# Basic Research
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Basic research is defined by the National Science Foundation (2010) in the USA as "systematic study directed toward fuller knowledge or understanding of the fundamental aspects of phenomena and of observable facts without specific applications towards processes or products in mind." Similarly, "basic research is experimental or theoretical work undertaken primarily to acquire new knowledge of the underlying foundation of phenomena and observable facts, without any particular application or use in view" (OECD, 1994:13). Vannevar Bush also notes that "Basic research is performed without thought of practical ends. In *Science the Endless Frontier* (1945), Bush pointed out that it results in "general knowledge and understanding of nature and its laws"

Research is often regarded as basic according to the nature of its outcomes. For example, scientists often refer to research as basic if it is uniquely innovative and represents breakthroughs relative to existing knowledge; if its results have a major impact upon a given field, or they turn out to be fundamental to much later work (Trajtenberg, Henderson and Jaffe, 1992:4). Basic research focuses on scientific laws rather than solving particular questions and offers solutions to old puzzles (e.g. Kuhn, 1962; Rosenberg, 1982). Thus, the research at the Bell Labs that led to the discovery of the transistor is an example of basic research, as are Watson and Crick's discovery of DNA, the laws of thermodynamics, and the mathematics of chaos (Nelson, 1962; Trajtenberg et al., 1992). On the contrary, pursuit of the knowledge or understanding necessary to meet specific and recognized needs is considered to be applied research (NSF, 2010).

The conduct of basic research involves providing researchers with more freedom than applied research does. In applied work, researchers need to work on defined problems while those working on basic research are released of such restrictions and are constrained only by their own imagination and creative capability (NSF, 1953).

A peculiar feature of basic research is that the payoff to basic research is uncertain, serendipitous, and distant and thus it is difficult to identify in advance the commercial value of the discoveries that result from basic research (Mowery and Rosenberg, 1989). Basic research involves investigation of observable facts without specific applications toward processes or products in mind. Thus, it is a game of chance in terms of its immediate utility. In the search for oil many a dry hole is drilled, but statistically the eventual output far outweighs the cost. So it is with research (NSF, 1953:39).

Another feature of basic research is that it produces knowledge that is virtually costless to reproduce and reuse and thus quickly moves into the public domain (Mowery and Rosenberg, 1989; Arrow, 1962). Thus, the outcome of a piece of basic research is freely available to all. The social returns to basic research exceed the private returns and therefore the market fails to provide adequate incentives for the private sector to invest in basic research (Arrow, 1962; Nelson, 1959). For these reasons, economists justify public subsidies for basic research (Teece, 2003).

Basic research is conducted primarily in universities, government labs, and not-for-profit organizations. Some amount of basic research is also conducted in large business enterprises; however, the amount is quite small because basic research is not focused on application, and thereby handicapping the ability of business enterprises to capture value from basic research. Rather, basic research is almost always delivered free of charge into the public domain, whether it is privately or publicly funded.

Some scholars have observed a more interactive relationship, wherein basic research proceeds new technology development, while focusing on industrial innovations (e.g. Gibbons and Johnston, 1974; Kline and Rosenberg, 1986; Nelson, 1990; von Hippel, 1988). Rosenberg (1990) argues that basic research often grows out of applied research funded by large corporations and thus the two are interactive. Rosenberg (1990:170) views investments in basic research as “a ticket of admission to an information network.” Applied research such as development activities can have an impact on basic research. The output of basic research is never a final product but rather is some form of new knowledge that may be used to play some further role in the development of new products (i.e.via applied research initiatives). Therefore pursuing simultaneous investment both in applied and basic research is desirable (e.g. Cockburn and Henderson, 1998). In a similar vein, March (1991:71) states that firms that invest in basic research to the exclusion of applied research “suffer the costs of experimentation without gaining many of its benefits.”

Much effort has been made to identify a variety of paths by which basic research leads to productive advancement. However, basic research outputs are difficult to observe by their nature. As noted, the benefits from basic research occur over the long term while a firm's investment in applied research is considered short term and results in the development of marketable products. These practical and conceptual problems make it difficult to measure the rate of return to basic research.

Despite the difficulty associated with measuring the returns to basic research, scholars have examined various types of contributions that basic research makes to society. The immediate increments to knowledge resulting from basic research itself are, sometimes, of the greatest economic significance (Rosenberg, 1992:381). Using historical analysis, Rosenberg (1992) argues that basic research contributes to economic performance by creating new scientific instrumentation and methodologies. Some measure basic research as publicly funded R&D and find a positive contribution to economic growth (Bergman, 1990). Basic research can lead to important product development and an increase in overall firm productivity (e.g. Griliches, 1986; Mansfield, 1980a).Mansfield (1980b) reports a positive relationship between basic research as a percentage of value added and the rate of growth of total factor productivity.

Notwithstanding the important contribution of basic research to innovation, it is impotant to recognize that at the center of the innovation process is design, not science. Research is often stimulated by the problems associated with trying to get the design right. Technology is not merely applied science. Any technological development draws on an array of science, not only that which is embedded in one or two recent findings. Moreover, important technological breakthroughs can often proceed even when the underlying science is not understood well (for example, the IUD for birth control). Products can often be made to work without much knowledge of why. Airframe design in the aircraft industry, for instance, has a large empirical component. Certain designs are known, from experimentation, to have certain performance features. However, the underlying scientific understanding of airframe design is rudimentary. Accordingly, wind tunnel testing is still an essential part of the development process (Teece, 1989: 35-36).

Basic research nevertheless provides the underpinnings for technological progress from which practical applications can be drawn. The output of basic research is a peculiar kind of good that may be used, not to produce a final good, but to play some further role in the invention of a new final good (Mowery and Rosenberg, 1989: 10). In other words, basic research frequently provides the foundation for subsequent applied research, and applied research often influences the direction of basic research. David, Mowery and Steinmueller (1992) document historical cases of specific technologies and publicly funded basic research programs to show how they lay the foundation for subsequent technological progress. Basic research might be thought of as the "seed corn" for much follow on activity. In the "linear model" of innovation (Kline and Rosenberg, 1986), innovation begins with basic research, the results of which are fed into applied research and also development, which subsequently lead to production and market sales.

Another mechanism by which basic research benefits industry is through the production of skilled graduates. Pavitt (1991) shows that basic research helps develop skills to translate knowledge into practice, solve complex technological problems, and to participate effectively in networks and to absorb and exploit the resulting knowledge and skills. Nelson (1987) highlights the importance of basic research as a source of the skills essential for young scientists to conduct industrial activities within a firm. Trained graduates are thus key benefits from publicly funded research that leads to technological innovation (Gibbons and Johnston, 1974).


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