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The Role of Basic Research in Innovation

This short article discusses the role of basic research in innovation. Policy-makers and researchers tend to agree that basic research is important for society, also for innovation and economic growth. There is, however, considerable debate about why it is important and the implications of this importance.

A practical example may serve as an illustration of the disagreement surrounding issues like the organisation of basic research, the need for improved university-industry relations and the increasing emphasis on academic patenting. In 2003, around 300 of the world's leading innovation researchers were gathered at the Science Policy Research Unit (SPRU, University of Sussex) in Brighton in memory of one of the field's greatest researchers, Keith Pavitt. During a panel debate, the audience was asked whether "increased user relations at universities are detrimental to basic research". The vote was 50/50, and after an hour of debate about the role of basic research in innovation, the vote was still 50/50. Pavitt himself, summarising many years of innovation research, had argued for broad funding of basic research but against any exaggeration of direct linkages between basic research and innovation. He warned against too much emphasis on "relevance" and "commercialisation": "Dealing with deficiencies in business R&D by making basic research more 'relevant' is like pushing a piece of string" (Pavitt 1991:117).

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One major problem is the frequent lack of definitions and precise formulations of the questions to be discussed. "Basic research" has many different meanings and definitions, and alternative terms like "strategic", "fundamental", "curiosity-driven", "researcher-controlled" and "autonomous" only contribute to making the issue more confusing. The research and development (R&D) statistics use an intentional definition where basic research refers to activities that have "no practical application in mind". Scientists themselves often use other flexible definitions, e.g. based on the degree of theoretical content or ambition in a project (Calvert 2006; Gulbrandsen & Langfeldt 2004). Sometimes basic research is regarded as the same as university research, but this is not necessarily correct. Statistical data show that in many countries, e.g. Norway, only about half of the R&D activities in the university sector are classified as "basic research". Some firms also carry out basic research, although this is most often too risky for private companies even though they may benefit from it in the future (Rosenberg 1990). Finally, it has been argued that influential researchers have often strived for fundamental understanding, yet worked primarily with projects of an applied nature (Stokes 1997).

Stokes calls this "Pasteur's quadrant", claiming that research policy should aim to fund projects that *combine* fundamental understanding and considerations of use. In other words, "basic research" is not a clear concept and may refer to many different activities.

It should also be added that there are numerous definitions of innovation, counting at least in the hundreds. Current literature (see Fagerberg et al. 2005) emphasises that innovations are not only new products and technological production processes, but refer to many more and wider phenomena, including new organisational forms and the creation of new markets. Furthermore, most of the innovation literature defines an innovation as something that is new to the firm adopting or developing it, rather than new to the whole market or indeed the whole world (e.g. Van de Ven et al. 1989). Given this wide definition, it is clear that basic research will not play a major role in many types of innovations.

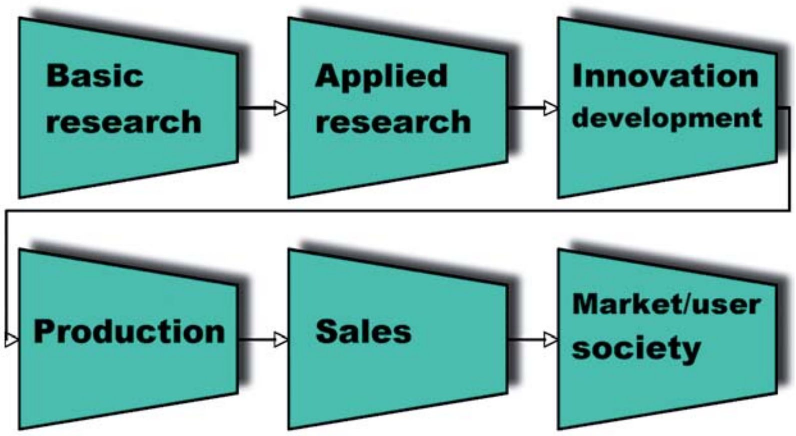

Figure 1. The linear model of innovation.

One reason for the heated debate about basic research and innovation is the historical strong dominance in many countries of what is known as the linear model of innovation (see Figure 1). This model states that the results of basic research feed into applied research and development, which in turn lead to production and sales on a market. Although perhaps never formulated as simply as in Figure 1, this way of thinking was nevertheless central, for example, in the creation of research units and science support structures from the end of the 19th century and after the Second World War. "Science invents, industry adapts and society conforms", which was the motto of the 1933 World Exhibition in Chicago.

For more than 30 years, however, the field of innovation research has presented empirical evidence that most innovations do *not* occur in this way. There are three main problems with the linear model (see Kline & Rosenberg 1986). First, it portrays research as the driver of innovation, while in most cases the key driver is a need found among certain users in the market or within a company. Second, it underestimates the many reverse processes and feedback loops inherent in technological change. A commonly used example is the transistor, which was developed years before the underlying scientific principles were formulated. Innovations and applied research may thus constitute an important *input* into basic research. Third, the linear model underestimates the importance of incremental changes, particularly related to production processes. Very few innovations are radical or disruptive – although research may be relatively more important in these cases (see Abernathy & Clark, 1985). Belief in the linear model may therefore lead to too much attention to the basic research end of the pipeline, assuming that the rest of the chain takes care of itself, and perhaps to overly high expectations of the impact and applicability of basic research results.

Some innovations are indeed developed in the way portrayed by the linear model. Sometimes – albeit rarely – important new inventions emerge from basic research organisations which may be transformed into innovations in a rather linear fashion. There are also big differences between disciplines and between technologies. Biotechnology is often used as an example of a field with somewhat more "linear" characteristics of its innovation processes. Furthermore, the stage of development of a scientific discipline may matter for the types of innovation that it can help create.

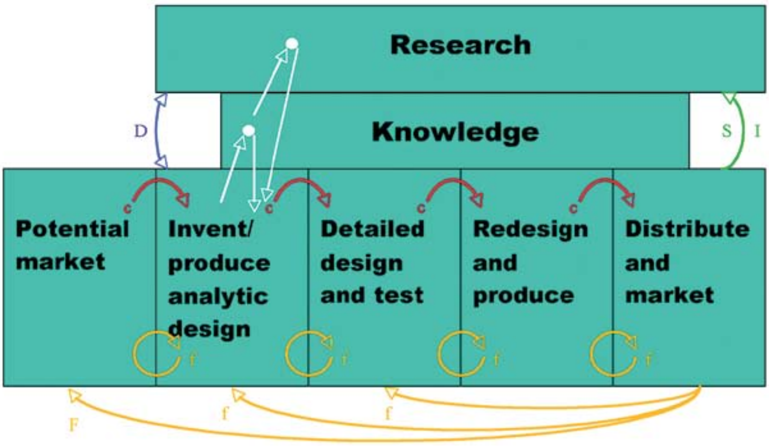

Figure 2. The chain-linked model of innovation.

A more up-to-date and commonly used model of technological innovation is the so-called chain-linked model (Kline & Rosenberg 1986, see Figure 2). The key process is to create a design based on needs and demands. Although the process can be sequential, there are numerous feedback loops. When a problem arises, participants turn to existing scientific and technical knowledge to look for solutions. Only when this fails is new research needed. Figure 2 shows how basic research is first and foremost an important contribution to the stock of existing knowledge and therefore an indirect influence on innovation, although it may give rise to new designs directly (the line marked D) and be influenced by innovations, particularly related to scientific instruments (the line marked I). Implicit in this view of innovation is that the knowledge and skills of the involved firms and individuals matter when it comes to being able to utilise relevant scientific and technical knowledge, an aspect often referred to as "absorptive capacity" (Cohen & Levinthal 1990). In other words, exploiting basic research also requires certain types of knowledge and experience that may be a more important bottleneck to the use of science in innovation than the quality of the research itself.

The most important effect of basic research on innovation is most likely through the training that PhD and other students receive, and they then move on to find work in innovative firms and increase their absorptive capacity (Pavitt 1991). Basic research is an excellent means of learning both specific knowledge and methodical ways of working, and it helps import and filter knowledge produced in other countries. These are more important justifications for public support of basic research than any direct contributions to innovation.

To some extent this is a problem for the scientific community, which used to receive funding and autonomy based on the view expressed in the simpler linear model. In a period with constraints on public expenditures and reduced core funding of basic research, scientists are eager to present evidence of a direct linkage between their professional activities and politically desired goals of innovation and economic growth. However, as the innovation literature has shown, even if the main linkages between innovation and basic research are indirect, this does not imply low importance of basic research, but perhaps even a strengthened argument for its public support and protection. The literature on the topic of university-industry relations is still only in its infancy, and more results will emerge in the years to come. So far, the studies have concluded that there seems to be a positive relationship between commercialisation and academic quality, but also that patenting may have harmful effects on knowledge production in the long run. Finally, it should not be forgotten that a cultural argument can be put forward – basic research is of course more than a servant of society's short-term needs. For many scientists, the opportunities for long-term immersion in important scholarly problems without immediate demands to utility value, is a key motivation to devote a lifetime to research. This perspective is not always visible in innovation theories.

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