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Science, accounting and statistics: The input–output framework

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Abstract

Statistics on science are often framed within an input–output framework: inputs are invested into research activities that produce outputs. This framework is a pure accounting framework based on the anticipated economic benefits of science. This paper asks where the framework comes from. It shows that the semantics on input and output in science can be traced back to the economic literature, and its analyses of growth via an econometric equation called the production function. Used extensively by economists in the mid-1950s to study science and its relationship to the economy, the semantics immediately offered official statisticians a conceptual framework for organizing statistics on science. This is due to the fact that the framework was perfectly aligned with policy discussions on the efficiency of the science system.

Keywords: Statistics; Science indicators; Input/output; Accounting; OECD

1. Introduction

With its periodic publication entitled *Report of the World Social Situation*, first published in 1952, UNESCO launched a series of measurements of society based on an accounting framework. The exercise would soon be imitated worldwide, first of all in the United States (US Department of Health, Education, and Welfare, 1970). According to Mancur Olson, contributor to the first such exercise in the United States, while the national income measures the growth or decline in the economy, a social report should measure "social gains and losses" (Olson, 1969, p. 86). The aim of social accounting is to go further than measurements of an economic type: "for all its virtues, the national income statistics don't tell us what we need to know about the condition of American society. They leave out most of the things that make life worth living (...). The most notable limitation of the national income statistics is that they do not properly measure those external costs and benefits that are not fully reflected in market prices" (Olson, 1969, p. 86). For Olson, the national welfare is also concerned, among other things, with learning, culture ... and science.

Despite these suggestions, the example or model behind a social accounting is that of economic accounting. In fact, "the figures on the national income are probably the most impressive and elaborate type of socioeconomic measure that we have", admitted Olson (Olson, 1969, p. 86). Therefore, "the structure and parallelism of the chapters of *Towards a Social Report* derives in part from the paradigm of the national income and product accounts" (Olson, 1969, p. 87).

Olson's proposal for including science in social reports had no impact. Rather, one has to turn to specific publications dedicated to this end. The first such exercise appeared in 1973 and was prepared by the

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National Science Foundation (NSF) in the United States (National Science Board, 1973). Inspired by the work of the OECD in the late 1960s when it collected multiple indicators to document technological gaps between the United States and Europe, the report collected several statistics that measured science according to several dimensions (Godin, 2002). The model used to collect and analyze the newly imagined data on science was framed in terms of input and output. Inputs are investments in the resources necessary to conduct scientific activities, like money and scientific and technical personnel. Outputs are what come out of these activities: knowledge and inventions. A very simple framework defined the relationship between input and output as follows:

Input → Research activities → Output

Since the early 1960s, this framework has guided analysts in organizing statistics into "meaningful" categories, within the academic literature (science and technology studies) as well as official circles like OECD and its member countries. As the OECD stated: "The term R&D [research and development] statistics covers a wide range of possible statistical series measuring the *resources* devoted to R&D stages in the activity of R&D [input] and the *results* of the activity [output]" (OECD, 1981, p. 17). An international community of official statisticians has, over time, developed standards for measuring inputs devoted to R&D activities – known as the OECD Frascati manual – and produced a whole "family" of methodological manuals specifically dedicated to measuring output. Today, both series of statistics are collected and published in documents called compendiums or scoreboards of science and technology statistics.

Where does the input–output framework come from? It is in fact a pure accounting framework based on the anticipated (economic) benefits of science: "in order really to assess research and development efficiency, some measures of output should be found", claimed the first edition of the OECD Frascati manual (OECD, 1962c, p. 11). This framework is not alien to a long tradition of cost-benefit analyses in engineering and its use in policy decisions.[1] It is also not alien to input–output tables, as originally developed by Leontief,[2] and used in the System of National Accounts. In this paper, however, the origin of the framework is traced back to the economic literature and its analyses of economic growth via an econometric equation called the production function. At exactly the same time governments were getting interested in measuring science systematically, such analyses were very popular (and still are today). Several of these works were published under the auspices of the US National Bureau of Economic Research (NBER). These were the first real attempts to integrate science into the economic equation. They immediately offered a semantic and framework to official statisticians for organizing statistics on science.

Some authors have argued that economics has been framed into an accounting "metaphor" for a very long time (Klamer and McCloskey, 1992). A metaphor is a figure of speech used to understand one thing in terms of another. This paper is concerned with how economics and the accounting metaphor got into a specific kind of activity – science and scientific research – an activity long reputed to be not favourable to measurement. The paper is divided into three parts. The first reviews the economists' model for studying science and its impact on the economy: the production function. Framed within an input–output vocabulary, the semantic was perfectly adapted to the official collection and interpretation of statistics. A large part of this section is devoted to the NBER conference organized in 1960 which examined for the first time in history various aspects of the "model". The second part looks at how the semantics of input and output entered into official statistics on science and technology. The work of the OECD and an influential consultant, Chris Freeman, serves here as the vehicle for examining the impact of the input–output framework on official science and technology statistics. The third part looks at what remains of the accounting framework in current official statistics. It argues that the input–output framework is a symbolic representation or metaphor and has little to do with accounting as such.

From the start, a distinction and a clarification must be made. The input–output framework should not be confused with another framework, called the linear model of innovation (Godin, 2007). The former is an accounting framework for science activities, and is concerned with measuring upstream and downstream quantities and establishing empirical relationships between the two. The linear model of innovation is devoted rather to explaining research activities themselves. It takes the following form:

Basic research → Applied research → Development

→ (Production and) Diffusion

[1] For the introduction of accounting in "science policy" (or public decisions and programs involving scientific and technological activities), see Porter's discussion of the role of engineers in cost-benefit analyses (Porter, 1995). On accounting and science generally, see Power (1994).

[2] Leontief founded input/output accounts, and developed his first I–O tables in the 1930s for studying the effects of technological change on the American economy. See Leontief (1936, 1953a,b).