The Social Construction of Technology: Structural Considerations

Hans K. Klein
Georgia Institute of Technology

Daniel Lee Kleinman
University of Wisconsin–Madison

Although scholarship in the social construction of technology (SCOT) has contributed much to illuminating technological development, most work using this theoretical approach is committed to an agency-centered approach. SCOT scholars have made only limited contributions to illustrating the influence of social structures. In this article, the authors argue for the importance of structural concepts to understanding technological development. They summarize the SCOT conceptual framework defined by Trevor Pinch and Wiebe Bijker and survey some of the methodological and explanatory difficulties that arise with their approach. Then the authors present concepts from organizational sociology and political economy that illuminate structural influences in shaping phenomena of interest to SCOT scholars. These structural concepts can be applied to the study of the design, development, and transformation of technology. The authors conclude that the limited amount of scholarship on structural factors in the social shaping of technological development presents numerous opportunities for research.

Researchers in the field of science and technology studies (STS) have produced a great deal of scholarship in recent years that documents and analyzes the social shaping of technology.[1] An important area of this scholarship, known as the social construction of technology (SCOT), traces its origins to Trevor Pinch and Wiebe Bijker's (1987) article, "The Social Construction of Facts and Artifacts: Or How the Sociology of Science and the Sociology of Technology Might Benefit Each Other." From this seminal work has flowed a body of research that is rich and diverse—but that has largely remained committed to an agency-centered approach. Despite some conceptual evolution in the direction of structural theory, most notably in Bijker's (1995) later and more comprehensive work *Of Bicycles, Bakelites, and Bulbs*, the SCOT approach has made only limited contributions to illuminating how social structures can influence the development of technology.

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This article suggests the importance of broadly structural concepts to an understanding of the social shaping of technology.[2] In what follows, we summarize the original conceptual framework defined by Pinch and Bijker (1987) and survey some of the methodological and explanatory difficulties that arise with their approach. Then, we present concepts from organizational sociology and political economy that illuminate structural influences in shaping phenomena of interest to SCOT scholars. These structural concepts can be applied to the study of the design, development, and transformation of technology to improve our understanding of the social shaping of technology.[3]

The Social Construction of Technology

We begin by summarizing the basic concepts of SCOT as well as some recent critiques of this work. As originally presented by Pinch and Bijker, SCOT's conceptual framework consists of four related components.[4] The first is interpretive flexibility. This idea, taken from the empirical program of relativism (cf. Collins 1975; Pinch 1977, 1986; Pickering 1984) in the social studies of science, suggests that technology design is an open process that can produce different outcomes depending on the social circumstances of development. Some sociologists of science argue that the very entities of physics, such as the particles studied in particle physics, are the products of intergroup negotiations over the interpretation of observations (Pinch 1996). SCOT scholars, in turn, apply the concept of interpretive flexibility to technological artifacts to show how artifacts are similarly the product of intergroup negotiations. Examples of this kind of scholarship include MacKenzie's (1990) account of the negotiations over the definition of missile accuracy, Pinch and Bijker's (1987; Bijker 1995) work on early bicycles, Bijker's (1987, 1995) studies of Bakelite and fluorescent lighting, Elzen's (1986) work on ultracentrifuges, and Misa's (1992) investigation of the manufacture of steel.[5] Technological artifacts are sufficiently underdetermined to allow for multiple possible designs, so whatever the design that finally results from the process, it could have been different.

The concept of the relevant social group is a second component of the SCOT approach. Relevant social groups are the embodiments of particular interpretations: "all members of a certain social group share the same set of meanings, attached to a specific artifact" (Pinch and Bijker 1987, 30). They are the agents in this agency-centered approach whose actions manifest the meanings they impart to artifacts. Technology development is a process in which multiple groups, each embodying a specific interpretation of an

artifact, negotiate over its design, with different social groups seeing and constructing quite different objects. For example, groups may have different definitions of a working technology, so development continues until all groups come to a consensus that their common artifact works. Design ceases not because the artifact works in some objective sense but because the set of relevant social groups accepts that it works for them (Bijker 1995, 270).

The third component of the SCOT framework is closure and stabilization. A multigroup design process can experience controversies when different interpretations lead to conflicting images of an artifact. Design continues until such conflicts are resolved and the artifact no longer poses a problem to any relevant social group. The multigroup process achieves closure, no further design modifications occur, and the artifact stabilizes in its final form. Somehow a final decision—or at least a cessation of further decision—occurs. Pinch and Bijker (1987) see this as occurring through closure mechanisms. They provide two examples of such mechanisms. In the case of rhetorical closure, a declaration is made that no further problems exist and that no additional design is necessary. Closure by redefinition occurs when unresolved problems are redefined so that they no longer pose problems to social groups. As today's software hacker would put it, "That's not a bug, it's a feature!"

Fourth, there is the wider context. This is the wider sociocultural and political milieu in which artifact development takes place. This plays a minor role in Pinch and Bijker's original conception of SCOT. The background conditions of group interactions, such as their relations to each other, the rules ordering their interactions, and factors contributing to differences in their power, remain largely invisible. It is here that most later critiques have focused; it is also here that many of the structural concepts we discuss belong.

Numerous scholars have criticized the original formulation of SCOT as insufficient. Indeed, the original authors have themselves acknowledged and even participated in this critique (Pinch 1996). Much criticism concerns an excessive emphasis on agency and neglect of structure.

A central target of criticism is SCOT's view of society as composed of groups. Pinch (1996) sums it up best when he states, "The particular way in which society is conceptualized and linked to artifacts is via the notion of *relevant social groups*" (p. 23). As Winner (1993) suggests, this is an essentially pluralist view of society. Implicitly, SCOT assumes that groups are equal and that all relevant social groups are present in the design process. This fails to adequately attend to power asymmetry between groups. Some groups may be effectively prevented from participating in the design process at all (Williams

and Edge 1996). Some groups may not be groups at all but may be a diverse collection of subgroups for whom some actor claims to speak (Russell 1986). The process of artifact development may be rife with intergroup (Haard 1993) and intragroup conflict. The assumption that the result of interaction among distinct social groups is typically consensus also merits critical rethinking. These presuppositions are far too agency centric. They overlook systematic asymmetries of power and how these power differences are rooted in structural features of social life.[6]

Since the original presentation of this framework, one major concept has been introduced into SCOT. To the four foundational concepts, Bijker (1995) added that of the technological frame (better understood as a "frame with respect to technology" [p. 126]). This is the shared cognitive frame that defines a relevant social group and constitutes members' common interpretation of an artifact. Like a Kuhnian (1970) paradigm, a technological frame can include goals, key problems, current theories, rules of thumb, testing procedures, and exemplary artifacts that, tacitly or explicitly, structure group members' thinking, problem solving, strategy formation, and design activities (Bijker 1995, 125). A technological frame may promote certain actions and discourage others: "Within a technological frame not everything is possible anymore (the structure and tradition aspect), but the remaining possibilities are relatively clearly and readily available to all members of the relevant social group (the actor and innovation aspect)" (Bijker 1995, 192).

Bijker's introduction of the technological frame to the SCOT framework is an important first step toward recognition of structure, yet numerous possibilities exist for additional insights. Various other authors have begun this process, but they have proceeded in a piecemeal fashion. For example, Kline and Pinch (1996) examine how the structure of gender roles influenced the rural (re)design of automobiles. The traditional role of the male as technical expert excluded women from processes of automobile design. Men adapted cars to serve as mobile power sources, while women simply operated the new machines. Another study focuses on the larger social context of the postmodern, "post-Fordist" economy. In that work, Rosen (1993) explains the design and continuous redesign of mountain bikes in terms of the flexible production systems that emerged in the mid-1970s. Like Bijker's theoretical additions, these studies begin to shed light on how the structured character of the larger social context affects technology. Still needed, however, is a broad recognition of the importance of structure and a more comprehensive project to bring such concepts into a broadly social constructivist approach.

The Importance of Social Structure: Method and Explanation

The difficulties with the agency-centric approach favored in SCOT fall into two broad and ultimately integrally related categories: method and explanation. As elaborated by Bijker (1995), method consists of two main parts. First, to identify the set of relevant social groups, one should "roll a snowball" (p. 46). The researcher interviews a few actors at the start, asking them to identify relevant groups, and in this way eventually builds up the set of all groups. One problem with this method is that of completeness. A simple comparison of Pinch and Bijker's (1987) analysis of the development of the bicycle with Bijker's (1995) more recent rendering suggests that this snowball method is no guarantee of accuracy or comprehensiveness and may introduce its own distortions. In the original essay, Pinch and Bijker explain the development of the bicycle primarily in terms of the contrasting visions of two groups of potential bicycle consumers. In Bijker's more recent analysis, manufacturers play a more prominent role. Parliament, advertising, and gender mores all receive attention. Is it just that Bijker's new snowball has more layers? If so, is a bigger snowball a better snowball? In other words, does more information make for a better explanation?

Another problem with the snowball approach, one common to pluralist theories in general, is that some relevant social groups may be excluded from participation and their (significant) absence may go unnoticed. Following the snowball method, both the exclusion and the reasons for it would remain hidden, with the concomitant risk that a major factor in technological change would go undetected. Bijker's (1995, 49) response to the problem of missing groups is to admonish researchers to exercise judgment in deciding whether to include or exclude groups. The difficulty is more serious than this response suggests, however. The snowball method is inadequate for identifying unrecognized and missing participants, while its emphasis on groups overlooks social structures that might account for such absences.

As his second methodological rule, Bijker, following Latour (1987), suggests that researchers must "follow the actors." Central to this technique is the idea that the only categories and lines of social demarcation of importance are those consciously recognized by the actors (Bijker 1995, 15). According to Bijker, retrospective distortion or more specifically Whiggish history—the idea that the present necessarily follows from the past—can be avoided by following this approach. Following the actors, however, risks falling into a crude empiricism that raises problems of its own. A central question is whether it will provide us with a complete picture of the process by which technologies are constructed. Factors that prevent groups from participating,

that prevent certain viewpoints from being embodied in a social group, or that promote the formation of certain social groups could all escape notice of historical actors—and the researchers who follow them.

It is worth noting, in this context, that Bijker (1995) himself does not always restrict his analysis to actors' categories but also draws on concepts from economics, like "capital intensive" and "oligopolistic market" (p. 200), in his discussion of the development of the fluorescent light. He himself admits some of the categories he uses are exclusively analysts' categories (p. 49). However, this methodological expansion remains little developed in his work. Perhaps anticipating the critique offered here, Bijker urges researchers to take his conceptual framework "in the right spirit—as a collection of sensitizing concepts that aims to provide the researcher with a set of heuristics with which to study technological development" (p. 49) rather than as a computer program to be followed blindly and mechanically. But if sensitive use of the SCOT concepts within the context of Bijker's method is required, it is not obvious why we might not use an alternative set of concepts with equally good or better results. Indeed, while Bijker's assertion that his concepts should be used as "sensitizing concepts" and "heuristic" devices may weaken the force of his method specifically, it is appropriate advice for the deployment of any set of concepts to the analysis of an inevitably partial portrait of an infinite world. Indeed, the two quite different analyses of the history of the bicycle in which Bijker participated clearly supports this claim. And this revelation weakens the admonition made by Bijker, Latour (1987), and others that we should make no a priori assumptions about the division of the world in which actors act. Of course, the implausibility of the idea that analysts ought to begin with no presuppositions has been a centerpiece of critiques of crude empiricism. But beyond this, since where one looks affects the kinds of divisions of the social world one sees, an argument can be made for the analyst's use of his or her own categories.

In our discussion below, we suggest an alternative to the SCOT methodological strategy. We argue that it may be appropriate to begin with a set of a priori categories and concepts that previous analyses have shown to be fruitful. At one level, these tools might serve a function akin to Weber's ideal type (see Shils and Finch 1949). By attempting to apply them we would not only see their relevance and the extent to which they require adjustment but would also gain purchase on what kinds of social categories (or relevant social groups) are not captured by our analysis.

Having examined how Bijker's (1995) SCOT approach creates methodological difficulties, we now consider how it creates problems of explanation. In this context, a second shortcoming of the SCOT approach revealed by Bijker's elaboration is its apparent inability to explain success and failure in

the struggle to create working technologies. In his analyses of the bicycle, Bakelite, and lighting technology, Bijker (1995, 60, 93, 94, 134) repeatedly points to the success of a relevant social group or artifact, but he never specifies the factors that contributed to this outcome. Similarly, he describes closure as the product of consensus (pp. 86, 249, 251) but does not explain how consensus develops. At the end of these accounts, we can understand that the technology worked for the relevant social groups. But we lack an explanation for why some groups' meanings had greater relevance than others and how differences were resolved (or suppressed).

What we believe is missing in all of these cases is a discussion of groups' capacity or power. What enables one group's interpretation to be embodied in the artifact? Toward the end of his book, Bijker (1995, 282) does introduce a casting of power linked to his notion of technological frame. Ultimately, however, this conceptualization comes too late and is overly vague. Throughout Bijker's text, power is either ignored or deployed in an ad hoc fashion. Echoing his work with Pinch, Bijker's diagram of the relationship between social groups and an artifact suggests groups are equivalently situated in terms of their capacity to shape artifacts (p. 47). At another point, Bijker refers to the rhetorical power of speed in the bicycle case (p. 89) but provides no explanation for what makes rhetoric powerful. In still another instance, Bijker refers to economic power (p. 200) but he does not define the term, explain its source, or carefully consider its effects. Finally, in the case of lighting technology, Bijker suggests that the "Edison Company had a relatively strong position because of the patents it held" (p. 201). In fact, Bijker devotes an entire section of a chapter to patent litigation, but he never considers how and why a patent strengthens an actor's position vis-à-vis an artifact. Bijker offers no discussion of the significance of or bases for actors' capacity to defend against patent infringement. Some actors have this capacity, and others do not, and this fact may affect the outcome of the technology construction process. We contend that a more cogent analysis of technology construction demands far more systematic consideration of matters of group capacity or power than is found in the SCOT literature. We will suggest below that group capacity should be understood in broadly organizational or structural terms, as it is such factors that fundamentally shape group capacity.

A final matter with which we take issue is the commitment to a position of "co-construction" (Fujimura 1996). As Bijker (1995) puts it, SCOT must move beyond the internalist/contextualist debate in the history of technology to "figure out a way to take the common evolution of technology and society as our unit of analysis" (p. 10). Or put differently, "modern society must be analyzed as a seamless web" (p. 15). Such a position makes distinguishing cause and effect impossible. Indeed, at its extreme, this approach makes

disaggregation and thus analysis itself impossible. To the contrary, we believe a causal analysis is called for. Taking this position does not demand that we reject the idea that over time technology and society are part of a reciprocal or dialectical process in which each constructs the other. At any given point in time, however, it is analytically possible to stop the process and ascertain, at least tentatively, what is affecting what. The concepts we introduce are intended to facilitate this understanding.

In what follows, we point to the advantages of using an alternative set of sensitizing concepts to those offered by SCOT. We elaborate a more thoroughgoing and clearly articulated set of structural factors that may influence technology design than has previous work.[7] Drawing from a range of theoretical traditions,[8] we outline a set of concepts and identify the kinds of questions they lead us to ask. In addition, we engage in some initial application of these concepts to empirical material. Our main interest, however, is conceptual.

Adding Structure: New Sensitizing Concepts

The fundamental premise of our approach is that the social world is constituted of historically established structures that at any given point in time confront actors as external and constraining. Following in the tradition of institutional political economy (cf. Hall 1986; Kleinman 1995; Lindberg 1982, 1985), we define structures as

> specific formal and informal, explicit and implicit "rules of play," which establish distinctive resource distributions, capacities, and incapacities and define specific constraints and opportunities for actors depending on their structural location. Power and its operation are then understood within this structural context. The rules of play that define structures give certain actors advantages over others by endowing them with valued resources or indeed by serving as resources themselves. (Kleinman 1998, 289)

An adequate understanding of the limits of interpretive flexibility, stabilization, and closure requires attention to power asymmetry. Here, we are in general agreement with Haard (1993, 420), who suggests that societies are structured around power asymmetries and that the bases of these can be found at a level above that of the interactions of the groups themselves (see also Schot and Rip 1996; Feenberg 1999). The capacities of relevant social groups and actors within them, furthermore, are shaped by their structural characteristics.

We acknowledge that these structures are themselves social constructs. However, we are less interested in exploring the process of their development

than in understanding their effects. Although we agree with Williams and Edge's (1996, 875) claim that "social setting shapes technologies as much as vice versa," we do not agree that "it is therefore clearly unhelpful to treat technologies and their social contexts as separate phenomena" (p. 875). If we cannot analytically distinguish between context and content (technology), then it is impossible, even in a tentative way, to understand how the social world shapes (the meaning of) artifacts.

With this broad vision of structure in mind, we survey a range of concepts that might usefully be brought to bear on SCOT. Through this exercise, we wish to illustrate the power and richness of broadly structural concepts and their relevance to questions of technology development. We consider the five components of SCOT—relevant social groups, interpretation, closure, technological frame, and the wider social context—and suggest how understanding them in structural terms can enrich our understanding of artifact development.

The Structure of Relevant Social Groups

As noted earlier, the SCOT approach, like most agency-centered approaches, treats both the existence of individual social groups and the set of all groups as unproblematic. This approach ignores the question of how existing groups were able to come into being, whether some individuals sharing common meanings were unable to unite into a group, and how groups entered the set of groups with access to the design process.

A number of scholars have studied how technology development is shaped by preexisting groups whose origins have less to do with the artifact currently under design than with the earlier history of the group. In his classic work *TVA and the Grass Roots*, for example, Philip Selznick (1980) analyzes how preexisting agriculture groups influenced the development of the Tennessee Valley Authority (TVA). These local groups were more the product of earlier agricultural extension policies than of any shared meanings about the TVA. The groups' existence predated the design process, and presumably any shared meanings occurred only after they encountered the TVA. Had an identical technosystem like the TVA been proposed and initiated elsewhere, the composition of the relevant social groups might have been very different, and so the final outcome might have been different. The very existence of groups is a fact to be explained, in this case by a preexisting social division of labor. To merely document the group's interactions might miss the fact that the TVA design was significantly influenced by groups created in earlier agricultural extension programs. One could investigate the way in which meanings created in agricultural extension came to be embodied in power generation.

As we noted earlier, the SCOT approach also risks overlooking significant absences. Simply because a multitude of individuals share a set of meanings does not ensure that they will organize themselves into a group to participate in a design process. Potential groups may confront significant barriers to organization and participation (cf. McAdam 1982, 39; Lukes 1974). Thus, some collective meanings with relevance to an artifact might not become organized to participate in the design process. This absence might have a great influence on the final artifact.

Not only may structural factors influence whether groups exist but they may also influence the composition of the set of all groups participating in design. Although Pinch and Bijker (1987) do not describe the forums within which bicycle design occurs, many collective processes for design and decision making unfold in contexts with rules of access. A number of scholars argue that such rules influence outcomes. By conditioning the composition of process participants, rules of access impart bias to the process from the start. For example, March and Olsen (1976) identify various configurations for access to organizational decision making. In one configuration, decision makers may participate only in decisions taking place at their level in the organizational hierarchy. In another constellation, decision makers may participate in decisions taking place at their level and at all lower levels in the hierarchy. These variations in the rules of access result in distinct outcomes. To take another example, Gordon Adams (1984) argues that most defense procurement decisions are made by a restricted set of agents who have the power to exclude other potential participants from the policy process. The result of this exclusion is that defense decisions, including the design of weapon systems, embody the meanings and interests of only a select subgroup of participants (see also Lukes 1974; Wright 1994).

Informed by concepts such as "design forum," "rules of access," and the "power to exclude," a researcher might direct his or her attention in quite different directions than simply following the actors. For example, in Bijker's (1995) account of fluorescent lighting, he traces how two relevant social groups, lamp manufacturers and electricity producers, designed a lamp that worked for them—but that quite clearly did not work for consumers. The industry-friendly "high intensity daylight fluorescent lamp" guaranteed continued consumer purchases of both bulbs and electricity, whereas another proposed design, the "high *efficiency* daylight fluorescent lamp" would have allowed consumers to reduce electricity purchases. Why did one design emerge rather than another, and how could a final working artifact emerge that harmed the interests of consumers? Bijker notes in passing that "the public was not informed" (p. 241). However, he does not explore the ability of

concentrated industry groups to more effectively pursue their interests than could dispersed consumers, nor does he examine the design forum with its tightly controlled access. These structural features may be more relevant than the industry groups' technological frame for explaining the final artifact.

The Structure of Interpretation

As initially formulated, the SCOT approach neglected structural factors affecting a social group's systems of meaning. SCOT advocates, of course, argue that social groups interpret artifacts differently and seek to shape them according to their different systems of meaning. But we would suggest that attention to structural factors offers an opportunity to understand the relative efficacy of systems of meaning and the role of meaning in shaping artifacts more thoroughly than the SCOT approach would. Systems of meaning themselves may merit explanation, and groups may vary in their ability to use their meanings to affect artifact development.

Relevant social groups may have systems of meaning that are so codified that they are no longer objects of awareness. To take one example, standard operating procedures (SOPs) can affect technology design.[9] As March and Simon (1958) argue, organizations employ predefined SOPs to perform tasks, and these SOPs constrain organizations by limiting their possible actions. This may explain design. In his study of the Cuban missile crisis, Allison (1971) found that Soviet units in Cuba deployed their missiles in a standardized trapezoidal configuration, a pattern codified in SOPs in their technical manuals. From surveillance photographs of the missile site, U.S. analysts deduced the presence of Soviet units because they recognized the Soviet SOP embodied in the artifact. The design manifested the organization's cognitive structures.

The internal structure of social groups may also allow internal factions to embody their particular meaning in an artifact. Michels's (1962) "iron law of oligarchy" suggests that as associations implement a division of labor they create an internal administrative elite whose perceptions and interests may diverge from the broader membership. Through the control of administration, this elite may impose its interests on the entire organization by avoiding actions that jeopardize elite privilege. When these elites participate in a design process as representatives of their association, they may impose their own meanings on the artifact. The division of labor internal to a social group and the resulting class structure can allow an elites' system of meaning to dominate the whole group.

Bijker (1995) deserves credit for bringing increased attention to groups' cognitive structures as well as to the existence of intragroup dynamics.

However, these topics beg for more thorough theoretical elaboration as they apply to technological change. The concepts mentioned here can provide powerful theoretical constructs for further elaboration.

Structural Factors Affecting Closure

Pinch and Bijker (1987) conceive of closure as occurring when all groups' problems have been addressed and groups achieve consensus on a particular design. Here again, we suggest that structural factors may play a role.

Closure, for example, may be affected by groups' enduring relations of power and dependency. Pfeffer and Salancik (1978) conceptualize interorganizational relationships in terms of the control of resources. One organization's essential inputs may be controlled by another organization, rendering the former vitally dependent on, and therefore acquiescent to demands of, the latter. In technology development, a more powerful organization may use such dependency to force others to accept closure even though the artifact may not work for them. Closure and consensus around a final design can only be explained with reference to the power relationships between groups.

Closure may also be conditioned by rules. McNaugher (1989) explains design pathologies in defense technology as the result of barriers to closure of the design process in U.S. policy institutions. In the U.S. system, many groups are able to gain access to the policy process, and thus design modifications may occur continuously throughout development. With so many groups able to impose demands, project managers continuously add features. Closure is elusive, but the reasons for that lie more in the decision-making rules dictated by the structure of the federal government than in the rhetorical skills of designers.

Structural insights like these suggest various questions for contemplating Pinch and Bijker's (1987) rendering of the history of bicycle design. Did deadlines force designers to make closure? Could a deadline for a trade fair or a bicycle exposition force some social group to demand or acquiesce to closure? Could some groups (say, the manufacturers) impose their will on other groups (say, the racers) to accept certain design features against their will, perhaps using the threat of a withdrawal of sponsorship to achieve closure? Would groups using different decision-making rules design different bicycles?

Some awareness of dependency relationships can be discerned in Bijker's (1995) account of why lamp manufacturers acquiesced to electricity producers' design demands. The lamp manufacturers "knew that they really couldn't put across any lighting promotion without the help of the utilities" (p. 239). Closure occurred because of the structural relationship between the two

groups. Rather than noting them in passing, however, such power relationships deserve focused attention.

Technological Frame

The addition of technological frame to the sensitizing concepts used by SCOT practitioners begins to point the SCOT approach in a more explicitly structural direction, but we believe it falls short and suggest below the kind of recasting called for. First, Bijker (1995, 123) argues that technological frames are not characteristics of systems or institutions but exist between actors. This position is consistent with the SCOT framework in its rejection of the possibility that there are larger structures within which technological development takes place. We would suggest that technological frames are not likely to emerge de novo in the case of each new technology. Instead, they are likely to draw on cultural elements with historical resonances in the society at large or at least resonance among similarly socially located actors (cf. Kleinman and Kloppenburg 1991). Put differently, Bijker never considers the ways in which deeply institutionalized social values shape components of a technological frame or actors' interactions or practices more generally. This is a matter that the new institutionalism in organizational studies has consistently addressed[10] (cf. Powell and DiMaggio 1991), and we discuss this matter in more detail in the next section.

Wider Social Context

Although Pinch and Bijker (1987) say little about the wider social context in their original article, this has emerged as a major focus for later critique and elaboration (cf. Feenberg 1999, 11; Haard 1993, 416; Williams and Edge 1996, 878). To understand the capacity of groups to shape a technology, we need to know where the groups are situated within some structural matrix. We need to know further what the relative power of the contending groups is and what the sources and varieties of this power are. We should understand potentially relevant social groups in relationship to one another and their structural characteristics and should be clear about the resources they have to draw on in their efforts to shape a technology. Here, we offer some general comments on structural features of that wider context. We examine two general classes of structure, one relating to concentration/dispersion and the other relating to resource accessibility.

While, in principle, there are no limits to the dimensions along which we might delineate these characteristics, since quite often we are talking about producers or developers on one side and consumers on the other, an important

consideration might be the relative concentration or dispersion of each group.[11] Industry is generally likely to have greater influence in shaping an artifact than retail consumers because retail consumers are typically atomized and unorganized. The individual consumer's investment is typically lower than the individual firm's, and industries tend to be more concentrated than consumers. In such cases, it is fair to say, as Williams and Edge (1996) do, that "the final consumer may have little opportunity to engage upon the design and development of such artifacts (e.g., domestic goods) other than the 'veto power' to adopt or not" (p. 878).

Of course, it is important to distinguish between types of consumers. Pinch and Bijker's (1987) analysis of the history of the bicycle does not even consider industry qua consumer.[12] The relevant social groups are each collections of retail consumers with different demographic profiles. Rosen's (1993) study of the mountain bike similarly focuses on an artifact aimed at retail consumers. Rosen's array of social groups is wider than Pinch and Bijker's. He takes seriously the role of home workshop developers and firms as well as consumers. But, of course, a wide array of artifacts is developed for use by manufacturers and the state, and these consumers have very different structural characteristics than retail consumers. Furthermore, there is a significant range of variation in the relationship between these consumers and developers/manufacturers across industrial sectors and countries. Firms, for example, may be organized to permit cooperation and coordination of the affairs of an industry through trade associations and peak organizations (cf. Schneiberg 1994).[13] Under such concentrated dynamics, they may collectively set standards for the quality and safety of goods.[14] In this context, one could imagine that the meanings of new artifacts would be negotiated. By contrast, one could equally contemplate a situation where consumers of a manufacturing technology were small dispersed firms in an unorganized industry and that they faced a monopolistic developer that was in a position to dictate its meaning. Thus, variation in the structural characteristics of producers/developers and consumers can dictate their relative capacity to shape artifact development.

In this context, it is worth mentioning Pinch's recent article with Ronald Kline (Kline and Pinch 1996, 773) on early user "resistance" to the automobile. One portion of their study discusses the anticar movement. They argue that the movement failed because increasingly cars were produced that could navigate rural roads, and cars were then a mechanism for ending rural isolation and facilitating rural tourism. In short, Kline and Pinch seem to suggest that rural people ultimately saw the advantages of the car. But this rendering of the story has a slew of problems. First, it seems odd that the authors would suggest that "the advantages of the car became all too clear cut" (p. 773), since a central claim of research in science and technology studies is that

things are rarely clear-cut and always open to interpretation. Surely, some people continued to resist, but the question is, why were they ineffective? This query leads to a second point: Kline and Pinch's rendering of this history ignores the character of power asymmetry. To understand the failure of the anticar movement, we need to be concerned about the movement's organizational structure as well as the resources to which the movement had access in its effort to promote its position. We should ask how the structural location of the auto industry positioned it to respond to the anticar movement. We might be concerned as well with how advertising affected rural sales of the automobile and with how the availability of cheaper cars affected rural demand. It is the concepts we put forward in this article that prompt these kinds of considerations—matters overlooked in early SCOT work and in the 1996 essay.

If we are considering the development of manufacturing technology, not only the role of business but also the role of labor is likely to be important (cf. Noble 19; Schot 1992). Here, again, we will find variation across sectors and countries. Where labor is poorly organized (highly fragmented or dispersed), capital is likely to be able to dictate the character of the technology. By contrast, in a corporatist environment where labor and capital are highly organized and work with the state to develop economic policy, technology development is likely to be the result of negotiation.[15]

Of course, the state can play a role in the development of technologies (stabilization and closure) in a variety of ways (cf. MacKenzie 1990; Noble 1984; Schot and Rip 1996). Three cases are worthy of mention. First, there is military or other state agency procurement. Here, where there is no market beyond state demand for the artifact under development, the state may be in a more powerful position than the contracting firm to shape the character of the technology. To the extent there are alternative consumers for this artifact, the position of the developing firm is strengthened. This is equally true where the consumer is a firm or set of firms and not the state. To the extent the developer can seek alternative consumers, its position is enhanced. Conversely, to the extent consumer firms can seek alternative developers, their position is improved.[16]

Another role played by states is in the area of industrial policy.[17] Again, there is, of course, substantial variation across countries in state capacity in this regard, but it is important to note that state interventions can influence the ways in which artifacts stabilize. Economic development grants, provision of credit, and technical advice can all affect the kinds of artifacts (and, indeed, the meanings attributed to them) developed by firms. Policy may allow states to precisely dictate artifact development or may provide a supportive environment for particular kinds of developments. Where business, labor, and the

state are all highly organized, we would suggest that negotiated development is most likely.

The state may also shape technological development through its role in standards setting. The process of designing standards for high-definition television, for example, became the object of interstate competition as different governments promoted designs favorable to their national interests (Neil, McKnight, and Bailey 1995).

The structural characteristics of potentially relevant social groups can give us some purchase on their likely impact on the development of artifacts. But in addition and often closely linked to issues of groups' dispersion and concentration, the relative breadth of demand and supply and coordinative capacity are matters of resource accessibility.[18] Here, we distinguish between four different types of resource. First, there are most obviously economic resources. All other things equal, the capacity of a relevant social group to shape artifact development will be enhanced the greater its access to economic resources. Second, there are political resources. This refers to the capacity of actors to shape policy outcomes. Of course, this capability will be significantly shaped by the organizational structure of the state, political parties, and social interests, including the relevant social groups under examination (cf. Hall 1986; Kleinman 1995; Lindberg 1982).[19] But the point here is that under certain circumstances, the capacity of potential producers or consumers to shape policy will enhance the ability of the group to influence the development of a given artifact and define the technology in the group's interest. In the case of the bicycle, for example, the economic resources of interested social groups was an important factor (Woodforde 1970). According to Woodforde, when use of bicycles by professionals and other elites—coroners, magistrates, and county and police officials—became significant, "highway authorities" (p. 6) felt compelled to pay attention to their complaints about road quality. And indeed, "the first buyers were young men of means and verve; they might be professional men, clerks, school masters or dons" (p. 47). Laborers could not afford some of the earliest bicycles, and so their "meanings" and desires could not have taken into account in early design considerations (p. 49). Finally, the interest of wealthy people in cycling, according to Woodforde, allowed manufacturers to experiment with design (p. 99). In short, the influence of social groups in design depended, at least in part, on their purchasing capacity—their access to economic resources.

A decisive factor in the development of artifacts is frequently cultural resources.[20] Here, we refer to what some authors call discursive legacies (Kleinman and Kloppenburg 1991). These amount to social common sense. The validity or rightness of these cultural elements is taken for granted (for

the case of technology development, cf. Feenberg 1999, 86; Schot and Rip 1996, 264). Actors who are in a position to draw on such cultural resources in their effort to promote a particular meaning of an artifact often have an advantage over those who wish to challenge what is widely taken for granted.

These cultural elements are quite akin to what Meyer and Rowan (1977) refer to as myths. Meyer and Rowan's work focuses on organizations, and their concern is with the ways in which social processes and obligations take on a rulelike status in thought and action, independent of their efficiency value for the organization. Thus, organizations that adopt the processes and obligations gain legitimacy and increase their survival prospects. These myths are widely taken for granted as legitimate, and thus, challenge is difficult. Treating cultural resources similarly, the position of relevant social groups interested in shaping the character of a given technology will be enhanced to the extent that they can draw on deeply institutionalized myths in making their case. It is in this context that we should think of the role of gender norms in early bicycle design. Historically, specific gender norms are diffused throughout society. They are social common sense, taken for granted by most members of a society (cf. Lorber 1994). Woodforde (1970) describes the environment in which producers and consumers of early bicycles found themselves: "the whole weight of late Victorian propriety set itself against the adoption by women of so masculine and revealing a posture" (p. 122) as they would be forced to take when riding high-wheeler bicycles. On one hand, the desires of women as consumers and consequently the meanings they will apply to an artifact in the making are not innate, but the product, in part, of taken-for-granted social norms. On the other hand, their explicit demands as consumers would not be required for producers to manufacture bicycles that met accepted standards of propriety. Victorian manufacturers, after all, were socialized in this society as well. They too took for granted gender norms of propriety, and these norms undoubtedly shaped their meanings. Again, we see the centrality of macro-level social-organizational factors in the development of early bicycles.

In thinking about cultural resources, we should also consider advertising. Rosen (1993) rightly points to the importance of advertising and the role of companies in developing markets for the shape and success of new artifacts. Advertising can play a crucial role in "pushing stabilization in a particular direction" (p. 492). Frequently, advertisers draw on social common sense—discursive legacies, myths (cf. Williamson 1978)—in their efforts to shape the meaning of artifacts. Organized consumer groups can sometimes effectively draw on such cultural resources in their effort to define developing technologies. In the battle over the development of biotechnology, assorted

collective movements have been effective in this regard (Kleinman and Kloppenburg 1991).

In addition to drawing on existing common sense to obtain support for their vision of new artifacts, advertisers engage in a process of generating novel desires. Indeed, Susan Strasser (1989) shows that it is often not the market through price that shapes consumer demand but the dedicated efforts of advertisers who seek "to meet the needs of production and company growth" (p. 27). Strasser looks specifically at the genesis of new desires in the early twentieth-century United States as modern consumer culture was under development. To a degree, promoting these new appetites drew on existing or emerging cultural elements. According to Strasser, "The most effective campaigns encouraged new needs and new habits, not by creating them out of whole cloth, but by linking the rapid appearance of new products with the rapid changes in all areas of social and cultural life" (p. 95). For example, advertisers linked safety razors to images of "modern life-styles" (p. 109), which had increasing allure.

Whether drawing on existing cultural legacies or constructing new desires out of whole cloth, advertising points to the important link between cultural and economic resources. Consumers, especially retail consumers, typically lack the capacity to promote alternative images of the artifact under development. Groups aiming to promote their definition of an artifact must have access to some means of communication, and generally, such access is predicated on the ability to pay.

Pinch and Bijker (1987) appear to assume that the attraction to bicycles is the product of something inherent in these instruments of conveyance. However, periodical advertising was not uncommon during the years of the nineteenth century during which substantial changes in bicycle design occurred. Woodforde (1970) describes the advertising campaign of one firm as "so energetic" that the "public was persuaded" (p. 60) to take the cycle seriously. And manufacturers promoted their products through riding schools, practice courses, and instructional booklets (Woodforde 1970, 23, 107ff). Finally, positive press coverage seems to have played a role in the bicycles in which consumers took an interest (pp. 31-33). Here, we see institutional actors with particular capacities shaping the development of the bicycle.

Finally, what might be referred to as technological legacies can be viewed as resources in the efforts of social groups to shape the meaning of an emerging technology. As Williams and Edge (1996) note, "earlier technological choices pattern subsequent development" (p. 867; see also Rip 1995, 419). The idea here is that groups looking to promote development of an artifact with a particular configuration (or the meaning of an artifact about which

there is controversy) might have an advantage if it links a popular existing technology to the new one. The converse is also the case. Connecting a new artifact to an unpopular technology may allow a group to stifle or alter the development of the new artifact.

Conclusion

The SCOT tradition has enriched our understanding of technology, and there can be little doubt that the work of Pinch and Bijker (1987) has been a tremendous source of inspiration for the outpouring of recent research on artifact design in the broadly SCOT tradition. But if the SCOT framework sometimes provides enticing suggestions of use in a broadly structural analysis, this avenue has been neglected in favor of an approach that provides no means to assess the relative capacity of actors in shaping artifact construction. With a conceptual focus on groups and social interactions, scholarship in this field has made little progress toward identifying structural influences on technological change. Both the need and the opportunity exist for a broader research project.

An across-the-board project of "bringing structures back in" can reveal additional dimensions in the social shaping of technology. Indeed, although they have not themselves done so, leading SCOT theorists proclaim the need to unite structural sociology and technology studies. Says Pinch (1996),

> SCOT can throw light on issues to do with social structure and power relationships. So those who criticize SCOT for its failure to treat these issues have a point. But this is not an inherent limitation in the approach, rather it reflects the early work within SCOT, which was located at the design end of technology and tended to avoid looking at the larger constellation of factors that shaped technology. (P. 33)

Bijker (1995) likewise notes an absence of attention to technology when he states,

> In the large sociological literature on power there is no detailed analysis of technical development. . . . The shaping of technology is not an important concern for such authors. (P. 61)

In this article, we have outlined such a project. The sensitizing concepts and conceptual concerns proposed here can serve as a starting point for efforts to investigate social structure and technological change. We have emphasized breadth rather than depth, identifying a variety of analytical categories and

suggesting the kind of insights they can provide. The empirical research required to adequately explore structural considerations in SCOT remains to be performed, providing rich opportunities for continued work in this field.

Notes

1. For reviews of the literature, see Williams and Edge (1996) and Pinch (1996).

2. We are by no means the only authors who have criticized the social construction of technology (SCOT) approach for its failure to conceptualize social structure in its analysis of the development of technology. See, for example, Russell (1986) and Williams and Edge (1996).

3. The prominence of SCOT-related work in the social studies of technology notwithstanding, we are by no means the only advocates of a more structural approach to studying technology. Indeed, one of the coeditors of the important collection *The Social Construction of Technological Systems* (Bijker, Hughes, and Pinch 1989) presents an analysis that, while sharing some of the tenets of a SCOT approach, is vastly more sensitive to structural considerations than SCOT work. Thomas Hughes (1989) focuses on what he calls "large technological systems." Importantly, in his analysis, systems can structure opportunities and constraints, and Hughes is attentive more generally to the role of organizations in large technological systems.

This is not the place to provide an exhaustive account of other work in the technology studies field that is attentive to structure, but beyond those analysts we cite in our article, a few additional examples merit mention. In his efforts to develop a critical theory of technology, Andrew Feenberg (1999, 76, 80, 86, 101, 127) draws on neo-Marxist literatures and most especially work in the Frankfurt School. In so doing, power asymmetries and their basis in the social organization of society are a central concern for Feenberg. Appropriately, in our view, he argues for attention "to macro-sociological concepts such as class and culture" (p. 11) in attempting to understand the development of technologies.

Work by Arie Rip and others who advocate constructive technology assessment (CTA) is also attentive to the ways in which social structures shape opportunities and constraints. Rip and Kemp, for example, describe technological regimes as technology-specific contexts that prestructure "the kind of problem-solving activities that engineers are likely to do . . . structure[s] that both enable . . . and constrain . . . certain change[s]" (cited in in Feenberg 1999, 88; see also Rip 1995, 420). CTA analysts are also aware that the social world is filled with power asymmetries between actors involved in the development of technologies (Schot and Rip 1996, 257). Finally, consistent with the analysis we present, Schot and Rip (1996) suggest that "dominant ideologies" (p. 264) can shape technology development.

4. Pinch and Bijker (1987) originally define three, but one of their subconcepts is so important as to merit equal status as a fourth component.

5. The interpretive flexibility of artifacts underlies the claim that the SCOT approach is novel and "radical" (Pinch 1996). We refrain from evaluating the ultimate significance of the insight and instead focus on elaborating it in structural terms.

6. Quite a number of analysts of technology do, indeed, recognize that power asymmetries rooted in the structure of social life affect the development of technologies. Among others, see Feenberg (1999), Noble (1984), Schot and Rip (1996), and Winner (1993).

7. Our critique of SCOT and its agency-centered character could be applied, with modification, to other prominent approaches in science and technology studies. For a critique of the agency-centered and astructural character of actor network theory and the social worlds approach, see Kleinman (1998). A critique related to ours and Kleinman (1998) might be also be

directed at the mangle approach championed by Pickering (1993, 1995). Pickering (1993) argues that science is "an evolving field of human and material agencies reciprocally engaged in a play of resistance and accommodation" (p. 567). He suggests that scientific practice should be viewed as "temporally unfolding" (p. 561) and defines the mangle as a dialectic of resistance and accommodation. While it may make sense to understand the practical obstacles to experimental success in terms of emergence and to explore how scientists and technologists accommodate to these sources of resistance to success, such an approach cannot help us understand, for it rejects such a possibility a priori the enduring influence of historically established institutions and discourses. Focus on resistances that "appear by chance" must lead advocates of this approach to dismiss the import or indeed the reality of structural features of the landscape that scientists or inventors inhabit and that at any given point in time might shape techno-scientific practice in generally predictable or at least consistent ways. Indeed, in discussions of machine tool development and science-military relations in the United States, Pickering (1995) is explicitly dismissive of the explanatory power of the kinds of institutions that we suggest play an important role in shaping technological design.

8. As we noted, we are not the only analysts in science and technology studies (STS) who have critiqued SCOT for its astructural approach to technology development, and we are not the only STS scholars to point to the importance of specific structural concepts in the analysis of technology development (cf. Feenberg 1999; Haard 1993; Russell 1986; Williams and Edge 1996). Overall, however, our analysis is a more thorough and systematic engagement with SCOT. Our positive contribution is to bring into STS debate a set of concepts from political economy and organizational analysis and suggest how pulling these concepts together can provide a cogent approach to analyzing technology development.

9. Bijker (1995, 265) is attentive to these kinds of factors in his discussion of technological frame. Our critique of his concept follows below.

10. Bijker (1995, 221) talks about wider cultural factors that affect the social construction of technology through technological frames, but he does not explain how this works.

11. This discussion is heavily influenced by work in organizational theory in the resource dependence tradition (Pfeffer and Salancik 1978) and institutional political economy (cf. Hall 1986; Hooks 1991; Lindberg 1982).

12. Bijker (1995) does do this in his more recent work.

13. Work in critical technology assessment is attentive to the importance of trade associations, banks, and the insurance industry in shaping technology development. See, for example, Schot (1992) and Schot and Rip (1996).

14. Bijker's (1992, 1995) work on light technology might be understood in these terms.

15. On the social organization of capital and labor and the problem of economic policy making, see Wilensky and Turner (1987).

16. In an analysis with considerably greater structural sensitivity than his 1992 essay, Misa (1995) explores these kinds of considerations through attention to "user-producer interactions" in his book *A Nation of Steel*.

17. For an interesting study of the role of political structures in shaping industrial change as well as technological choice, see Dunlavy (1994).

18. Russell (1986) makes a related point:

> An explanation of technological change must show not only what different social groups think about an artifact, but also what they are able to do about it—their differing abilities to influence the outcome of its development and adoption. Thus we must relate not only their objectives to their social location, but also the resources of

knowledge and power with which they can bring about change to suit those objectives. (pp. 335, 336).

19. Significantly, Bijker (1995, 93) describes the importance for the development of the bicycle of pressure group lobbying of parliament for better roads. He fails to explain the political success of these groups, however. We would suggest that one must look at the structure of the state, political parties, and social interests to understand the lobbying successes of these groups.

20. Our discussion here resonates with Rosen's (1993) call for attention to the importance of cultural meanings in shaping artifacts.

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Hans K. Klein is an assistant professor in the School of Public Policy at the Georgia Institute of Technology. His research focuses on Internet governance, institutional design, and large technical systems. Klein is also the chair of Computer Professionals for Social Responsibility, where he performs policy work related to global democracy and Internet governance.

Daniel Lee Kleinman is an associate professor in the Department of Rural Sociology at the University of Wisconsin–Madison, where he is affiliated with the new science and technology program. He is the editor of Science, Technology, and Democracy *(SUNY, 2000). He has several research projects currently under way, including one on biotechnology policy in Europe and another that explores the simultaneous commercialization of the university and the academicization of high-tech industry in the United States.*