

Innovation and growth in Germany over the past 150 years

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Abstract. This contribution starts from today's definitions of innovation indicators and traces their evolution back over the past 150 years. It is divided into a descriptive and an econometric part. The German innovation system has generally been very stable, even though it witnessed several political changes over the past century. This allows a comparison of the period 1850–1913 with 1951–1999. In the first period, the overall empirical results indicate a linear innovation relation between student numbers as well as public science expenditure, the number of patents granted, and economic demand. However, the second period suggests a different logic in the innovation process: demand drives total R&D expenditure, while patent output does not follow demand. The real domestic product does not seem to depend strongly on innovation activities.

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1 Introduction and structure of the contribution

If we want to understand our modern science and technology (S&T) system as an outcome of its evolution, we have to understand how it came about historically. This is an important task for historians of technology and economic historians, but not the prime concern of this paper. Rather, we want to understand what drives an innovation system over long periods, including external shocks which could be disruptive to the arrangement of driving factors. Can we provide evidence as to how such an innovation system reacted to earlier structural changes? Do we observe paradigm shifts or more persistent elements?

Germany is an ideal object of study as it has undergone many territorial and governance changes: it existed as a large array of individual states before 1871, was united in 1871 from Alsace-Lorraine (in the South-West) to East Prussia (in the North-East), reduced in 1918 after World War I and split into the GDR and West Germany from 1949 to 1990. You can hardly imagine more external shocks to an innovation system.

A suitable measurement concept is essential for such an endeavor. A practicable way to measure innovation and growth in the long term could be the elaboration of definitions and measurement methods historically, with the objective of recording the enormous changes characterizing innovation activities. However, our contribution takes the opposite point of departure: starting from today's definitions, an investigation of the comprehensive statistical material, including related indicators, is carried out, followed by an attempt to trace and complete these indicators back to before the foundation of the German Empire. This means that the presently achieved level of theory and methodology serves as a point of departure.

Consequently, this contribution tries to include a considerable number of quantitative variables in the form of *time series*. This analysis can be included in the field of *cliometrics*, the "new" kind of economic history, which is based on quantitative methods, including econometrics, aimed at reconstructing and interpreting the past (Bannock et al., 1998, p. 61). This method has been criticized by evolutionary economists (Freeman and Louçã, 2001, pp. 9; Walter, 1997, p. 75) since *indicators* cannot be *facts*; however, no fundamental difference exists between the description of facts and the interpretation, since every description already represents a certain interpretation which, moreover, depends on the definitions presently available (Lorenz, 1997, p. 32). This is aggravated by the fact that the theoretical constructs of innovation research are not clearly defined. Up to the present, rival and incompatible innovation theories still exist in several disciplines (Grupp, 1998). Linear models are widespread, presuming a sequential succession of innovation-oriented phases, the point of departure of which is an unpredictable serendipity in basic research or exogenous technical progress which falls like manna from heaven. It is evident that the definition of innovation, as it is used nowadays, cannot be considered as an anchor for the investigation period since 1850. Prior to the 1960s, innovation phenomena were described using other definitions: archives, libraries, and research institutions, as well as documents from management, personnel departments, or from production centers use terms that differ from those used according to present standards (like laboratory, try establishment, experimental factory).

According to today's view, the concept of a specific research process that leads to measurable innovation and that requires personnel and financial expenditure, is based on Bernal (1939), who distinguished the role of public research expenditure from that of civil research and – as things stood at the time – from that of the war industry. The first statistics on expenditure for "industrial research" by British companies are found in the annexes of his works. As reported by Freeman (1992, p. 3), the definitions used by Bernal during his lectures at the London School of Economics were brought to international committees (by Freeman himself, as well as by others). Here, in the 1960s, work was done on another standardization of definitions, which resulted in a first paper on the measurement of output of research