

Technological Development as an Evolutionary Process: A Study of the Interaction of Information, Process, and Control Technologies, by J. Hagedoorn, P. Kalff and J. Korpel, Elsevier, Amsterdam, 1988, 220 pp., ISBN 0-444-70488-4, Dfl. 130.00.

This book, part of a larger research program on “information technology and process control” at the Centre of Technology and Policy Studies in The Netherlands, explores development of process control technology from economic and technological perspectives. The authors have backgrounds in industrial economics and applied physics. They make a concerted effort to reach out beyond these particular academic specialties, as is stated in the first of their three principle objectives:

- to present an analysis of several technological developments in which the complexity of technology is explained at a level of detail which remains understandable for economists and other social scientists;
- to measure concrete technological developments in a dynamic context;
- to relate the analysis of technological development to an analysis of the industrial structure.

The researchers were primarily interested in developing a conceptual and theoretical framework, based on empirical observations, for understanding technological development. They picked process control technologies as a focal point as it allowed them to focus on the “interplay of several fields of technological development such as process technology, information technology, and process control technology”. Process control technology is defined as “a particular field of engineering technology dealing with ways and means by which conditions of processes are brought to and maintained at determined and desired values”. The book focuses on both the evolution of process technologies in three *user* industries – iron and steel, food, and chemical – and the structure of the process control equipment *producer* industry.

The book starts out with some very interesting primers. Chapter 2 is an introduction to chemical, steel, and food processing technologies focusing on the history of their core process technologies and the accompanying process control technologies. Chapter 3 is an introduction to information technology including brief histories of the development of computers, software and artificial intelligence, and telecommunication.

Chapter 4 introduces us to some principles of process control. Basic systems diagrams and simple graphs are used to illustrate process control principles which lead to quite technical descriptions of a variety of types of process control technologies, e.g., off-line control, on-line control, in-line control, proportional controllers, proportional integrating controllers, and proportional integrating differentiating controllers. To characterize the history of process control technologies, the authors draw on the concept of “technological re-

gimes". These are basic designs which remain essentially the same in their core principles over a number of years. At some point a shift in the design is substantial enough to be considered a new technological regime and a more fundamental change in technological regimes constitutes a change in "technological paradigms". The authors view process control as proceeding through two major paradigms in which the use of computers distinguish the shift from the old to the new paradigm. Each paradigm has three regimes. The old pre-computer paradigm moved from local manual control to local automatic control to central control. The current paradigm marked by the introduction of computer technology moved from central computer control to distributed control and is now moving toward integrated control. Through systems diagrams we are walked through the main features of these six technological regimes of process control.

Chapter 5 provides detailed descriptions of the application of process control technologies in each of the three user industries. That is, what are the key historical developments and how is process control practiced today? Different process control approaches applied to different manufacturing processes within the three industries are explained. For example, in the section on the iron and steel industry we learn about the control of blast furnaces and hot stoves, control of basic oxygen furnaces, control of continuous casting, and control of milling processes. There are distinctive characteristics of process control within and across the three industries.

Chapter 6 returns to process control at a more general level explaining the core features of the various technological regimes and how the technology of process control has evolved over time. We learn in the conclusion that this is the final stage of technical description of the study which has taken two thirds of the book.

In Chapter 7 the authors shift from the user side to the producer side and look at official statistics on process control equipment producers in a variety of countries. This starts to fulfill the measurement objective of the book which is another way of saying that many aggregate-level economic statistics are presented. Since the process control industry is not directly related to any standard classification of industries or products across countries the authors had to do a considerable amount of digging to put together the many tables of statistics in this chapter, e.g. patent activity and sales by country.

Chapter 8 continues the statistical overview of characteristics of process control equipment producers this time based on a survey of manufacturers conducted by the authors. We learn such things as the age of producing plants, the percentage of companies manufacturing different key elements of the technology (e.g., sensors, process control systems, etc.), mergers and takeovers in the industry, patent activity, and many other macro-level economic indicators of innovative activity and performance of these companies.

Finally, Chapter 9 draws some conclusions from the study. We learn where

a study of this type fits within the more general innovation literature by economists. Basically the authors take a sanguine view of the contributions of economists which they claim stays at too abstract a level and relies too heavily on elegant analyses of official statistics that may in fact be inaccurate. They argue that their study operationalizes the concept of technological regime and deals with a level of analysis “where technology and its concrete applications could be linked to the measurement of technological sophistication and performance of companies”. They also argue that they have been able to concretely operationalize the concept of technological trajectory. The rest of the conclusion section continues to be largely general claims about what the authors accomplished by picking apart the evolution of process control technology in the way they did in the book. There are no real conclusions per se beyond what already appears in the earlier chapters.

The strength of the book is clearly in the detailed historical description of this particular class of technologies – those related to process control. We learn a great deal about this technology, as well as something about basic process technologies in the three industries and even something about the basics of information technology.

The book’s strength is also its major weakness. Though the authors argue that they are only using process control technology as a case example of a broader conceptual scheme, the proverbial forest gets lost in the trees. The 67 figures and tables drive much of the discussion which focuses heavily on detail. At many points I had to literally drag myself away from the detail and ask myself what larger point the authors were trying to make. What was I learning about the process of technological innovation or the process by which users adopt particular technological forms? What was I learning about how industries shift in their technological paradigms? How does a particular regime or paradigm establish itself and what dynamics lead to change? The answer was that I am still not sure what I learned about the answers to these questions. I learned a whole lot more than I wanted to about the technology of process control in these industries and the aggregate economic characteristics of producers of the technology. As someone interested in more micro-level organizational issues related to technological innovation, I was disappointed that the authors completely ignored the human/social side of process control technologies but I understand that their objectives were to examine macro-level issues. However, theory of any kind bringing the myriad of facts and detail to life was sorely lacking.

Who can benefit from this book? Well certainly it is must reading for researchers interested in process control technology as a major focus of their research or even as one of the types of technology under study. Economists interested in innovation over time could also learn a good deal about the evolution of one particular class of technologies. Organizational researchers interested in technological innovation might be surprised by the large differences

in the characteristics of process control technologies within and between industries. We often talk of the interaction between task, technology, and organization; and even within this one realm of technology any simple classification of task and technology will only gloss over its complexity. Managers and practitioners might be interested in seeing where their companies fit in as users of process control technologies and might benefit from the discussion of different approaches to process control. However, they will be disappointed if they are looking for any clear prescriptions from the study such as insights to help formulate a technology strategy for process control.

Few readers will want to read the book from cover to cover as there is far too much detail. It will be particularly useful as a reference if read with particular questions in mind. The authors have obviously put an enormous amount of time into compiling a great deal of information on process control technologies and making complex technology accessible to the reader, and those who need this information will find the job of mining it worth the effort.

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