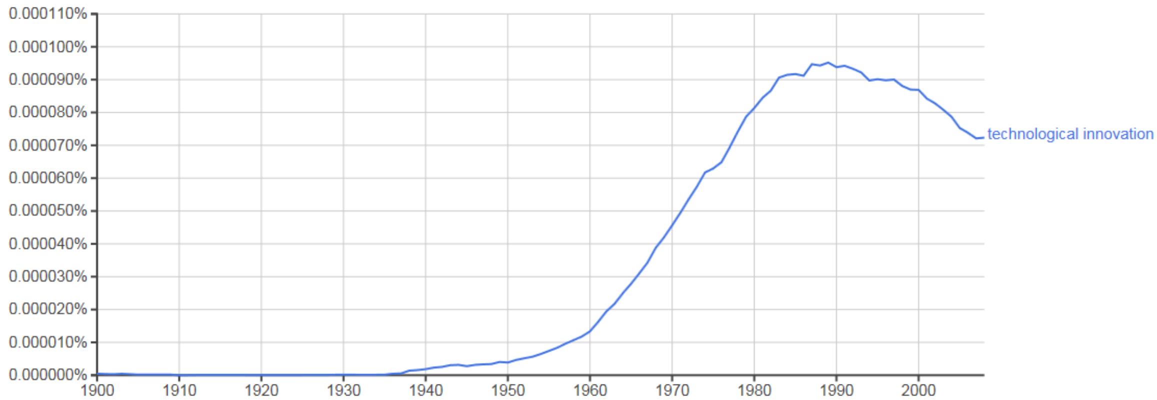
In spite of these works which made research a key concept of the twentieth century, a parallel but opposite discourse on research emerged in the 1960s and after. "The 1960's saw the emergence of a new awareness that research by itself does not provide direct answers to the problems faced in the practical world" (Havelock and Havelock, 1973: 1). "Research alone is not enough" (Rogers, 1962: 2), "Creativity is not enough" (Levitt, 1963), "R&D are not enough" (Morton, 1971: 4). It is use that matters: only the application of research results leads to progress, not research *per se* (see also Lorsch and Lawrence, 1965: 109; Morse and Warner, 1966: 15, 17). Certainly, development stresses economic considerations: "As one moves from invention to development the technical considerations give way to the market considerations" (Jewkes, Sawers and Stillerman 1958: 18-19). But there are many activities other than development involved in technological innovation. Highlighting these activities is the function of the concept or phrase *technological innovation* and its diffusion (see Figure 2).

---

certain amount of financial resources must be specifically allocated to the work. This means that diffused, discontinued or scattered S&T activities, i.e.: activities carried on sporadically, or from time to time, within the various services of an institution, thus not meeting the above-mentioned minimum requirements of a *systematic* activity, should not be taken into account. There follows, therefore, that non-institutionalized, individual and/or discontinued, diffused or scattered activities are to be excluded for the presentation od international statistics (UNESCO, 1977a: 10)**.**

[19] In 1993 the OECD offered the following rationale for measuring research conducted on a regular basis: "R&D has two elements. R&D carried out in formal R&D departments and R&D of an informal nature carried out in units for which it is not the main activity. In theory, surveys should identify and measure all financial and personnel resources devoted to all R&D activities. It is recognized that in practice it may not be possible to survey all R&D activities and that it may be necessary to make a distinction between "significant" R&D activities which are surveyed regularly and "marginal" ones which are too small and/or dispersed to be included in R&D surveys" (OECD, 1993: 105-106). American accountant Robert Anthony offered the same rationale in 1952: "The fact that there are almost 3,000 industrial research organizations can be misleading. Most of them are small … Over half employ less than 15 persons each, counting both technical and non-technical personnel. Many of these small laboratories are engaged primarily in activities, such as quality control, which are not research or development. [Therefore] this report is primarily concerned with industrial laboratories employing somewhat more than 15 persons" (Anthony, 1952: 6-7).

Figure 2.
Technological Innovation: Frequencies
(Google Ngram)



Initially, technological innovation was explained in terms of what is known today as the "linear model of innovation" (Godin, 2003; 2006a). What was originally a dichotomy (basic research/applied research), then a classification of types of research (basic research, applied research, development), gave rise to a sequence. Innovation is a process that starts with basic research, followed by applied research, then development, then commercialization. Critics of the linear model of innovation usually stress that basic research is not the starting point of technological innovation, or that technological innovation is not a linear sequence, beginning with basic research. Yet, what is missing in the criticisms is a historical perspective, that takes the inventor of the model (economic historian Rupert Maclaurin) seriously (Godin, 2008). Maclaurin was broadening the discourse of the time, on (basic) research leading automatically to technological innovation. Using radio as a case study, he illustrated "the steps which are required to bring a new scientific concept from the theoretical stage to a successful commercial product" (Maclaurin, 1946: 426). Technological innovation is not only the affair of scientists: "The innovator as an individual takes his place with the pure scientist and the inventor as a key figure in material progress" (Maclaurin, 1953: 105). Innovation includes activities other than basic research as necessary stages: "Advances in science are not automatically translated into advances in the practical arts" (Maclaurin, 1949: xiii). Between fundamental research and its applications, there is a "continuum" or "sequence" of activities, or "stages".

This is exactly the rhetoric that served the early 'theorists' of technological innovation. Innovation is a *total* process (Morton, 1971: 3-4):

> Innovation is not just one single act. It is not just a new understanding or the discovery of a new phenomenon, not just a flash of creative invention, not just the development of a new product or manufacturing process; nor is it simply the creation of new capital and consumer markets. Rather, innovation involves related creative activity in *all* [Morton's italics] these areas. It is a connected process in which many and sufficient creative acts,

> from research through service, couple together in an integrated way for a common goal … By themselves R&D are not enough to yield new social benefits. They, along with capital resources, must be effectively coupled to manufacturing, marketing, sales, and service. When we couple all these activities together, we have the connected specialized elements of a *total* [our italics] innovation process.

These views were part of a widespread discourse among engineers and managers of the time. A symposium sponsored by the US National Academy of Engineering in 1968 concluded, "There appears to be general agreement that the process of successful technological innovation depends on many more factors than the mere generation of scientific and engineering information" (US National Academy of Engineering, 1968: Foreword, no page number). To managers too, innovation was seen as a total process. The summary statement of the annual meeting of the Industrial Research Institute (IRI) on innovation, where over one hundred research managers gathered in April 1970, begins with the following "authoritative picture" of innovation: "Innovation is the process of carrying an idea – perhaps an old, well known idea – through the laboratory, development, production and then on to successful marketing of a product … The technical contribution does not have a dominant position" (Research Management, 1970: 45).

The emergence of the concept of technological innovation represents a desire to enlarge the discourse on science. Innovation is action contributing to the practical, namely economic progress, while science is strictly mental and contributes only indirectly to technological innovation, when it contributes at all. An influential input into these views came from the US Department of Commerce. In 1964, the US President asked the Department to explore new ways of "speeding the development and spread of new technology". To this end, Herbert Hollomon, as Secretary for Science and Technology, set up a panel on invention and innovation. Its report was published in 1967 as *Technological Innovation: Its Environment and Management*. The report began by making a distinction between invention and innovation as the difference between the verbs "to conceive" and "to use". To the Department, innovation is a "complex process by which an invention is brought to commercial reality" (US Department of Commerce, 1967: 8). R&D is only one phase or step in this process. Innovation includes R&D, engineering, tooling, manufacturing and marketing. Using "rule of thumb" figures from "personal experience and knowledge" of the members of the panel, the Department reported that R&D corresponds to only between five and ten percent of innovation costs. "It is obvious that research and development is by no means synonymous with innovation" (Department of Commerce, 1967: 9).

The Department paved the way for an influential representation of innovation in the following decades. Policy-makers, supported by engineers/managers and scholars, embraced this representation without reservation. Technological innovation is not just R&D (Godin, Forthcoming 2016-b). [20] It is a "total process", an "entire venture", embedded in a "total environment" (US Department of Commerce, 1967: 2, 8, 11, 14): [21]

---

[20] "The factors involved are by no means all, or mainly scientific; some of the most important are indeed sociological" (British Advisory Council on Scientific Policy, 1964: 8); "technical innovation depends

The term ‘technological innovation’ can be defined in several ways … At one extreme innovation can imply simple investments in new manufacturing equipment or any technical measures to improve methods of production; at the other it might mean the *whole* [our italics] sequence of scientific research, market research, invention, development, design, tooling, first production and marketing of a new product (British Advisory Council for Science and Technology, 1968: 1).

Invention and innovation encompass the *totality* [our italics] of processes by which new ideas are conceived, nurtured, developed and finally introduced into the economy as new products and processes; or into an organization to change its internal and external relationships; or into a society to provide for its social needs and to adapt itself to the world or the world to itself (US Department of Commerce, 1967: 2).

Technological innovation has given rise to a new semantic pair. The century-old basic research/applied research dichotomy is concerned with, or internal to, science. It contrasts two types of research. The twentieth century brought in a new pair or dichotomy: research/innovation. Technological innovation sprang from a tension between science (for its own sake) and society, or aspiration to action. The contrast is no longer internal to science, one between types of research, but between research and society. Innovation is contrasted to research, particularly basic research, in society’s name. Research has to be useful to society – through the market. [22]

Conclusion

Two intimately linked issues were the driving factors explaining a shift in the meaning of research over the twentieth century. The first was national issues. Mobilisation for war, then national progress (e.g. economic progress) defined the discourse on research as whole. A nation needs the coordination of all the research

---

not only on R and D, but also on the capacity of firms to use its results” (OECD, 1966: 11); “a high level of R and D is far from being the main key to successful innovation … Government support should be given to the *whole* [our italics] process of technological innovation, in contrast to its present overwhelming emphasis on the opening phases of research and development … The most difficult and complex problems in the process of technological innovation generally lie in this final phase [of marketable products which the customer wants and the producer can make at profit], the phase which includes aggressive and sophisticated marketing” (British Advisory Council for Science and Technology, 1968: 9, 15).

[21] In terms of government policy, total means the “co-ordinated and concerted action” of several ministries (OECD, 1966: 7), and the combination of direct (funding) and indirect (climate) measures (OECD, 1966: 10).

[22] In the 1960-70s, the scholarly literature on science and technology was witness to similar debates that, in the end, contributed to the marginalization of research. In the late 1960s, a much debated study from the Department of Defense “confirmed” the results from the US Department of Commerce: most military innovations do not depend on basic research (US Department of Defense, 1969). The National Science Foundation contested the results with its own numbers (IIT Research Institute, 1968; Battelle, 1973). A long lasting controversy followed among scholars, as to whether technological innovation is science-push or market-pull … or both. Most scholars concluded that both factors are “coupled” together in the process of innovation (e.g.: Myers Marquis, 1969; Langrish et al., 1972). Research has no exclusive role.

resources at its disposal if it is to prosper. The second issue was organizational: industry needs systematic research to advance and, by the way, to contribute to national progress.

The idea of research as a whole opened a new semantic field and led, more generally, to a new framing of the discourses on science. Over the twentieth century, science changed considerably, shifting from being a central cultural value of society to a subsidiary one, at least in public discourse and public policy, and among theorists on innovation. In this article, we looked at how the concept of research contributed to this shift:

- Research is not the province of the university alone.
- Research is not the task of individuals but that of organizations and (organized) laboratories.
- Research is research and development.
- Research is not always the driving factor of economic progress.

Steven Shapin (2008) has demonstrated how academics in the twentieth century portrayed the industrial scientist as a second-rate scientist, limiting the idea of real science to their own activities. In research policy and innovation discourse, however, this hierarchical order seemed to be flattened earlier than in the overall academic discourse and in the scholarly discourse of STS in particular. Within the changing policies, which has been characterized as a shift from science to technology to innovation (e.g.: Elzinga and Jamison, 2001), [23] it was and still is research as a whole from which experts and the public expect a contribution to technological progress, economic prosperities and innovation in general. This article showed that research is more than a simple word denoting scientific activities. It turned into an institutional category since nations started to align science primarily with economic and governmental interests. It is worth of becoming an object of conceptual history like the concept of innovation, which has recently attracted scholarly attention (Godin 2015, forthcoming-a, fortcoming-b)

[23] We disagree with Aant Elzinga and Andrew Jamison on some aspects of their periodization, that of the OECD.

References

Anthony, Robert N. (1952), *Management Controls in Industrial Research Organizations*, Boston: Division of Research, Graduate School of Business Administration, Harvard University.

Arthur D. Little (1913), Industrial Research in America, *Science*, 38 (984), 7 November: 643-656.

Bartlett, Howard R. (1941), *The Development of Industrial Research in the United States*, in National Resources Planning Board (1941), Research: A National Resource II: Industrial Research, Washington: 19-77.

Battelle-Columbus Laboratories (1973), *Interactions of Science and Technology in the Innovative Process: Some Case Studies,* Report to the National Science Foundation, Washington: National Science Foundation.

Bernal, John D. (1939), *The Social Function of Science,* Cambridge (Mass.): MIT Press [1967].

Bernard, Luther Lee (1923), Invention and Social Progress, *American Journal of Sociology*, 29 (1): 1-33.

British Advisory Council for Science and Technology (1968), *Technological Innovation in Britain,* London: HMSO.

British Advisory Council on Scientific Policy (1964), *Annual Report 1963-1964*, London: HMSO.

Buckley, Oliver E. (1942), Research Laboratories in Industries, *Science*, 96 (2483), 31 July: 100-102.

Bud, Robert (2012), "Applied Science": A Phrase in Search of a Meaning, *Isis* 103: 555-63.

Canadian Department of Reconstruction and Supply (1947), *Research and Scientific Activity: Canadian Federal Expenditures 1938-1946*, Government of Canada: Ottawa.

Clarke, Sabine (2010), Pure Science with a Practical Aim: The Meanings of Fundamental Research in Britain, circa 1916-1950, *Isis* 101: 285-311.

Cattell, James McKeen (1906), *American Men of Science: A Biographical Directory*, New York: Science Press.

Cohen, I. Bernard (1948), *Science Servant of Men*, Boston: Little, Brown and Co.

Dear, Peter (2005), What is the History of Science the History of? *ISIS* 96: 390–406.

Dearborn, De Witt C., Rose W. Kneznek and Robert N. Anthony (1953), *Spending for Industrial Research*, *1951-1952*, Division of Research, Graduate School of Business Administration, Harvard University.

Derksen, Maarten and Tjardie Wierenga (2013), The History of 'Social Technology', 1898-1930, *History and Technology* 29 (4): 311-30.

Dupree, A. Hunter (1957), *Science in the Federal Government*, New York: Harper and Row.

Elzinga, Aant and Andrew Jamison (2001), Changing Policy Agenda in Science and Technology, in Sheila Jasanoff, Gerald E. Markle, James C. Peterson and Trevor Pinch (eds.), *Handbook of Science and Technology Studies*, Thousand Oaks (CA), Sage: 572-97.

Epstein, Ralph (1926), Industrial Invention, Heroic, or Systematic?, *Quarterly Journal of Economics*, 40: 426-476.
Forman, Paul (2007), The Primacy of Science in Modernity, of Technology in Postmodernity, and of Ideologies in the History of Technology, *History and Technology*, 23: 1-152.
Furnas, Clifford C. (1948), *Research in Industry: Its Organization and Management*, Princeton: D. van Nostrand.
Gibbons, Michael, Camille Limoges, Helga Nowotny, Simon Schwartzman, Peter Scott and Martin Trow (1994), *The New Production of Knowledge: the Dynamics of Science and Research in Contemporary Societies*, London: Sage.
Gilfillan, S. Colum (1935), *The Sociology of Invention*, Cambridge (Mass.): MIT Press.
Godin, Benoît (2005), *Measurement and Statistics on Science and Technology: 1920 to the Present*, London: Routledge.
Godin, Benoît (2006a), The Linear Model of Innovation: the Construction of an Analytical Framework, *Science, Technology, and Human Values*, 31 (6): 639-67.
Godin, Benoît (2006b), Research and Development: How the "D" got into R&D, *Science and Public Policy*, 33 (1): 59-76.
Godin, Benoît (2008), In the Shadow of Schumpeter: W. Rupert Maclaurin and the Study of Technological Innovation, *Minerva*, 46 (3): 343-60.
Godin, Benoît (2015), *Innovation Contested: The Idea of Innovation Over the Centuries*, London: Routledge.
Godin, Benoît (Forthcoming-a), *Models of Innovation: History of an Idea*, MIT Press.
Godin, Benoît (Forthcoming-b), Technological Innovation: The Emergence and Development of an Inclusive Concept, *Technology & Culture*.
Gooday, Graeme (2012), "Vague and Artificial": The Historically Elusive Distinction Between Pure and Applied Science, *ISIS*, 103 (3): 546–554.
Grandin, Karl et al., eds. (2004), The Science-Industry Nexus. History, Policy, Implications. Nobel Symposium, 123. Sagamore Beach: Science History Publications/USA.
Hart, Hornell (1931), *The Technique of Social Progress*, New York: H. Holt and Company.
Havelock, Ronald G. and Kenneth Dean Benne (1967), An Exploratory Study of Knowledge Utilization, in Goodwin Watson (ed.), *Concepts for Social Change*, NTL Institute for Applied Behavioral Science, National Education Association, Washington: 47-70.
Havelock, Ronald G. and Mary C. Havelock (1973), *Educational Innovation in the United States*, report to the National Institute of Education, US Office of Education, Washington.
Hintz, Eric S. (2011), The Post-Heroic Generation: American Independent Inventors, 1900-1950, *Enterprise & Society*, 12 (4): 732-748.
Holland, Maurice (1928c), Research, Science and Invention, in Frederic W. Wile (ed.), *A Century of Industrial Progress*, American Institute of the City of New York, New York, Doubleday, Doran and Co.: 312-334.
Holland, Maurice and William Spraragen (1933), *Research in Hard Times*, Division of Engineering and Industrial Research, National Research Council: Washington.
Hoover, Herbert (1927), The Nation and Science, *Science*, 65 (1672), 14 January: 26-29.

Hounshell, D. A. (1980), Edison and the Pure Science Ideal in 19th Century America, *Science*, 207: 612–17.

Hughes, Thomas P. (1976), The Development Phase of Technological Change, *Technology and Culture*, 17: 423-31.

Hughes, Thomas P. (2004), *American Genesis: A Century of Invention and Technological Enthusiasm, 1870-1970*, Chicago: University of Chicago Press.

Hull, Andrew (1999), War of Words: the Public Science of the British Scientific Community and the Origins of the DSIR, *British Journal of the History of Science*, 32: 461-481.

Huxley, Julian S. (1934), *Scientific Research and Social Needs*, London: Watts and Co.

IIT Research Institute (1968), *Technology in Retrospect and Critical Events in Science (TRACES),* Washington: National Science Foundation.

Jewett, Frank B. (1918), Industrial Research, *Reprint and Circular Series of the National Research Council*, No. 4, National Research Council.

Jewett, Frank B. (1932), The Philosophy and Practical Application of Industrial Research, in Malcolm Ross, Maurice Holland and William Spraragen (eds.), *Profitable Practice in Industrial Research: Tested Principles of Research Laboratory Organization, Administration, and Operation*, New York: Harper and Brothers Publishers: 1-39.

Jewkes, John, David Sawers and Richard Stillerman (1958), *The Sources of Invention*, London: Macmillan [1969].

Kevles, Daniel J. (1971), *The Physicists: the History of a Scientific Community in Modern America*, New York: Knopf.

Kline, Ronald (1995), Construing Technology as Applied Science: Public Rhetoric of Scientists and Engineers in the United States, 1880-1945, *Isis* 86: 194-221.

Kohler, Robert E. (1991), *Partners in Science: Foundations and Natural Scientists 1900-1945*, Chicago: University of Chicago Press.

Latour, Bruno (1993), *We Have Never Been Modern*, Cambridge/Mass: Harvard University Press.

Latour, Bruno (1998), From the World of Science to the World of Research? *Sciences 280* (5361, 10/04/1998): 208–09.

Langrish, John, Michael Gibbons, William G. Evans and Frederic Raphael Jevons (1972), *Wealth from Knowledge: Studies of Innovation in Industry,* London: Macmillan.

Levitt, Theodore (1963), Creativity is not Enough, *Harvard Business Review*, May-June: 72-83.

Lorsch, Jay W. and Paul R. Lawrence (1965), Organizing for Product Innovation, *Harvard Business Review* 43: 109-22.

Lucier, Paul (2012), The Origins of Pure and Applied Science in Gilded Age America, *Isis* 103 (3): 527-36.

Maclaurin, William Rupert (1946), Investing in Science for the Future, *Technology Review*, May: 423-454.

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

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

Macleod, Roy, and E. Kay Andrews (1970), The Origins of the DSIR: Reflections on Ideas and Men, 1915-1916, *Public Administration*, 48: 23-48.

Marx, Leo (2010), Technology: The Emergence of a Hazardous Concept, *Technology and Culture* 51 (3): 561–77.

Mees, C. E. Kenneth (1914), The Future of Scientific Research, *The Journal of Industrial and Engineering Chemistry*, 6 (8): 618-619.

Mees, C. E. Kenneth (1916), The Organization of Industrial Scientific Research, *Science* XLIII (1118), 2 June: 763-773.

Mees, C. E. Kenneth (1920), *The Organization of Industrial Scientific Research*, New York: McGraw Hill, 1950.

Morse, Dean and Aaron W. Warner (eds.) (1966), *Technological Innovation and Society*, New York: Columbia University Press.

Morton, Jack Andrew (1971), *Organizing for Innovation: A Systems Approach to Technical Management*, New York: McGraw Hill.

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

Nikiforova, Natalia (2015), The Concept of Technology and the Russian Cultural Research Tradition, *Technology and Culture* 56 (1): 184-203.

Novick, David (1960), What do we Mean by R&D?, *Air Force Magazine*, October: 114-118.

Novick, David (1965a), Statement of David Novick, in US Senate, *Hearings before the Subcommittee on Antitrust and Monopoly of the Committee on the Judiciary*, Part III: Concentration, Invention and Innovation, Washington: USGPO: 1241-56.

Novick, David (1965b), The ABC of R&D, *Challenge*, June: 9-13.

Nutting, Perley G. (1917), Organized Knowledge and National Welfare, *Science*, XLVI (1185), 14 September: 247-252.

OECD (1962), *The Measurement of Scientific and Technical Activities: Proposed Standard Practice for Surveys of Research and Development*, Paris: OECD.

OECD (1966), *Government and Technical Innovation*, Paris: OECD.

OECD (1970), *The Measurement of Scientific and Technical Activities: Proposed Standard Practice for Surveys of Research and Experimental Development*, Paris: OECD**.**

OECD (1972), *Science, Growth and Society*, Paris: OCDE.

OECD (1993), *The Measurement of Scientific and Technical Activities: Proposed Standard Practice for Surveys of Research and Experimental Development*, Paris: OECD.

OECD (2015), *The Measurement of Scientific, Technological and Innovative Activities: Guidelines for Collecting and Reporting Data on Research and Experimental Development*, Paris: OECD.

Owens, Larry (1994), The Counterproductive Management of Science in the Second World War: Vannevar Bush and the OSRD, *Business History Review*, 68: 515-576.

Perazich, George and Philip M. Field (1940), *Industrial Research and Changing Technology*, Works Projects Administration, National Research Project, report no. M-4, Pennsylvania: Philadelphia.

Phillips, Denise (2012), *Acolytes of Nature: Defining Natural Science in Germany, 1770-1850*, Chicago: University of Chicago Press.

Pielke, Roger (2012), ‘‘Basic Research’’ as a Political Symbol, *Minerva*, 50: 339–361.

Purcell, Carol (1979), Science Agencies in World War II: The OSRD and its Challenges, in Nathan Reingold (ed.), *The Sciences in the American Context: New Perspectives*, Washington: Smithsonian Inst. Press: 359-78.

Reich, Leonard S. (1983), Irving Langmuir and the Pursuit of Science and Technology in the Corporate Environment, *Technology and Culture*, 24: 199-221.

Reich, Leonard S. (1985), *The Making of American Industrial Research: Science and Business at GE and Bell, 1876-1922*, Cambridge/London/New York: Cambridge University Press.

Research Management (1970), “Top Research Managers Speak Out on Innovation”, November: 435-43.

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

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

Schatzberg, Eric (2012), From Art to Applied Science, *Isis* 103: 537-45.

Schauz, Désirée (2014), What is Basic Research? Insights from Historical Semantics, *Minerva* 52 (3): 273-328.

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

Schmookler, Jacob (1957), Inventors Past and Present, *Review of Economics and Statistics*, 39 (3): 321-33.

Schmookler, Jacob (1960), Technological Progress and the Modern American Corporation, in Edward S. Mason (ed.), *The Corporation in Modern Society*, Cambridge (Mass.): Harvard University Press: 141-65.

Schumpeter, Joseph A. (1942), *Capitalism, Socialism and Democracy*, New York: Harper and Row [1976].

Shapin, Steven (2008), *The Scientific Life: A Moral History of a Late Modern Vocation*, Chicago: University of Chicago Press.

Skinner, Charles E. (1917), Industrial Research and its Relations to University and Governmental Research, *Transactions of the American Institute of Electrical Engineers*, 36: 871-882.

Stewart, Irvin (1948), *Organizing Scientific Research for War*, New York: Arno Press [1980].

Topham, Jonathan R. (ed.) (2009), Historicizing “Popular Science”, *Isis* 100: 31-368.

UNESCO (1968), *Provisional Guide to the Collection of Science Statistics,* COM/MD/3, Paris: UNESCO.

UNESCO (1974), *The Quantitative Measurement of Scientific and Technological Activities Related to R&D*, **J.-C. Bochet**, CSR-S-2, UNESCO: Paris.

UNESCO (1977a), *A Study of Key Concepts and Norms for the International Collection and Presentation of Science Statistics*, **K. Messman**, COM-75/WS/26, UNESCO: Paris.

UNESCO (1977b), *Guide to the Collection of Statistics in Science and Technology*, Paris: UNESCO.

Usher, Abbot P. (1929), *A History of Mechanical Invention*, New York: McGraw Hill.

US Department of Commerce (1967), *Technological Innovation: Its Environment and Management*, Washington: USGPO.
US Department of Defense (1969), *Project Hindsight: Final Report*, Office of the Director of Defense Research Engineering.
US National Academy of Engineering (1968), *The Process of Technological Innovation*. Washington: National Academy of Sciences.
US National Bureau of Economic Research (1962), *The Rate and Direction of Inventive Activity*, Princeton: Princeton University Press
US National Research Council (1920), Research Laboratories in Industrial Establishments of the United States of America, *Bulletin of the NRC*, March.
US National Resources Planning Board (1941), *Research: A National Resource (II): Industrial Research*, National Resources Planning Board, Washington: USGPO.
US National Science Foundation (1953), *Federal Funds for Science*, Washington.
US National Science Foundation (1957), *Federal Funds for Science: The Federal Research and Development Budget, Fiscal Years 1956, 1957, and 1958*, NSF 57-24, Washington.
US President's Scientific Research Board (1947), *Science and Public Policy*, Washington: USGPO.
Varcoe, Ian (1979), Scientists, Government and Organized Research in Great Britain, 1914-16: the Early History of the DSIR, *Minerva*, 8: 192-216.
Whitney, Willis R. (1934), Science and Industry in the Coming Century, *The Scientific Monthly* 39 (1): 67-78.
Whitney, Willis R. and L. A. Hawkins (1932), Research in Pure Science, in Malcolm Ross, Maurice Holland and William Spraragen (eds.), *Profitable Practice in Industrial Research: Tested Principles of Research Laboratory Organization, Administration, and Operation*, New York: Harper and Brothers Publishers: **XX-XX**.
Wise, George (1980), A New Role for Professional Scientists in Industry: Industrial Research at General Electric, 1900-1916, *Technology and Culture*, 21: 408-429.

Appendix 1.
Official Taxonomies of Research

US National Research Council (R. Stevens, C. M. A. Stine)

- Fundamental research: quest for facts about the properties and behavior of matter, without regard to a specific application of the facts discovered.
- Pioneering applied research: research aimed at the development of new processes and their application to manufactured products.
- Development: this category is "defined" via specific activities, i.e.: test-tube or bench research, pilot plant, improvement, trouble shooting, technical control of process and quality.

V. Bush (Bowman Committee)

- Pure research: research without specific practical ends. It results in general knowledge and understanding of nature and its laws.
- Background research: provides essential data for advances in both pure and applied research; the objective and the methods are reasonably clear before an investigation is undertaken.
- Applied research and development: the objective can often be definitely mapped out beforehand; results are of a definitely practical and commercial value.

US President's Scientific Research Board

- Fundamental research: theoretical analysis, exploration, or experimentation directed to the extension of knowledge of the general principles governing natural or social phenomena.
- Background research: systematic observation, collection, organization, and presentation of facts, using known principles to reach objectives that are clearly defined before the research is undertaken, to provide a foundation for subsequent research or to provide reference data.
- Applied research: extension of basic research to the determination of the combined effects of physical laws or generally accepted principles with a view to specific applications, generally involving the devising of a specified novel product, process technique, or device.
- Development: adaptation of research findings to experimental, demonstration, or clinical purposes, including the experimental production and testing of models, devices, equipment, materials, procedures, and processes.

US Institute for Industrial Research (C. C. Furnas)

- Exploratory research: exploration (the realm of try and see) pursued with or without preconceived objectives.
- Fundamental research: investigation of the fundamental laws and phenomena of nature and the compilation and interpretation of information on their operation.
- Applied research: pursuit of a planned program toward a definite practical objective – a preconceived end result. It takes the results of fundamental or exploratory research and tries to apply them to a specific process, material, or device.
- Development: application of technology to the improvement, testing, and evaluation of a process, material, or device resulting from applied research. It includes engineering, design and pilot plants, tests, market research.

US Office of Naval Research (W.C. Dearborn R. W. Kneznek and R. N. Anthony)

- Uncommitted research: pursue a planned search for new knowledge whether or not the search has reference to a specific application.
- Applied research: apply existing knowledge to problems involved in the creation of a new product or process, including work required to evaluate possible uses.
- Development: apply existing knowledge to problems involved in the improvement of a present product or process.

US National Science Foundation

- Basic or fundamental research: research projects which represent original investigation for the advancement of scientific knowledge and which do not have specific commercial objectives, although they may be in the fields of present or potential interest to the reporting company.
- Applied research: research projects which represent investigation directed to discovery of new scientific knowledge and which have specific commercial objectives with respect to either products or processes.
- Development: technical activity concerned with non-routine problems which are encountered in translating research findings or other general scientific knowledge into products or processes.

OECD

- Fundamental research: work undertaken primarily for the advancement of scientific knowledge, without a specific practical application in view.
- Applied research: work undertaken primarily for the advancement of scientific knowledge, with a specific practical aim in view.
- Development: the use of the results of fundamental and applied research directed to the introduction of useful materials, devices, products, systems, and processes, or the improvement of existing ones.

Appendix 2.
Official Definitions of Research

US National Resources Committee (1938)

Investigations in both the natural and social sciences, and their applications, including the collection, compilation, and analysis of statistical, mapping, and other data that will probably result in new knowledge of wider usefulness that aid in one administrative decision applying to a single case (p. 62).

US National Research Council (1941)

Organized and systematic search for new scientific facts and principles which may be applicable to the creation of new wealth, and presupposes the employment of men educated in the various scientific disciplines (p. 6).

US Atomic Energy Act (1946)

Theoretical analysis, exploration, and experimentation, and the extension of investigative findings and theories of a scientific or technical nature into practical application for experimental and demonstration purposes, including the experimental production and testing of models, devices, equipment, materials, and processes (Section 3e).

Federation of British Industries (1947)

Organized experimental investigations into materials, processes and products, and scientific principles in connection to industry, and also development work, but excluding purely routine testing (p. 4).

Canadian Department of Reconstruction and Supply (1947)

Purposeful seeking of knowledge or new ways of applying knowledge, through *careful* consideration, experimentation and study (p. 11).

US Institute for Industrial Research (C. C. Furnas) (1948)

Observation and study of the laws and phenomena of nature and/or the application of these findings to new devices, materials, or processes, or to the improvement of those which already exist (**p. X**).

US Office of Naval Research (W.C. Dearborn R. W. Kneznek and R. N. Anthony) (1953)

Activities carried on by persons trained, either formally or by experience, in the disciplines and techniques of the physical sciences including related engineering, and the biological sciences including medicine but excluding psychology, if the purpose of such activity is to do one or more of the following things: 1) pursue a *planned* search for new knowledge, whether or not the search has reference to a specific application, 2) apply existing knowledge to problems involved in the creation of a new product or process, including work required to evaluate possible uses, 3) apply existing knowledge to problems involved in the improvement of a present product or process (p. 92).

US National Science Foundation (1953)

Systematic, intensive study directed toward fuller knowledge of the subject studied and the *systematic* use of that knowledge for the production of useful materials, systems, methods, or processes (p. 3).

OECD (1970)

Creative work undertaken on a *systematic* basis to increase the stock of scientific and technical knowledge and to use this stock of knowledge to devise new applications (p. 31).

UNESCO (1978)

Any *systematic* and creative work undertaken in order to increase the stock of knowledge, including knowledge of man, culture and society, and the use of this knowledge to devise new applications (**p. X**).