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François Caron, *Dynamics of Innovation: The Expansion of Technology in Modern Times*. New York and Oxford: Berghahn Books, 2013. xvii + 247 pp. Selected bibliography and index. \$95.00 U.S. (cl). ISBN 978-0-85745-723-3.

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Caron's book provides the reader with a metanarrative of the ways in which Western industry advanced in the period between the eleventh and twentieth centuries via the application of technologies. Caron argues that, by examining application, technological knowledge (learning) can be categorized into three forms: tacit knowledge, or the "how to" of producing; formalized knowledge, which implies a theoretical explanation of the formation of "how to" knowledge; and codified knowledge, or the institutionalization and transmission of formalized knowledge between and among a specialized group of individuals (p. xv). Using a historical model, Caron divides his text into four parts, focusing each part on a specific range of dates as well as on one or two specific technologies as illustrative case studies. In this way, Caron posits that he can provide answers to three specific questions: first, how technological studies are chosen; second, how technology has evolved; and third, how technological knowledge is categorized. The answers to these questions, then, will reveal how knowledge evolves from tacit to codified, and how this evolution leads to innovation and expansion of technical knowledge.

Caron's text is divided into four parts, each of which focuses on a specific time period. Part one, consisting of chapters one through four, examines the period between the eleventh century and the beginnings of the industrialization of Europe between 1760 and 1830. Chapters one and two trace the progress made in manufacture's transition from artisanal to proto-industrial production, and acknowledge the appearance of the "expert" when both institutions and legislation began to privilege certain technological knowledge (pp. 27-30). These chapters provide salient examples of both tacit and formalized knowledge, illustrated in trades such as printing, cloth making and construction. Caron points out that tacit knowledge, or simply knowing how to erect a structure or weave a piece of cloth, is very different from formalized knowledge—knowledge that, he argues, evolved due to the emergence of applied mechanics and scientific inquiry at the university level.

While part one is a relatively benign history of the period, one is not sure when reading this section whether the book is about the application of technology or about the process through which Europe became industrialized via a capitalist economic model with the assistance of technology. Sections on pottery, construction, and the manufacture of timepieces in chapter one illustrate tacit knowledge, but serve to chronicle less about the innovations that expanded the knowledge in these industries, than on production. Several questions emerge as a result, including what led to innovations, which seem to appear without need or precedent. What need arose that changed the way construction sites were organized? What led to the shift from traditional hand-weaving to the use of the metal crochet hook and the spinning wheel? There seems little justification to shift from one form of tacit knowledge to another if an existing method worked. However, the shifts occurred, and tacit knowledge (know-how only) evolved when formalized knowledge (the phase during which innovations took place) was introduced. The links between the two forms of knowledge are not solidly forged, and this trend continues as Caron expands his treatment of formalized knowledge in the next two chapters.

Chapters three and four examine more closely the process through which knowledge became formalized. While chapter three begins to introduce the role of the intellectual into the process of technological advance and application, chapter four provides case studies on energy and chemistry in order to illustrate Caron's point regarding the evolution of knowledge from tacit to formalized. In these chapters, it becomes slightly clearer to the reader how the process of innovation infiltrated production and manufacture. Innovations seem to emerge more from an identified need, such as in the application of hydrological technologies to the process of mining, rather than from pure curiosity or for the sake of advancing knowledge. McLaughlin and Freudenthal's work on the Scientific Revolution supports this idea, and they argue that, rather than innovation, technologies were simply adapted to an identified need.[1] It seems that they, like Caron, would support the idea that economic and social forces determined what technologies advanced more than the curiosity of an individual or group.[2]

In part two, Caron examines the codification of knowledge in chapters five, six and seven. Focusing on the period between 1850 and 1930, Caron argues that global models begin to emerge, providing standardization of codified knowledge. Chapter five provides a solid background for what Caron dubs "The Creation of Enterprises." He states that enterprise is "one of the privileged sites of innovation and the construction of new technological and scientific knowledge" (p. 52). His chronicling of the various waves of entrepreneurial innovation in Europe provides a progressively successful run of new technologies being applied in the iron, textile, and chemical industries, and illustrates how important universities had become in providing both educated men to conduct research and laboratories in which to experiment. Caron notes that industry, too, made use of these educated men, and established research laboratories of their own. These became, he argues, "a basic element of business" that led to the improvement of "products and procedures...by profiting from eventual discoveries belonging to engineering and theoretical science" (pp. 57, 59). What is striking about chapter five is its assumption that there need not be any exploration beyond the elite, Western, male cohort that controlled science by the nineteenth century to support the notion that a global model emerged. There is no question that, with their codified knowledge received through university educations, men—white, European men—made great strides in furthering industry through the application of science. Never mind that these advances often came at the expense of countless people and resources, much of which came from the colonial holdings of individual European states.

Chapter six provides a case study which illustrates this phenomenon. BASF, or the Baden Aniline Soda Fabrik, began in 1865 as a small chemical company that used coal tar to produce a series of dyes. Focusing on the company's quest to produce synthetic indigo during the 1890s, Caron showcases both the individuals and the chemical processes they used to arrive at this notable achievement. He does clarify that the demand for industrial dyes helped to drive this development, but does not relate the demand to the larger issues of the day. It is curious that Caron chooses to omit the fact that indigo could only be obtained from tropical regions, which usually meant European colonies, and that it was in short supply at the end of the nineteenth century. Additionally, he chooses to ignore the demand that drove the quest for synthetic indigo, which was in fact the denim fabric industry in the US, which provided sturdy clothing to the working class. While not entirely necessary to Caron's narrative, these details would make the history livelier, decidedly more complex, and closer to global.[3]

Moving into the period from 1930 to 2000, part three introduces the idea that practical motivations for technological change and adaptation emerged with the involvement of the consumer as an actor in the development process. While chapter eight focuses on the impact of the consumer, chapter ten examines the effect of networks in society on technological innovation. A history of the expansion of technology in modern times that omits certain key components of a narrative, as does Caron's, is less convincing in its arguments that it could be. In this case, instead of engaging in a true analysis of the ways in which the wide array of consumer demands drove technological applications, Caron reaches back to the medieval period to discuss in detail one specific technology—metallurgy. This is understandable, given

his work on the railroad industry, to which the metalworking process was paramount. However, instead of truly including the consumer as actor, Caron traces metallurgy's history through sword and armor production, and then discusses the applications of cast iron in the agricultural, transportation and nautical fields. He concludes by noting that tractor blades were a direct beneficiary of the improvements to the metalworking process, implying that innovations in metallurgy would not have been possible without consumer input (pp. 148-156). While this is an appropriate case study, it nonetheless renders the individual consumer invisible by using statistics regarding customer satisfaction and suggestions for innovation as the means to illustrate their influence on technology. In addition, by focusing so narrowly, this chapter also excludes two other primary consumer groups--women and markets outside Europe--whose roles as shapers of technology originated in the nineteenth century, and whose influence continued to expand even more in the twentieth century. Caron furthers his examination of the interaction between consumers and producers in chapter nine, noting that networks proliferated "to assure the emergence of new technology, whether on a global or local scale" (p. 160). These networks, which Caron describes as hierarchical, exist between concentrated centers of knowledge, and are inextricably linked to a business interest or enterprise (pp. 168-178).

Part four also examines the role of the consumer on production, this time reverting to 1830 to examine the transition to a consumer society in Britain and France, using the last two chapters to explore telecommunications and computer technology. He posits that "the appearance of new products fueled mounting aspirations to enjoy more welcoming homes...[which] undergirded a consumption centered on domestic comfort and urban planning" (pp. 183-184). This consumer-driven model suggests that Caron rejects the idea of a product-focused model in which needs are created not by the consumer, but by the producer. It also assumes the consumer's socioeconomic status allowed for the purchase of goods that had no utility, and were merely for decoration (p. 184). One can ask many questions regarding this model that go unanswered, including what kinds of technological innovations, advancements and applications focused on the lower classes who could not participate in the for pleasure consumerism of the nineteenth and twentieth centuries. For example, Caron points out that many consumers were often motivated to purchase by the desire to impose stricter standards of hygiene. Such consumable strictures could not be purchased by the working classes, whose standard of hygiene was a direct reflection of their lack of income.

The final section of the book focuses on the period between 1830 and 2000, and examines the consumer demands of the late nineteenth and early twentieth centuries on technology, as well as more recent technological innovations in the fields of telecommunications and computers. Caron's examples include new forms of housing in Paris, as well as the mass production of a variety of consumer goods that, he posits, appeared in response to consumer needs. Noting that liberal economists in Great Britain and France had hopes that economic growth could be achieved via technological progress and international commerce, Caron quickly points out that popularization distorted this model of consumption and rendered it unreliable (pp. 184, 222).

He concludes by providing five answers which, at times, seem contradictory. For example, Caron claims that "technological changes have an essentially cultural character," but he subsequently writes that "enterprise should be considered the primary site of innovation and technical change" (p. 228). Clearly, culture and enterprise need not be perceived as mutually exclusive; however, there is little attempt to situate the technological change within the larger cultural context of several of the periods, most notably the latter part of the nineteenth century as well as the beginning of the twentieth century, when massive cultural shifts began to emerge as a result of agitation for legal equality by workers and women, and colonial holdings began to provide both resources and markets for European manufactured goods of all types.

Read as a theoretical text, Caron's arguments are solid. He does provide proof of shifts in the industrial process, gives evidence that various types of technological knowledge exist, and illustrates successes in

technological advancement through a variety of case studies. Where the argument falters is in its reliance on terms such as cultural and social, which are less well-developed but would have added a richness to the narrative that can only be achieved when including the full array of human, geographic and natural factors that played important roles in the expansion of technology in modern times.

NOTES

[1] McLaughlin and Freudenthal argue that technological development did not occur in the absence of a corresponding economic need. See Gideon McLaughlin and Peter Freudenthal, *The Social and Economic Roots of the Scientific Revolution: Texts by Boris Hessen and Henryk Grossman* (Boston: Springer, 2009).

[2] For more information on technology in mining, see Michael Coulson's *The History of Mining: The Events, Technology and People Involved in the Industry that Forged the Modern World* (Petersfield, U.K.: Harriman House, 2012).

[3] To examine a concurrent history of a non-Western nation's technological application and expansion, consult Tetsurō Nakaoka, *Science and Technology in the History of Modern Japan: Imitation or Endogenous Creativity?* (Tokyo: United Nations University, 1980).

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