Framing Production

Technology, Culture, and Change in the British Bicycle Industry

Paul Rosen

The MIT Press
Cambridge, Massachusetts
London, England

Set in New Baskerville by The MIT Press.
Printed and bound in the United States of America.

Library of Congress Cataloging-in-Publication Data

Rosen, Paul, 1963–
Framing production : technology, culture, and change in the British bicycle industry / Paul Rosen.
p. cm. — (Inside technology)
Includes bibliographical references and index.
ISBN 0-262-18225-4 (hc. : alk. paper)
1. Bicycle industry—Great Britain. 2. Bicycle industry—Technological innovation—Great Britain. I. Title. II. Series.
HD9993.B543 G77 2002
338.4'76292272'0941—dc21

2001056240

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Technology, Culture, and the Politics of the Bicycle

The Personal, Political, and Intellectual Contexts of the Bicycle

Bicycles have many meanings. They were for many of us a treasured part of childhood, marking the stages of our growing independence—our first experience of being beyond immediate parental control in the park or local streets (even if our parents were only a few hundred yards away); the fear and excitement of achieving independent balance when the training wheels were first removed; traveling to school or elsewhere by ourselves or with friends, no longer dependent on the good will and driving skills of adults; and perhaps the means to earn some money of our own delivering newspapers. Unfortunately, in recent decades such experiences have become a source of worry for parents. Perhaps bicycles are no longer so central to childhood independence as they once were. Adult cyclists have become increasingly rare. Yet not so many years ago, cycling was the main form of utility transportation for working people, and a major leisure activity too.

Nevertheless, new meanings associated with health and fitness, leisure, and the environment have begun to spring up. Cycling, which once symbolized children's independence, might now mark a shared family experience, such as Sunday rides away from the traffic, perhaps on one of the many leisure cycling routes that have been built recently by groups such as the UK charity Sustrans. Cycling has also been appropriated by the "green transportation" lobby as a solution to traffic congestion and pollution. In many cities it will get you to work more quickly than other transportation modes, and more healthily: although cyclists are vulnerable to exhaust fumes, these are worse for those sitting in the closed environment of a car, and the cyclist has the added bonus of getting exercise without having to go to a gym.

Alongside these newer developments in the meaning of bicycles are longer-established and more specialized ones. Engineering enthusiasts have been developing alternative designs for bicycles and their components and accessories since the bicycle's earliest days. Sometimes they do this for the sake of technical improvement—for greater speed, less wind resistance, or greater comfort or safety; sometimes they do it simply for fun. Occasionally they do it with a social goal in mind—to remove the moral or material obstacles facing women riders, to help give some independence to the disabled, or just to provide an alternative to the private automobile. And hobbyists and amateur historians have been charting (and arguing about) cycle history and collecting vintage machines for almost as long. In recent decades their numbers have grown substantially, accompanied by exhibitions, displays, conferences, and vintage cycle rides (complete with authentic costumes).

Cycle sport may be the aspect of cycling most visible to the general public. Established races such as the Tour de France and Olympic pursuit cycling and newer competitions for BMX and mountain bikes have together seen a growth of interest, especially since the 1980s. This has been fueled both by the positive environmental image of cycling and by the rapid technological change that makes every race or exhibition a spectacle featuring the latest innovations, such as the Lotus Sport "Superbike" on which Chris Boardman won the 1992 Olympic pursuit competition. All this is helped by the specialist and the popular media and by the sports promotion industry, which together further encourage the development of highly specialized niche markets and audiences.

Personal engagement with technology in hobby, sport, or professional activities can be crucial in giving it meaning (Pacey 1999). There is a great deal of literature on the various meanings of bicycles—general accounts of the technical development of the bicycle or the social history of cycling; histories of significant firms, machines, and sporting events; biographies of prominent cyclists, designers, and entrepreneurs; cycling novels; health and transportation policy reports; glossy coffee-table books; and manuals for building and repairing bikes and their components.[1] However, this book is concerned primarily with bicycle *production*, which has been somewhat neglected in the cycling literature. Bicycles are, like other consumer objects, products of an industry based on complex networks of supply and demand—an industry dependent on fickle consumers who need to be cajoled into changing brand loyalty or upgrading equipment that could easily last a few more years. Innovation and change are thus as central to bicycle production as they are to cycle sport. Indeed, innovations tested on the racetrack often are adapted for the consumer market.

Product innovation in the bicycle industry has, throughout its history, been part of a much wider process of change—a process that combines new product designs with new materials and production methods, new ways of organizing firms, new ways of addressing consumer demand, and new social structures and cultural values within and beyond the bicycle market. This book is, then, not only about bicycles and cycling; it is also about the interaction of technological, industrial, organizational, social, and cultural change.

The book focuses mainly on two periods of change in the British bicycle industry—periods in which multiple factors (the modernization of production and of the ways in which the industry organizes itself, changing relations among industrial players, the link between labor relations and production innovations, the interaction between changing markets and product development) came to the fore in interlinked ways. The first of these periods was the interwar years, especially from the mid 1920s until just before World War II. It was during this time that the British industry transformed itself from a craft-based industry into a factory-based one, adopting automated equipment for large-scale production that borrowed elements from Fordist mass production and from Taylorist "scientific management." New products, production methods, and management techniques were tried out during this period, while established methods were questioned and in some cases abandoned. The industry began to consolidate around a small number of large manufacturers through buyouts and mergers. At the same time, the bicycle market was growing rapidly. Bicycling both for utility and for leisure was at its peak. The second period I will focus on spans the 1980s and the 1990s. A steady decline in the cycling market during the preceding two decades had been matched by a near collapse of the British industry. Again, a number of factors came together at this point to revive both the industry and the market. The emergence of environmentalism and health consciousness as spurs to cycling coincided with an innovation—the mountain bike—that caught the imagination of the "baby boomer" market, a market with considerable disposable income. Production innovations were again crucial to the growth of this market, but more important was a fundamental transformation of how the industry was organized on a global scale. As a result, the British cycle industry is very different today from what it was in the past.

The focus on production makes this book a meeting point for a number of intellectual and political perspectives, spanning topics including the labor process, economic history, innovation studies, and organizational studies. Central to the discussion are debates on Fordism and what followed it (most commonly labeled post-Fordism) and sociological and cultural analyses of modernity, postmodernity, and globalization. One of the book's objectives is to bring the insights of these various approaches together within a critical analysis rooted in the sociology of technology. In drawing such links among technology, society, and culture I hope to throw some new light onto processes of technological change, especially the possibilities for directing change in ways that make the control and the accessibility of technology more egalitarian for producers and consumers, for designers and users, and for employers and employees.

I hope this study will also offer insights that might benefit the causes of radical social and political actors such as the environmentalists and transportation activists who champion bicycles. The roots of such perspectives lie within a further strand of thinking about technology—a strand that is linked to the counterculture and the alternative-technology movement of the 1960s and the 1970s and also to more philosophical interrogations of the politics of technology (e.g. Mumford 1975; Winner 1986; Sclove 1995; Feenberg 1999; Martin 1999; Kleinman 2000). These kinds of critical engagement with technology are highly pertinent in a context where bicycle advocacy has to engage with a politics and a culture of transportation that take the dominance of the automobile for granted.

Much of the book draws on archival material that is only just beginning to be systematically analyzed by researchers. The research was carried out between 1991 and 1994 and was revised after supplementary research in 1997 and 1998. The four main components of my research were (1) exploratory interviews with mountain bike owners, since the project began as an investigation of the technological and cultural changes that had occurred with the development of mountain bikes, (2) more strategic interviews with "key personnel" in the bicycle industry and the cycling culture, (3) observations of bicycle-related gatherings, notably several public and trade cycle shows, and (4) documentary research. The documentary research drew on several sources, most notably the Raleigh Cycles archives held by Nottinghamshire County Council, other archives pertaining to Raleigh held by Nottingham Local Studies Library, and cycling magazines (dating back to the 1880s but mostly from the 1980s and the 1990s). A complete list of the interviewees is given in appendix A, and the archival sources are listed in appendix B.

The perspective from which the material was collected and analyzed mixes together a variety of sociological and anthropological approaches, especially as they have informed the multi-disciplinary field of *science, technology, and society* (STS) and its subfield *social studies of technology* (SST). This reflects both my interdisciplinary background (veering across anthropology, cultural studies, sociology, and STS) and the multi-dimensional nature of my subject matter. Many academic disciplines can claim insights into the history and culture of cycling and cycle production. Research on different aspects of this topic has spanned technology design (Hult 1992; Roy 1983, 1984), economic history (Harrison 1977; Millward 1990, 1995; Lloyd-Jones and Lewis 2000), design history (Oddy 1994, 1995), social history (Ritchie 1975; McGurn 1987, 1999), and social geography (Patton 1995). The large subculture of mostly amateur cycle historians adds another dimension—especially since STS itself began to pay attention to the bicycle, with the publication of Pinch and Bijker's (1984) analysis of late-nineteenth-century cycle design. This has drawn a mixed response from academics (Russell 1986; Winner 1993; Rosen 1993) and cycle historians (Oddy 1995; Ritchie 1995; Clayton 1999). This book thus involves conflicting disciplinary perspectives, on which I draw as seems appropriate for each of the components of my argument. Underlying the eclecticism, though, is a commitment to understanding technological change in a way which is neither technologically nor socially determined, which pays attention to the contingencies and uncertainties of change, and which treats critically both the relationship between technology and society and the rhetorics of those who promote change.

Technology and Culture in the Project of Modernity: From the Manifesto of the Communist Party to the Manifesto for Cyborgs

A central theme underlying my argument will be the need to take seriously within the sociology of technology issues and debates from other intellectual fields. Most prominent among these in my discussion will be debates (which have become central to the sociology of culture) concerning modernity, postmodernity, and globalization. Accounts of these phenomena concern themselves with questions about the nature of social and/or cultural change, with how such change is constituted, and with what it means to the people who experience it. Technology, or rather technological change and innovation, is central to many of these accounts. However, what it is that constitutes technology for theorists of modernity and postmodernity is rarely articulated in much depth. Technology might be regarded instrumentally, as something used for specific objectives by the people or classes who are seen to have brought about major social and cultural change, or it might be treated as a social actor in its own right, with an intrinsic logic propelling society into an uncertain, dangerous, yet exciting future. More often it is regarded somewhere between these two poles. Technology is seen to bring about social change at the same time as it propels such change in specific directions. Rarely, though, do such theorists look more closely at technology, at the detail of how interactions among the social, the cultural, and the technical shape both artifacts and the processes of change. The detail of technology is, rather, usually incidental to the main arguments of such writings, even if its absence would make those arguments untenable. Despite the centrality of technology to the shaping of modernity, then, there has been a tendency to assume, in the words of Langdon Winner (1977: 2), that "the true problems of modernity could best be understood in ways that excluded all direct reference to the technical sphere."

Modernity and Postmodernity: Experience, Identity, and Culture

Marshall Berman (1982: 13) describes modernity primarily as an experience by which people "are moved at once by a will to change—to transform both themselves and their world—and by a terror of disorientation and disintegration, of life falling apart." He identifies this experience in writings by Goethe, Marx, Dostoevsky, Baudelaire, and others, linking it also to certain urban landscapes—in Paris, St. Petersburg, and most notably in the New York planning "vision" of Robert Moses. Berman goes on to describe "the highly developed, differentiated and dynamic new landscape in which modern experience takes place" (ibid.: 18–19):

> This is a landscape of steam engines, automatic factories, railroads, vast new industrial zones, of teeming cities that have grown overnight, often with dreadful human consequences; of daily newspapers, telegraphs, telephones and other mass media, communicating on an ever wider scale; of increasingly strong national states and multinational aggregations of capital; of mass social movements fighting these modernizations from above with their own modes of modernization from below; of an ever-expanding world market embracing all, capable of the most spectacular growth, capable of appalling waste and devastation, capable of everything except solidity and stability.

People experiencing this new world are, for Berman, caught up in the sense of living in a revolutionary age, in "the sense of being caught in a vortex where all facts and values are whirled, exploded, decomposed, recombined" (ibid.: 121).

A similar picture of modernity is painted by David Harvey, whose interest goes beyond Berman's primary concern with literature (and Berman treats even Marx's writings more as literature than as any other form of discourse). Harvey draws on geographical concerns with space and time, and on organizational and sociological questions concerning economics, production, and culture. Harvey goes beyond modernity to include its extension into "postmodernity," taking as his starting point Baudelaire's comment (quoted in Harvey 1989: 10) that "modernity is the transient, the fleeting, the contingent; it is the one half of art, the other being the eternal and the immutable." Like Berman, Harvey pays most attention to the first half of this formula, which he sees as even more important in the shaping of postmodernity than it was in the shaping of modernity. He examines the cultural episodes of new movements in the arts that have constituted "modernism" and "postmodernism," and he links them to the compression of space and time that have come about as a result of political and cultural change and to technical and social innovations such as those described in the quotation from Berman. He then traces these changes back causally to specific moments of overaccumulation and crisis in the economic sphere, which he argues were responsible for sparking both modern and postmodern forms of cultural representation.

For Harvey, then, the experience of modernity and postmodernity is simultaneously the experience of capitalism, whose inherent tendencies toward crisis lead not just to economic but also to social, political, and cultural upheaval. The depression of 1846–47 in Britain thus had multiple effects—it resulted in a crisis of representation that was manifested in the revolutions that swept across Europe in 1848 and in the publication of the Manifesto of the Communist Party (Marx and Engels 1977); it led to the emergence of new systems for organizing stock and capital markets; and it sparked new forms of art and literature that began to address questions of internationalism, synchrony, temporality, and economic exchange (Harvey 1989: 261–263). Similar crises in the 1960s and the 1970s have generated a further compounding of these features, resulting for Harvey in the emergence of postmodernity. He locates the distinction between modernity and postmodernity in a radical shift in politics, economics, and the experience of time and space. He sees as crucial to this shift certain changes in production and economics—from Taylorism and Fordism in the early to mid twentieth century to a globalized system of flexible accumulation along with related changes in the political sphere. While he makes it clear that he regards the shift to postmodernity as having been generated by the same crisis tendencies that precipitated modernity, it is the intensity of these tendencies that make the postmodern qualitatively different.

Zygmunt Bauman (1992) and Mike Featherstone (1991), in their discussions of the shift from a production-centered culture that goes with Fordism to a post-Fordist, postmodern consumer culture, pay more attention to the cultural rather than the economic practices associated with these changes. For Bauman (1992), this consumer culture is a social system that has replaced the modern producer culture, leading to a decentering of work in the industrialized West. This dynamic of production and consumption is central to modernity-postmodernity debates, since the shaping of Western culture in the twentieth century and the development of mass and then more flexible approaches to production have been closely intertwined. One important dimension of this, which is too often neglected in the enthusiasm to explore "consumer culture," is the geographical specificity of the shift from production to consumption, from industrial to "post-industrial" society. Notable here is the ubiquity of the concept of "globalization," which has become significant as a way of accounting for how the spatial aspect of postmodernity has taken on the same significance that modernity attached to the temporal (Featherstone et al. 1995). A strong focus on the globalized and somewhat homogenized consumption of cultural products means, however, that the more visible differences between the relationship of different regions and populations to production is often missed. As the production of goods in the West has declined in favor of growth in knowledge-based service industries, the job of meeting the demands of increased Western consumerism has fallen increasingly on producers in the developing countries and in the newly industrialized countries of the Pacific Rim (Barbrook 1990; Lipietz 1992). For people in these societies, it is modernization and not postmodernization that describes their current experience, yet this is a significantly different kind of modernization than that which has characterized the West since the sixteenth century (Featherstone et al. 1995; Seabrook 2000). It has emerged as a consequence of global transformations of industrial capitalism, and of the modern experience, but people in developing countries are at the receiving end of these processes and are not, for the most part, their initiators (Friedman 1995; King 1995).

There is a danger, then, of overlooking the complexity of the relationship between production and consumption by focusing on only one or the other. This has been a common theme of critiques of more traditional production-based analyses of modern society. Baudrillard (1988) criticizes Marx and the Marxists who focus solely on production, neglecting the socially mediated construction of use and of need and neglecting the role of consumption as an integral element of the production process. Similarly, Johnson (1986–87: 55) criticizes the "productivism" of Gramsci, in which the cultural life of a product is seen to be determined by the conditions of production rather than its interplay with consumption. This interplay is increasingly being explored in work produced at the borders of cultural studies and technology studies. In contrast to the sharp distinction drawn by earlier writers between production and consumption, many are now increasingly concerned with the active work of consuming. Consumers don't just blindly accept the output of producers; they make creative choices about what they consume—choices linked especially to the establishment of consumer identities (Miller 1987; Du Gay et al. 1996; Silverstone and Hirsch 1992).

The construction of consumer identities is a concern of producers, too. Concepts such as "champions of innovation" and "early adopters" are used in the literature of business studies to refer to customers with "needs" ahead of the rest of the market, who can provide information on potential new avenues for innovation (Bailetti and Guild 1991). The feedback of early users of new products can also be valuable as a guide in refining the design of subsequent models. This is frequently the case with information technology (Skinner 1992), and it has been documented with regard to consumer products too (Cockburn and Ormrod 1993; Akrich 1995; Du Gay et al. 1996). While these kinds of processes can—from the perspective of producers—facilitate attempts to shape consumer identities in ways that can have commercial benefits, they are also, of course, open to resistance and contestation (Woolgar 1991; Akrich 1992). What they show is that production and consumption are multiply interwoven in ways that were central to the dynamics of postmodernity in the late twentieth century.

Technological Change and Cultural Change

If modernity was sparked by a combination of the Enlightenment, industrial capitalism, and European colonialism, it could not have happened without the technological changes that accompanied these episodes. However, despite their sophisticated analyses of cultural change, accounts of modernity and postmodernity rarely subject the relationship with technology to any serious scrutiny. Harvey's 1989 account of postmodernity explores the mutual shaping of technological and social change in relation to Fordism and the emergence of flexible specialization. However, his broad-brush approach, relying on national and international statistics combined with fairly sweeping statements about the nature of flexible specialization, prevents any consideration of technical detail. More problematic is how Lyotard (1984) and Baudrillard (1988) treat as given technologies that they cite as central to the postmodern—notably, computerization and television—without (to paraphrase Mulkay 1979: 80)[2] showing what it is that makes these technologies postmodern in the 1980s when earlier they would presumably have been just modern. A teasing out of how the emergence of (post)modern society has been shaped by and has subsequently shaped technological developments is largely absent.

One exception is the work of Donna Haraway, whose "manifesto for cyborgs" (1989) takes a broad and unremittingly political approach to the hybrid, multi-dimensional nature of technology. Haraway (ibid.: 178) writes about "the informatics of domination," the networks of new information technologies that have serious yet hidden implications:

> Our best machines are made of sunshine; they are all light and clean because they are nothing but signals, electromagnetic waves, a section of a spectrum, and these machines are eminently portable, mobile—a matter of immense human pain in Detroit and Singapore. People are nowhere near so fluid, being both material and opaque. Cyborgs are ether, quintessence.
>
> The ubiquity and invisibility of cyborgs is precisely why these sunshine-belt machines are so deadly. They are as hard to see politically as materially.

Haraway directly links globalization to technology in postmodernity. She points out that production is as likely to take place in the Pacific Rim as in the West, with the same poor conditions for workers. Marx responded to bourgeois capitalism's globalizing tendencies (see Marx and Engels 1977) with an equally "grand design," the call for "workers of all countries [to] unite!" Instead of this, Haraway adopts what she calls the "cyborg myth" as a postmodern form of resistance that matches the less tangible movements of global capital in postmodernity. However, like Marx, she portrays a two-sided vision, populated by both oppressive and resistant cyborgs. Her vision shares with other feminist utopias (e.g., Piercy 1979, 1992) an ability to see technology as simultaneously liberating and threatening, though in essence neither. The sociotechnical trajectory of an oppressive social structure might yet develop in a different direction—it is always open to the disempowered to try to bring about change, and no outcome can be taken for granted as certain.

The Politics of Technology Studies

Haraway's desire to promote an alternative vision to a technologically based authoritarianism is matched elsewhere in a wide range of technological critiques and visions. Within STS itself, an early component of the field—alongside the parallel "radical science" movement (Levidow 1986)—was a critical account of the way science and technology were developing during the Cold War, linked to the peace and environmental movements of the 1960s and the 1970s (Cutcliffe 1989; Bijker 1993). The STS principle of deconstructing established notions of what constitutes science and technology is highly compatible—in principle if not often in practice—with a number of critical strands of technology analysis. In particular, Mumford (1975), Ellul (1964), Illich (1973), Winner (1977, 1986), Sclove (1995), Bookchin (1974), and Feenberg (1991, 1999) have focused on questions about how well different kinds of technology facilitate democracy, autonomy, and community. Fundamental to these analyses are questions as to who authorizes the development of an artifact or a technological system, who then decides on its design, and how this then informs the relationship among policy makers, innovators, and "the public" (Sclove 1995; Joss 1999).

Such concerns also bear on practices within STS, where political commitment and outcomes have been topics of ongoing debates. Pinch and Bijker's constructivist approach to technology—the Social Construction of Technology (SCOT) approach, which I will be adapting later in this chapter for use as the basis for my own analysis—has been criticized by Stewart Russell (1986: 335–336) for not addressing the political relations among the "relevant social groups" that are seen to shape technological meaning, and for not exploring these groups' "differing abilities to influence the outcome" of technological development and adoption. These concerns are reiterated by Winner (1993: 440–442), who argues that constructivist accounts of technology unwittingly serve the interests of the powerful by asking only how the meanings associated with an artifact become stabilized, and not why this occurs or to whose benefit. By extension, Winner regards constructivism as narrowly academic in its concerns because he sees it as refusing to take a political standpoint on technological issues.

In fact, a concern with the political dimensions of technology has been central to STS since the field was established. This concern has, though, only occasionally filtered through into work that has, like SCOT, followed the tradition of the sociology of scientific knowledge (SSK), as opposed to other disciplinary components of STS. The work of BrianWynne (1988) is a notable exception, bringing together approaches from SSK with critiques of technology assessment, risk assessment, and other aspects of public policy, particularly where this involves a clash between institutional and "lay" knowledges and interests. The politics of SSK has itself become subject to debate more recently (Ashmore and Richards

1996), while other dimensions of STS—studies of technology and work, and technology and gender, for example—have served to redress some of the political shortcomings of the field (MacKenzie and Wajcman 1999; Noble 1984; Wajcman 1991).

There is, nevertheless, some justification for Winner's argument that broader political questions can get lost in programmatic accounts of how specific artifacts come to be socially constructed. Pinch and Bijker's (1984) account of the relevant social groups in the world of nineteenth-century cycling pays little attention to the class aspects of who was able to afford a bicycle at that time, or to how this changed between the 1870s and the 1890s; nor does it address, despite discussing the role of women in shaping the meaning of bicycles, the position of women in British society, or how this compared with that of French women (McGurn 1999).[3] From a slightly different angle, both Bijker's (1992) analysis of fluorescent lighting in the 1940s and Callon's (1986a, 1987) analysis of electric vehicles in the 1970s miss the opportunity of exploring the role of "new social movements," notably environmental ones, in raising new political questions about technology. In the 1980s and the 1990s, the "high-intensity lamp"—whose stabilization in the 1940s is described by Bijker—was reconstructed as a "low-energy" lamp that met the ecological requirements of reducing carbon dioxide emissions from electric power stations. Similarly, the search for ways to develop satisfactory electric vehicles has received a new stimulus from the changing international policy agenda concerning pollution and sustainability, also raising questions about individualistic transportation policies.

Developing from this kind of problem with STS studies, a focus on the minute details of design alongside only the narrowest of social contexts means that many studies fall short of asking the kinds of questions that Winner and many feminist analysts would want to ask about technological change in relation to the kind of society we wish to live in. In other words, these studies rarely question the basis on which specific technologies are developed in the first place. Military technology is an important case here. Law and Callon's (1992) account of the TSR.2 aircraft, for example, traces how the relationships among the local and global networks of government, defense agencies, and the aerospace industry shaped the construction of this sociotechnology. As Mort and Michael (1998) note, a different account might have questioned the commitment of various actors in the story to a defense system based on nuclear weapons, or explored the implications of the tendering process for the workforces of the two companies engaged to build them. (See also MacKenzie 1990.)

Despite these misgivings about certain aspects of technology studies, I do not concur with Winner's argument (1993: 449) that themes running through the sociology of technology—such as the insight "that the course of technological development is not foreordained by outside forces, but instead a product of complex social interactions"—are "increasingly redundant." While studies such as those just discussed often fail to make broader political and ethical connections, much of what constitutes "the sociology of technology" is compatible with a more than purely descriptive analysis (Feenberg 1999). Bijker (1993) and Grint and Woolgar (1997) argue for a more politically relevant sociology of technology, although they do not quite manage to achieve this objective in these particular books. Nevertheless, this is not to negate the "deconstructive capacity" of constructivist sociology of technology "to show interpretative flexibility, to suggest alternative technological choices, to debunk the sociotechnical ensembles constructed by the powerful" (Bijker 1993: 130).

The Social Construction of Technology

How can constructivist technology studies fulfill its "deconstructive capacity"? A widely stated objective within SST is to take seriously the detailed technical content of particular artifacts, but at the same time to locate this detail within a social and cultural context (Staudenmaier 1985). This perspective profoundly challenges the notion of any inherent technological trajectory that might direct technological change toward a supposedly inevitable end point (MacKenzie and Wajcman 1985; Winner 1977). Rather, technology is presented as something contingent and emerging—something that in different circumstances "might have been otherwise" (Bijker and Law 1992: 3).

At the same time, as events unfold in the story of any particular technological artifact or system, SST analysts recognize that the technological and social paths that are established do begin to solidify such that they become less easy to dislodge. In other words, anything could happen in the earliest days of an innovation, but this becomes less and less so as time goes on. As the cultural meanings associated with an artifact stabilize alongside its technical features, it becomes less malleable and more fixed. The configuration of technology and society within an artifact thus becomes more resistant to change—more obdurate (Bijker 1995). Social studies of technology resist, then, treating technology as given—it is regarded as part of a seamless web that also includes society, culture, politics, economics, "etcetera, etcetera" (Hughes 1986). How these different elements come together to form sociotechnical ensembles (Bijker and Law 1992) which are embodied in specific artifacts deserves further study, and this also holds the key to unpacking the politics embedded in technology in ways that can benefit those at the margins. Yet this is made more difficult by the fact that, in a reversal of the problem with cultural theory, while aiming always to problematize technology, SST accounts rarely give "society" the same treatment. Social studies of technology tend to restrict their conception of the social to the immediate social context of a particular artifact. A typical contextual study will focus on the social circumstances surrounding a technology's invention and diffusion—for example, significant events involving the economic, political, and/or social relations among companies that result in the emergence of one specific configuration of that technology rather than another. It is less common in artifactual case studies to locate technology within a broader context of social or cultural change, particularly in relation to change at a "macro" level (Feenberg 1999). Reversing this trend requires, I believe, some adjustments to SST theory. My conceptual approach in this book draws on one particular version of SST: the SCOT framework, developed by Trevor Pinch and Wiebe Bijker (1984; see also Bijker 1995). I will first sketch the basic SCOT framework, then highlight a number of shortcomings (shared in many cases with other SST approaches too)—in particular, an imbalance between the technical and the social or cultural, and a focus on discrete artifacts. This can be problematic in the case of a messier setting in which several different artifacts are equally significant. Despite these problems with SCOT, there are also benefits to using this framework; I will therefore go on to sketch out an alternative way of approaching the social construction of technology. Based on the concept of sociotechnical frames, this conceptualization allows, I believe, a better articulation of the political dimensions of sociotechnical change—and hence a better chance of contributing to a more radical political agenda for technology.

SCOT is actually a developing framework, having been refined and modified since the mid 1980s—especially by Bijker and Pinch themselves, but also by others (Bijker and Bijsterveld 2000; Aibar and Bijker 1997; Kline and Pinch 1996; Elzen 1986; MacKenzie 1990; Misa 1992; Blume 1997). The essence of the approach is that technology is understood to be constructed not just by means of engineering but also by the other activities of engineers and of others associated with an artifact. The construction of technology is thus simultaneously social and technological, meaning that technology should be more accurately labeled sociotechnology (Bijker 1995). Sociologists of technology using the SCOT approach have endeavored to trace how it is that certain configurations and not others of social and technical elements combine to form particular sociotechnical ensembles (Bijker and Law 1992). For Bijker, for Pinch, and for others, understanding this process is achieved by means of a theoretical toolbox that includes four main concepts: relevant social groups, interpretative flexibility, closure, and stabilization. These concepts cohere around a theoretical structure that Bijker terms a technological frame, in relation to which actors may experience a greater or a lesser degree of inclusion.

The heuristic of the relevant social group plays a central role in SCOT as a guide in tracing sociotechnical change. Relevant social groups are a means of "following the actor" (Latour 1987), of understanding technology from the inside; for Bijker, focusing on the problems and solutions each relevant social group attaches to an artifact is the key to understanding the fluidity of technological change. Competing interpretations of an artifact by different relevant social groups result in interpretative flexibility. In other words, something that is a successful technology for one group may be a serious failure for another, and both meanings can coexist for the same artifact. Consequently, there is no clear way of defining technological "success" or "failure," and Bijker stresses his refusal to explain the development of an artifact in terms of a retrospective reconstruction of success—a common feature of non-constructivist, linear, accounts of technology. Such an account would claim that today's bicycle, refrigerator, or computer is the pinnacle of technical development, the "natural" successor to earlier versions. SCOT shows that such is rarely if ever the case.

SCOT explains the elimination of interpretative flexibility by means of closure and stabilization. Bijker's own distinctions between these two concepts is at times slippery, but it seems most useful to see closure as what occurs when a consensus emerges among all relevant social groups in regard to an artifact's dominant meaning, allowing alternative meanings to fall into disuse (Bijker 1995: 86). This can be brought about by a number of different closure mechanisms (Pinch and Bijker 1984; Beder 1991). Bijker (1995: 271) argues that the process of closure is "(almost) irreversible." Its irreversibility explains for Bijker what he terms the "obduracy" of sociotechnical ensembles—that even though technologies might have been otherwise at one point, once the interpretative flexibility of an artifact has closed it is extremely difficult to revive former meanings. Once closure has occurred, "stabilization" can proceed. By this

Bijker generally means the gradual process by which the technical characteristics of an artifact become standardized and begin to be taken for granted—in other words, closure is achieved materially as well as interpretively. He draws on Latour and Woolgar's (1979) use of modalities attached to statements about scientific facts as a means of ascertaining how stable an artifact has become—in other words, an artifact is stable when no qualifying terms are needed in order for somebody to understand what is being referred to (Bijker 1995: 86–87).

This set of theoretical building blocks, used by Bijker and others to explain technological change, is underpinned by the structural concept of technological frames, which, for Bijker, are constituted through interactions concerning particular artifacts, and which develop alongside relevant social groups. If there are no interactions concerning an artifact, there will be no technological frame and no relevant social group (Bijker 1995: 123). This allows Bijker to move away from the myth of the individual inventor genius producing an artifact by himself (or, rarely, herself) in the laboratory or the workshop, instead locating the act of invention within a social context that allows both continuity and change in the development of technology. This is achieved in particular via the notion of inclusion. An actor can be simultaneously a member of several relevant social groups, and involved in a variety of technological frames, but the degree of his or her inclusion in each frame will vary. Greater inclusion in a frame will mean that an actor's activities are highly structured by it, and they will frequently draw on it as a resource (ibid.: 143). Where they have a lower degree of inclusion, this will be less the case. Bijker suggests that significant episodes of technological change often come about when a significant actor shifts his or her primary association from one frame to another and, at the same time, brings to the new frame methods and approaches from the first frame. In this way, technological frames provide a way in which stability is maintained among a community of actors sharing an interest in particular artifacts; at the same time, they allow a structured understanding of sociotechnical change. This theoretical approach offers many benefits to those trying to understand the interaction of technological, social, and cultural change—to understand sociotechnical change. It offers the ability to span the risky dichotomy between agency and structure by providing a framework that recognizes the influence of a cultural milieu on the inventors who push technological change forward. It takes account of the myriad social groups that influence how change develops, and the complex ways in which these groups interact. And it tries to understand how a drive toward change can exist alongside a much greater degree of technological continuity.

However, SCOT is still an emergent theory, not yet fully and consistently developed, as Bijker himself recognizes. Most prominent among its shortcomings is that it focuses primarily on technical concerns. Crucial here is what Grint and Woolgar (1997) characterize as *technological essentialism*—the common assumption that there is a clearly identifiable essence that underpins technology and its effects on society. If technologies develop in ways that are contingent and context-dependent, there can be no "true" technological essence. Grint and Woolgar argue, therefore, for a post-essentialist position that moves beyond mere anti-essentialism by resisting the technicist assumptions frequently included—often unwittingly—in many anti-essentialist writings. As they recognize, it is difficult to develop a consistent anti-essentialist standpoint while still holding onto some level of technicism, a problem that is visible in Bijker's (1995) main exposition of SCOT. As Grint and Woolgar might predict, despite Bijker's strong and convincing argument that technology should be treated as more than just technical, he and other SCOT proponents still fall short of fully integrating within their analyses the non-technical aspects of technology along with the technical. This criticism applies both to the many case studies of technological change that have been published and to the way SCOT separates stages of analysis first along technical lines and then along social lines (Pinch and Bijker 1984; for a critique of this, see Rosen 1993). For example, Bijker initially (1987: 168) described a technological frame as "a combination of current theories, tacit knowledge, engineering practice (such as design methods and criteria), specialized testing procedures, goals, and handling and using practice". Later (1995: 125), Bijker refined and extended this definition into the following list of elements:

goals
key problems
problem solving strategies
requirements to be met by problem solutions
current theories
tacit knowledge
testing procedures
design methods and criteria
users' practice
perceived substitution function
exemplary artifacts.

This list includes features that Bijker regards as applicable to all relevant social groups—not just those of engineers—on the ground that "all social groups should a priori be treated as equally relevant" (ibid: 123). Thus, while its components derive primarily from the concerns and from the language of engineers, Bijker wants them to be interpreted in relation to other relevant social groups, and some indeed are specifically related to users rather than to designers and builders. Nevertheless, despite Bijker's clear commitment to a notion of sociotechnology, it isn't clear what the place of society is within a technological frame, except for the very specific society of specialist engineers working in the relevant field.

Another gap within SCOT is the cultural dimension of technological change. Beyond the narrowly defined problems and solutions pertaining to a particular artifact, there are wider cultural factors at play which also contribute to its shaping but which could be lost sight of in this framework. Mulkay (1979: 95) writes how scientific knowledge is established "by the interpretation of cultural resources in the course of social interaction." For Mulkay, scientists draw on both the cultural resources of their narrower scientific culture and the cultural resources of the wider society in which they live. This explains "the dynamic social processes whereby science absorbs, reinterprets and refurbishes the cultural resources of modern industrial societies" (ibid.: 121). This notion can be applied equally to technological and to scientific practices, and it is valuable in making clear the equal importance of diverse cultural influences on the development of technology. The more specific "cultures" that take shape around specific artifacts also should be borne in mind. These "cultures" include activities, events, and publications that promote and support the consumption of an artifact; they also include the cultures, practices, and narratives of the various organizations producing, promoting, and using the artifacts (McLaughlin et al. 1999).

It is important to recognize the distinct role played in sociotechnical change by the users of an artifact. Users' concerns appear to be treated within Bijker's technological frames as secondary to those of designers and engineers, and usually just in relation to the early stages of the product life cycle—primarily conception and design. As I have already discussed, though, users influence both the social and the material construction of an artifact throughout its life cycle, both by feeding back to manufacturers ideas that can be incorporated into the next model and by appropriating artifacts within their own systems of meaning in the process of consuming them (Skinner 1992; Silverstone, Hirsch, and Morley 1992; McLaughlin et al. 1999). More fundamentally, users' practices should be understood as concerned not just with artifacts themselves but also with broader strategic and discursive objectives. These can change as the relationship between user and artifact changes, and they can vary between different groups of users who might adopt different strategies in relation to it. Thus, discursive practices might further our understanding of sociotechnical change.

Another significant problem with Bijker's approach arises out of the fact that he applies the concept of technological frames only in relation to discrete artifacts, specifically Bakelite and lamps. Had he instead set his study of high-intensity fluorescent lamps within the context of the broader electrical industry, or had he revisited the bicycle industry, he would have found it difficult to apply this framework without some revision. In particular, it is not easy to go on applying the notion of technological frames only to discrete artifacts when faced with a more diverse group of machines and tools that might bring up somewhat different design problems and objectives but which nevertheless share many other features and can only be understood meaningfully in relation to each other. Examples would include a range of separate but related products of the same industry, the changing features of what is nominally the same artifact over a period of time, or a group of different artifacts that play complementary roles within a single technological process. These possibilities raise the question of what actually counts as "an artifact" for SCOT, in terms of there being a discrete set of features that constitute a distinct technological frame around which different relevant social groups can mobilize.

An analysis of sociotechnical change that is focused on production will have to account for a range of practices and activities that cut across social groups, across artifacts, and across moments in the life cycle of any specific artifact—an empirical setting that lies beyond the analytical capacity of Bijker's framework. The difficulty faced by Bijker's version of SCOT in addressing such a situation resembles a problem Grint and Woolgar (1997: 126) identify in the sociology of the workplace: ". . . just as most sociology of work has turned out to mean the sociology of the factory assembly line so, most of it has turned on the production of artefacts through technology rather than the consumption of technological artefacts." Here Grint and Woolgar refer especially to the organizational consumption of production technology as opposed to individual consumption of the artifacts being produced. (See also McLaughlin et al. 1999.) A parallel though partially inverted problem presents itself in the sociology of technology, which concerns itself almost exclusively with the design and consumption of artifacts and pays little attention to their production or to the technologies of production. With Bijker's conceptual framework, it is easy to see why this problem exists. The framework he uses works well when applied to products that can be conceived as fairly discrete artifacts caught for the most part in exchanges between producers and consumers—albeit artifacts in a state of interpretative flexibility. But he does not bring into the frame other artifacts that interact with these products within the sphere of production.

The move from the design workshop and the marketing department to the factory floor presents problems for SCOT. Here the products being manufactured encounter other technological artifacts, notably the production equipment used to make them. These two kinds of artifact are each essential for understanding the other, since they have been mutually shaped—products by the nature of the production equipment used, equipment by the specific requirements of product design. There is, though, no way of accounting for their interdependence within the context of a technological frame, which has space only for separate and discrete artifacts. Similarly, the shop floor complicates relations among social groups—we are no longer dealing only with competing designers, communities of engineers, and users and non-users of an artifact. Rather, the production of goods involves a wide variety of staff categories within an organization, differentiated both within and between the workforce and management. This situation renders even less sustainable the engineering bias of the elements that Bijker sees as constituting a technological frame.

In fact, Bijker makes no definitive claims for his theory—indeed, he considers his list of features of a technological frame to be tentative, empirically generated, and open to change (1995: 125). It is this openness that makes it appropriate to try to adapt and improve SCOT in order to overcome its shortcomings. What I want to do here, then, is suggest how the components of the SCOT framework can act as stepping stones toward an approach that more adequately supports its own program of analyzing technology as socially constructed. This revised version of SCOT will then underpin my account of sociotechnical change in the bicycle industry.

Sociotechnical Frames and Sociotechnical Change

How can Bijker's framework be adapted to overcome the difficulties I have outlined? How can cultural resources, organizational practices, interlinked technologies, and the interactions between designers and users be incorporated into a technological frame? Even if this could be made to work satisfactorily, what status would they hold in relation to the elements already listed?

What I propose as an alternative framework for understanding the complexity of sociotechnologies is set out in figure 1.1. A sociotechnical

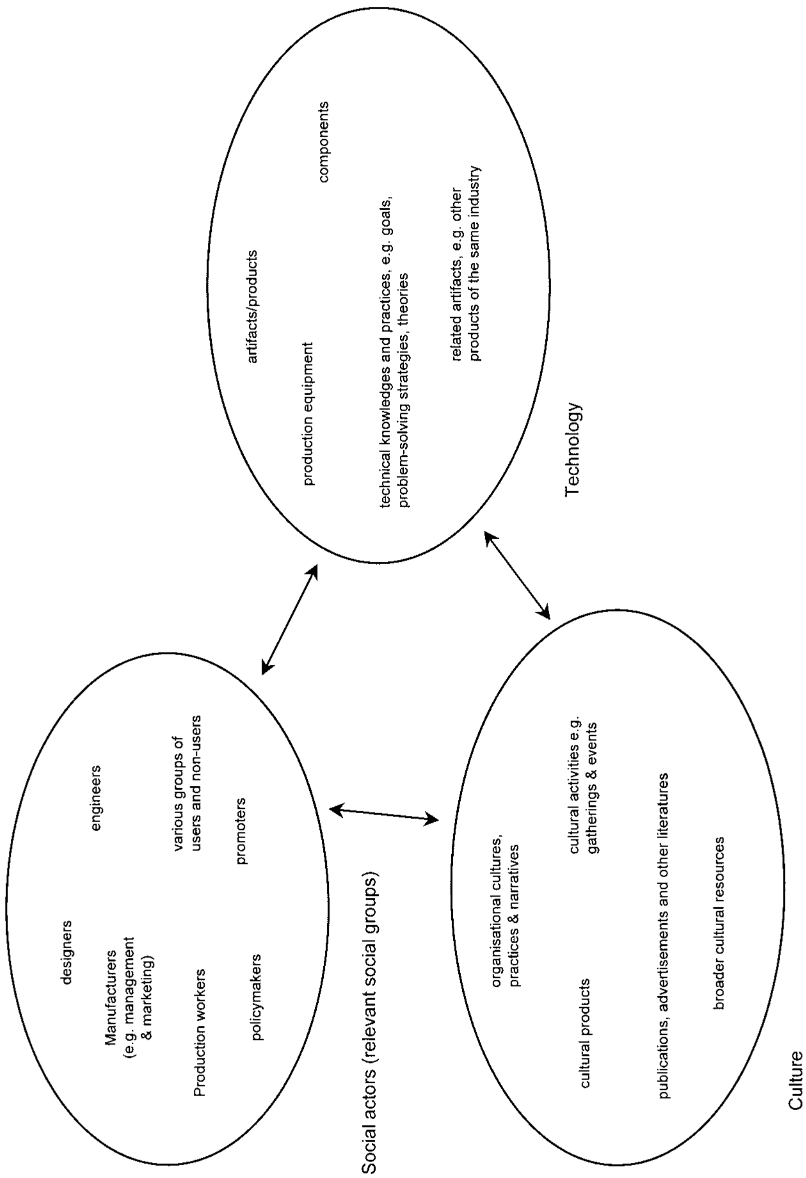

Figure 1.1
Elements of a sociotechnical frame

frame situates the technology of an artifact as just one of three components of the frame, taking us away from the narrower technical focus of a technological frame. The three components of a sociotechnical frame are (1) the social world of social actors—individual and organizational—associated with particular artifacts (Bijker's and Pinch's relevant social groups), such as designers, engineers, manufacturers (including groups differentiated along lines such as "management" and "labor"), promoters, policy makers, and various groups of users and non-users, (2) the technological world of artifacts and their components, process and production equipment, and other, related, artifacts, and (3) the cultural world that develops around artifacts in the form of organizational cultures, narratives and practices, gatherings and events, literatures, and other products, along with broader cultural resources on which various social actors can draw.

A sociotechnical frame is, in fact, something quite different qualitatively from Bijker's framework. His theoretical structure is primarily about the relations of engineers to their machines. The elements Bijker lists relate quite closely to the particular world views of communities of engineers associated with a specific artifact, even though it is intended not to exclude relevant non-engineers. Sociotechnical frames, in contrast, are not primarily about engineers and their machines. Rather, they structure the relations of a more heterogeneous group of actors and artifacts—not only relations between engineers and machines, but also relations between non-engineers and machines, between different kinds of related machines, and between different groups of actors (engineers and others). Mediating these relationships are the cultural values and practices that express the concerns of social actors and groups focused on a specific artifact or process. Sociotechnical frames thus encompass not only the elements of a technological frame (as outlined by Bijker) but also the groups of artifacts that have meaning for those involved, the significant events in the construction of the central artifact, and related technical processes and technologies.

How does this framework account for sociotechnical change? Bijker's framework offers two different models of change, set out in his case studies of Bakelite and fluorescent lamps. With the latter, he examines how a new artifact was constructed out of the conflicting interests of actors working within different technological frames—between manufacturers (whose goals and problem-solving strategies were geared toward selling lamps) and utility companies (whose major focus was to sell electricity and provide a public service) (Bijker 1995: 236–238). The result was a compromise between these two sets of goals that generated a new artifact and a new technological frame. (See figure 1.2.) In the construction of Bakelite, change in one technological frame was brought about through the work of an actor whose training and commitment lay within a different frame. A low level of inclusion within a technological frame can result, then, in an actor's finding radical solutions to a problem that are incompatible with established methods. This can then lead to the emergence of a new technological frame (figure 1.3). This conception of change as the outcome of tensions between technological frames is convincing, but it cannot provide an adequate explanation of how change is achieved across the messier interactions of the variety of technologies, actors, and events that constitute a sociotechnical frame. Changes to the meanings, the constructions, or even the material basis of one particular artifact will not necessarily bring about a transformation of the entire sociotechnical frame within which it is located. For that, it is necessary to look for instances in which the two processes Bijker describes are operating in tandem—that is, processes in which a clash between two frames takes place at the same time as marginal actors step outside the conventional frame, learn from

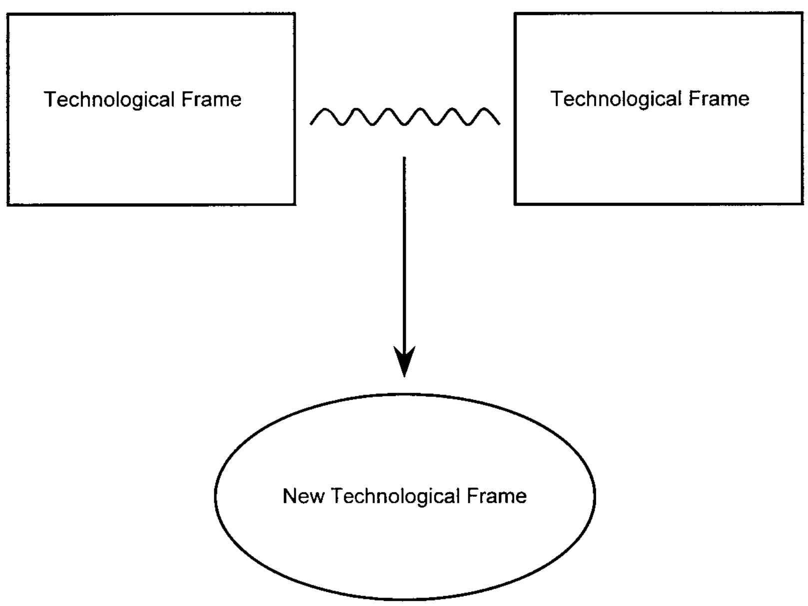

Figure 1.2
Bijker's account of how conflict between two existing technological frames leads to the establishment of a new one.

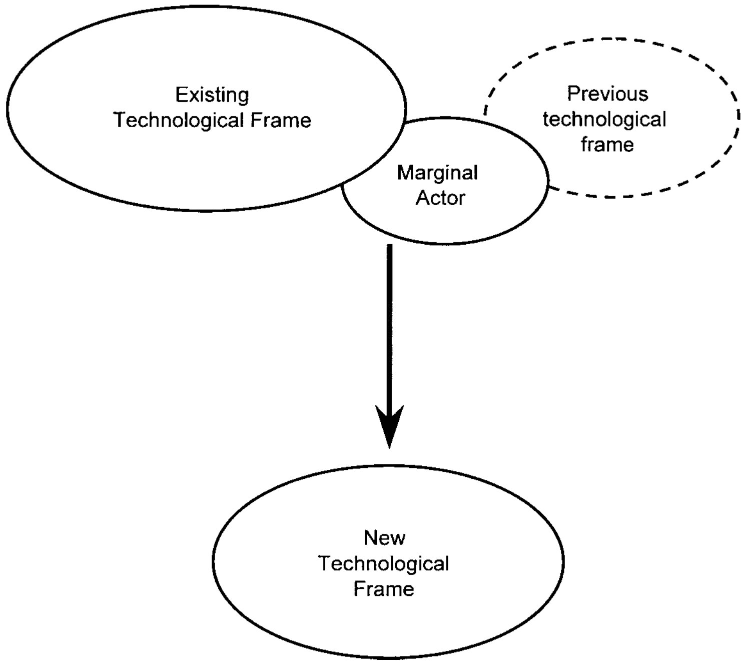

Figure 1.3
Bijker's account of how an actor with low inclusion in an existing technological frame establishes a new one.

alternatives, and thus develop a new frame (figure 1.4). The transitions that consequently take place from one frame to another hold the key to sociotechnical change—indeed, transitions between frames, rather than stability within them, are the focus of my empirical study. Such transitions come about when the three components of a frame (the social, the cultural, and the technological) get out of step with one another—more specifically, when the cultural component's mediating role between technology and society is no longer effective. According to Sharon Traweek (1992: 437–438), a scientific community is "a group of people with a shared past, with ways of recognizing and displaying their differences from other groups, and expectations for a shared future." "Their culture," Traweek continues, "is the *ways,* the strategies they recognize and use and invent for making sense, from common sense to disputes, from teaching to learning; it is also their ways of making things and making use of them and the ways they make over their world. . . ." The demise of a sociotechnical frame results when the social actors involved with a particular arti-

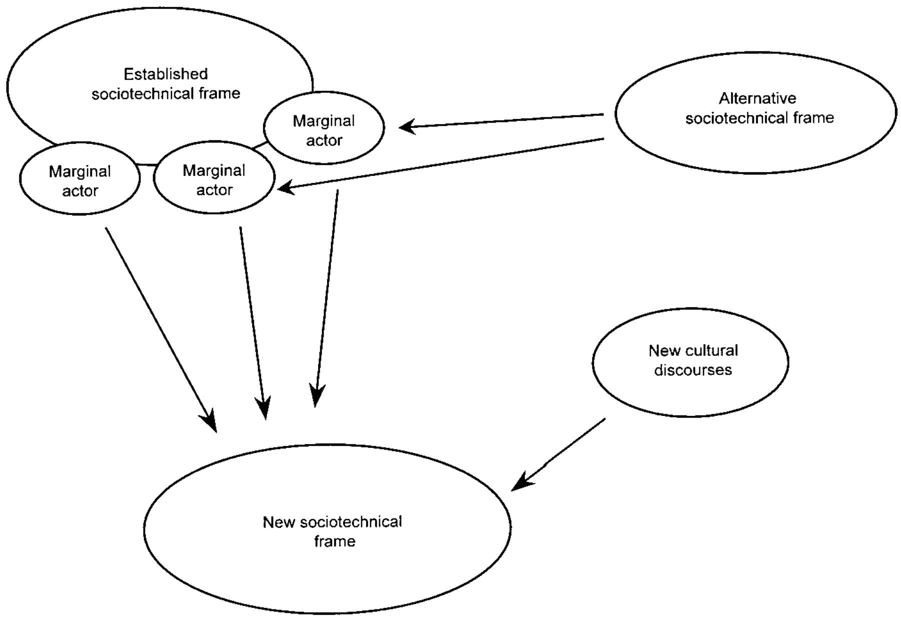

Figure 1.4
How marginal actors establish a new sociotechnical frame through encounters with alternatives.

fact no longer have these shared ways in relation to it. This might arise because cultural change has meant that different groups of actors no longer relate to each other or to the technology in the same way, or because the makeup of the social groups concerned with that artifact has changed, or even because the technology itself has changed (either through innovation or obsolescence) in such a way that it has lost its relevance for those social groups.

The value of using the concept of sociotechnical frames to understand this material is that it goes beyond the boundaries of the artifact and its immediate relevant social groups to account for a more complex interrelationship of technology, society, and culture. This then allows an understanding not only of change but also of stability. At a time when technology is being increasingly opened up to question, an important role of social studies of technology must be to examine closely the process by which technologies shift from being in a state of openness, of interpretative flexibility, to being fixed, embedded, stabilized, or locked into social structures (Nelis 1999; Bijker 1995; Winner 1977). How final is such fixing? Is the direction taken in any specific episode of technological change truly inevitable? And what scope does the process of sociotechnical change leave for movement away from technologies that are regarded as harmful—whether to the environment or to society—if, as Bijker writes (1995: 271), the process of technological closure is "(almost) irreversible"? Trying to find answers to such questions is crucial to achieving any kind of resolution in the politics of technology or in the politics of transportation and the bicycle.

The Politics of Production and the Politics of the Bicycle

How does this revised SCOT framework account for the unfolding story of the bicycle? In the following chapters I will apply this approach in describing the two significant changes in the British cycle industry: the transition from a sociotechnical frame of the factory bicycle to one of the mass bicycle and the transition from the latter to a frame of the globally flexible bicycle. I will then explore how constructivist technology studies might help precipitate another shift in the sociotechnical frame of the bicycle by promoting a participatory politics of bicycle technology.

This sociotechnical progression—from the local factory to a global arena—will be set against the background of wider changes in society, culture, and the politics of production. How did new forms of organizing the bicycle industry, its methods, its products, and its markets come about? What have the outcomes been? Where have such changes left British bicycle production and consumption? More generally, what does this story tell us about technological and organizational change, innovation, and the relations between technology and culture, between producers and consumers, and between manufacturers and their workers? Who are the agents of change, and how do their personal goals tie in with wider cultural values? How easy or difficult would it be to direct change in more purposeful, and hence less contingent, ways in order to achieve particular objectives? What implications does an analysis of industrial production have for social studies of technology? Such questions have barely been touched on in the cycling literature—or indeed in much other literature on technological or cultural change. Yet developments in bicycle design, production, and use were highly influential in the development of modernity from the late nineteenth century on. In the late nineteenth century, bicycles stimulated desires for personal transportation and for speed. They provided a private alternative to the public transportation offered by trains and horse-drawn coaches without the overhead or the infrastructure that these required. They shrank distances between villages and towns, breaking down boundaries that had previously defined the limits of communities, families, and working life and stimulating inventors to further refine the bicycle and to find ways of replacing human pedal power with other kinds of power. In addition to this role as a conceptual stepping stone toward the automobile, the nascent American bicycle industry of the late nineteenth century also served as a stage in the progression toward the mass-production auto industry that emerged just a few decades later.

Having played such a pivotal role in the great social, cultural, and technological upheavals of the late nineteenth century and the early twentieth, the bicycle has again become central to change. Long after its replacement by the automobile as the primary means of transportation in the developed countries, the bicycle remains predominant in many developing countries. Now, as those countries begin to look toward greater industrialization and an automobile-based economy, the bicycle is again being highlighted as the solution to the transportation problems of Western cities. Campaigners for "green transportation" and appropriate technology have long recognized the role that bicycles could play in making transportation more responsive to human needs and less harmful to the environment. As congestion and pollution levels increase, the car culture that has dominated Western social and economic life during recent decades is no longer regarded as sustainable. The alternative being promoted is an integrated approach to transportation, focusing on buses, trains, walking, and cycling.[4]

The changing fortunes of the bicycle and of cycling—varying historically in the West and also varying at any particular time in different geographical locations—exemplify the importance of understanding sociotechnical change within its social and historical context. They also point to the strong embedding of politics within technology. Political disputes inform the story of the bicycle at every level of analysis and at every stage in the life cycle of this artifact. In design, important questions arise as to who machines are designed by and for, and this extends also to the related practices of marketing, selling, and using bicycles. In the production process, the relations between the sellers and the buyers of labor power are as tense in the bicycle industry—and are just as subject to continual change—as in industries more commonly discussed in regard to the politics of production. Aside from these tensions between capital and labor, the bicycle industry as a whole has throughout its history been dogged by struggles among corporate rivals, the outcomes of which have