Living in a Material World

Economic Sociology Meets Science and Technology Studies

edited by Trevor Pinch and Richard Swedberg

The MIT Press
Cambridge, Massachusetts
London, England

Set in Stone Serif and Stone Sans on 3B2 by Asco Typesetters, Hong Kong. Printed and bound in the United States of America.

Library of Congress Cataloging-in-Publication Data

Living in a material world: economic sociology meets science and technology studies / edited by Trevor Pinch and Richard Swedberg.
p. cm.—(Inside technology)
Includes bibliographical references and index.
ISBN 978-0-262-16252-4 (hbk. : alk. paper) — ISBN 978-0-262-66207-9 (pbk. : alk. paper)
1. Economics—Sociological aspects. 2. Technology—Economic aspects. I. Pinch, Trevor. II. Swedberg, Richard.
HM548.L59 2008
306.301—dc22 2008018948

10 9 8 7 6 5 4 3 2 1

Introduction

Although it is generally agreed in the social sciences that technology plays an important role in the economy, it is also recognized that it is difficult to understand what this role is and how to conceptualize it. Economists have traditionally treated technology as an exogenous factor and a black box. So-called growth theory has succeeded in endogenizing technology but has made little progress in developing a concrete and empirical type of analysis. Though economists inspired by Joseph Schumpeter have, in recent decades, developed the influential ''economics of innovation'' (Rosenberg 1994; Dosi 2000; Freeman 1982; Nelson and Winter 1982; McKelvey 2000), this approach does not, by and large, open the black box of technology, and it fails to engage with the increasingly sophisticated analyses of technology coming from history and sociology of technology. Bringing economy and technology together in one coherent analysis that is both analytically interesting and empirically oriented is, therefore, still very much on the agenda of the social sciences.

In this book, an attempt is made to reconceptualize the meeting between the economy and technology with the help of Science and Technology Studies (STS) and economic sociology.[1] Both of these approaches are relatively young and have developed new sets of ideas and concepts that have not yet been assimilated into mainstream social science.[2] The theoretical point at which we suggest that economic and technological analysis may come together is in the idea of *materiality*, or the notion that social existence involves not only actors and social relations but also objects. This is an approach that has been developed in STS and which we think constitutes a useful point of departure.[3] We have titled the volume *Living in a Material World* because the word 'material' also has another meaning than objects and materia, as the 1984 song by Madonna reminds us: it can also refer to something economic.[4]

A number of disciplines have recently embraced the ''material turn.'' For instance, in communications in the 1980s there were calls to analyze the material dimension, led by the German scholars Hans Ulrich Gumbrecht and Karl Ludwig Pfeiffer.[5] But it is within anthropology and archeology, with the revival of the notion of ''material culture,'' that one finds sustained attempts to develop a notion of materiality. Arjun Appadurai's 1986 collection *The Social Life of Things* marked a renewed anthropological interest in things and in particular commodities, and in how these might be tied to concerns with culture. Things and how they circulate and are exchanged in different historical and social milieus can be thought of as the low-hanging fruit of materiality. Ever since Georg Simmel's investigations into the role of money, conducted around the turn of the twentieth century (see Simmel 1978), it has been clear that objects can take on value in exchange, and, as Appadurai argues, this insight can usefully be extended to different regimes of value in space and time. That material forms matter to social science was increasingly recognized in the 1980s and the 1990s. It is now obvious that the social world is partly constituted by things, including the built environment of the cities we inhabit, the clothes we wear, the restaurant menus we peruse, and the food we eat.[6]

This new interest in material forms and in what they mean for humans has been marked by the emerging subdiscipline of Material Culture Studies along with a new *Journal of Material Culture*. The notion of ''material cultures'' has been of particular significance to the group of anthropologists around Daniel Miller at University College London, and Miller has edited two collections (1998, 2005) on materiality and material cultures.[7] Miller and his collaborators share with us a desire to theorize materiality without falling into the usual dichotomies raised by treating signification as separate from materiality *per se*, as in familiar tropes of subject versus object. This means moving beyond treating materiality and the world of things as passive objects that gain meaning only in symbolic terms in regard to the signification work that humans alone do. Most of the work on material culture, however, does not yet examine the technical working of technologies (as is done in STS) or explore the workings of the economy (as is done in economic sociology).

If things and commodities are the low-hanging fruit for social scientists, things that ''bite back,'' or things that themselves have emergent powers or to which some form of agency may be ascribed, are much trickier to deal with. The classic example is, of course, technology. The pitfalls of examining technology from the perspective of hermeneutic social science were noted by Michael Mulkay (1979) at the dawn of the emergence of the field

of Science and Technology Studies. Mulkay argued that there is a world of difference between the sociological analysis of a television that is working and one that is sitting in a room broken. At stake is what it is materially that such an object comprises. The non-working television can certainly be invested with human meaning; it can mark boundaries in a house, it can even serve as an object for exchange, and in the spirit of the literature on cargo cults it might take on all sorts of properties assigned to supernatural beings. But a functioning television is a very different sort of object because materially it has different capabilities. For one thing, a functioning television is embedded within a complex socio-legal-technical network—what sociologists of technology call a *sociotechnical ensemble*. Just try to write down the list of things (and actors) that are involved with a working television in the United States—obvious items might include electricity, cables, plugs, television studios, advertisements, actors and presenters, Hollywood, Fox, Rupert Murdoch, and the Federal Communications Commission, but this is only a start. As soon as one thinks about particular television programs, such as the popular *American Idol*, the list becomes even larger and would include other socio-technical ensembles, such as the telephones whereby watchers send in their votes for contestants. The signification of the different genres of programs for the viewers is itself a whole field of cultural analysis.[8] But the analysis of a technology such as television becomes even more complex if one takes up Mulkay's challenge and examines the material technology that enables a television to work at all. This means delving into the different ways televisions work—cathode-ray tubes versus flat screens, LEDs versus plasma. It also means delving into the struggles of engineers and television manufacturers as they develop the new standards, and into the visual and sonic technologies that are hidden within the box we users operate. The rallying cry within the sociology of technology and STS in general is to ''open the black box'' of technology; to see that the social does not start or stop with processes of signification produced by programs but that televisions are social all the way down (Bijker, Hughes, and Pinch 1987; Latour 1987; MacKenzie 1991; Bijker 1995a; Pinch and Trocco 2002). This richer notion of materiality, which encompasses technology, the social practices that constitute it, and the myriad ways we interact with it, is at the heart of STS.

STS offers a series of concepts that, we suggest, may be of help in developing a better understanding of technology and economy. The terms 'actor network' (Latour 1999) and 'sociotechnical ensemble' (Bijker 1995b) are used in STS to suggest that objects and humans should be understood to always exist together. Material objects and humans mutually constitute each

other and should not be separated for analytical purposes. Analysis must start from the fact that people and objects always come together and that it would be artificial to draw a sharp line between the two. Objects and people are always entangled to various degrees. One may even argue that, as technology develops, this quality of entanglement—which is material as well as symbolic—becomes increasingly complex and important.

As one would expect of a lively new field, STS has not reached unanimity on how to analyze technical objects. Where there is unanimity, it is on the requirement that the analysis of materiality should not shy away from treating the same technical entities that engineers deal with. For example, Diane Vaughan's 1996 sociological analysis of why the Space Shuttle *Challenger* crashed (see also Collins and Pinch 1998) involves looking at how the testing of the O-rings of the solid-fuel booster rockets was carried out, because the social analysis of the accident rests in part on understanding how technical uncertainty was dealt with by different groups of engineers working within different organizational contexts. Where analysts part company is on how to treat the powers, emergent properties, or affordances that make technology so interesting to examine. It is obvious that technologies can do new things and that technologies are better than humans at doing some things. An electronic synthesizer can make a range of sounds of which no human is capable, an airplane can fly in a way no human has ever mastered, and a tractor can quickly beat the strongest ''tug of war'' team. But this way of phrasing the issue is not quite correct. In setting up some sort of opposition between technologies and humans, we tend to play down or forget that technologies gain their powers through the often hidden work of humans. Airplanes may fly, but they cannot fly without flight controllers and pilots. Indeed, it is in looking at the detailed embedding of humans with machines, as Edwin Hutchins (1995) does in examining the ''distributed cognition'' required to land a modern airplane, that one see the complexity involved in the coordination of humans and machines and the embedding of each with the other. A pilot may be talking to the flight controller one moment, manually adjusting a dial in the cockpit (a routine skill) the next moment, and assigning control of the airfoils to a computer the next. Much of today's STS research is concerned with the ''plans and situated actions'' (Suchman 1987) and ''communities of practice'' (Lave and Wenger 1991) that exist in the liminal space between machines and humans. Here one finds that materiality means examining not only the affordances enabled by machines (see chapter 11 of this volume) but also the material social and cognitive practices whereby humans interact with technology.

No easy separation between human and technological agency is possible when the thick description of technologies is concerned (Alder 2007; Bijker 2007). Furthermore, we fully agree with Bruno Latour (2007) that an idealistic notion of materialism, where some geometrized property of machines, as is found in engineering diagrams that delineate technologies in terms of their functions, must be resisted. Nevertheless, legitimate differences exist in the field of STS as to how best to treat the agency given to technology. Some analysts try, with ever-increasing complexity (Collins and Kusch 1998), to keep ledgers of the kinds of actions that can properly be assigned to humans and to non-humans. Others (e.g., Latour and Callon in their development of Actor Network Theory[9]) level the playing field, refuse to make any analytical distinction between human and non-humans, and talk in general about ''actants.'' Some of these debates over humans versus non-humans surface in the present volume, most obviously in Mirowski and Nik-Khah's chapter on the allocation of the FCC spectra, which is in part a polemic against Latour and Callon's actor-network approach and against what Mirowski and Nik-Khah interpret as neglect of some good old-fashioned human political influences in the Federal Communications Commission's allocation of spectra.

Two other concepts from STS can usefully be employed to relate economy and technology to one another: *interpretive flexibility* and *closure* (Bijker 1995; Pinch 2006a). The former refers to the fact that actors are capable of interpreting a technology differently or investing it with different meanings. For example, a bicycle that old people consider dangerously unsafe may be perfectly acceptable to sporty young men (Bijker and Pinch 1987). These meanings of a technology are highly consequential for agency because they lead to different uses and different design trajectories. For example, some early bicycle companies, in responding to the meaning of the ''ordinary'' or ''penny farthing'' bicycle as ''macho,'' built bicycles with larger and larger front wheels to make them even faster and more thrilling to ride.[10] Closure means that a novel technology will eventually stabilize, at which point it acquires a generally accepted meaning. Thus, the significantly named ''safety bicycle,'' which emerged from a variety of design possibilities in the period 1880–1890, remained a remarkably stable technology until the appearance of the ''mountain bike'' in the early 1970s (Bijker 1995a; Rosen 2002). The links between objects and actors, in short, can be drawn differently depending on the meaning structure involved—but there is also a tendency for the meaning to stabilize in the sense of becoming general and accepted by large numbers of social groups.[11] The roles of *users* and *intermediaries* in how these meanings are generated and

stabilized are also important in the STS account of technology (Oudshoorn and Pinch 2003).

Economic sociology, in its turn, has also developed concepts and ideas that can be useful in the attempt to relate the economy and technology to each other.[12] The term 'embeddedness', introduced by Karl Polanyi, is often used in sociological circles in connection with networks. (See e.g. Granovetter 1985.) Whereas most sociologists (including economic sociologists) look only at social relations and ignore the role of objects, here we suggest that the term 'embeddedness' should be used together with 'materiality', in the sense that objects and people are indissolubly embedded in each other. This new type of material embeddedness has its own distinct structure, which it is up to the analyst to try to outline. This structure can be described as a configuration of objects and social relations. Using 'embeddedness' in this sense is close to Actor-Network Theory in STS (Latour 2005). Actor-network approaches, however, have not been used to analyze economic topics until recently (Callon 1998; Latour forthcoming).

Economic sociologists have used networks to describe and explain a huge number of economic phenomena, often with a high degree of technical skill. Among the topics that have yielded quite nicely to this approach are markets, industries, consumption, entrepreneurship, business groups, and relationships inside as well as between firms (Baker 1984; Powell 1990; Burt 1992; DiMaggio and Louch 1998; McGuire and Granovetter 1998; Granovetter 2005). Insights from studies of this type would benefit STS—which, in turn, would add its insights about technology and materiality, with new and interesting insights as a result.

The concept of *field*, as used in economic sociology, may also be of assistance in further developing the idea of materiality in dealing with technology and economy. A field is usually understood as a type of social space or social structure that assigns a place to each actor (Powell and DiMaggio 1991: 64–65; Wacquant and Bourdieu 1992: 94–115). Power is part of a field; the actors may also constitute the field either through interaction or through orientation to other actors. These actors can be individuals as well as organizations; and both of these are typically perceived by sociologists as purely social entities, devoid of any materiality. But even if the concept of field does not take materiality into account, it nonetheless complements the idea of collectivity in a useful manner, not least in drawing attention to the structures of inequality and hierarchy that tend to develop between individuals as well as organizations. Fligstein's 1990 study of the evolution of the huge firm in the United States since the late 1800s is an example of this.

If a field is thought of as constituted by both social and material entities, hierarchies and inequalities can be conceived of in a new way. Material technologies allow old hierarchies to be reconfigured. Think, for instance, how the hierarchy in the nuclear family can be subverted by the introduction of the cell phone. Teenagers can now arrange meetings with their friends without parental control. The introduction of the telephone itself played a dramatic role in reconfiguring social relationships, particularly between women in rural communities (Martin 1991; Fischer 1994).

The concern with materiality in STS has an old ancestry in the philosophical school of materialism. This deserves to be highlighted, not least because this older type of materialism influenced Karl Marx, who is considered one of the founding fathers of economic sociology. Marx reacted as strongly against the abstract nature of Hegel's philosophy as Latour and others are reacting today against a generation of social scientists who see only social relations when they look at reality. Marx rejected the mechanical and old-fashioned type of materialism and strongly advocated the introduction of history and social relations into material analysis. Proceeding in a similar way may be useful for advocates of the modern approach to materiality too, not least since Marx's view of materiality is wedded to a sharp insight into the nature of capitalism and the centrality in modern life of economic power.

In *Capital*, Marx's version of materiality comes out most clearly in two ways. First, according to Marx, workers have to be reproduced if surplus value is to be produced, and Marx carefully describes the costs for reproducing the body of a worker and how these costs differ between countries. Here 'materiality' refers primarily to the body and its needs. Marx's concern with materiality in *Capital* is also evident from the attention he pays to the everyday life of the workers, such as the physical constitution of the factories in which they spend most of the day and the machines with which they work. Drawing on factory reports, Marx pointed to a number of material circumstances that wore down and tormented English workers as they carried out their tasks.

Marx also initiated the tradition in economic sociology of trying to analyze the systemic dimension of capitalism and connect it to what happens at the micro level in the factory. What drives this type of economic system, according to Marx, is the need for accumulation. "*Accumulate*! *Accumulate*! That is the Moses and the Prophets [of the modern economy]," we read in *Capital* (Marx 1976: 742). Similarly, Max Weber analyzed capitalism at a later stage of its development and emphasized its "pursuit of profit, and forever renewed profit, by means of continuous, rational, capitalistic

enterprise'' (1988: 17). Profit's role in driving the modern economy forward is central to Marx and Weber, and it must be taken into account in modern analyses of materiality (including technology).

The mentions of Marx and Weber remind us that modern economic sociology has a long classical tradition to draw on—a tradition that is centered around a strongly realistic and social structural approach. Issues such as the relationship between the economy and (say) religion, law, or politics were worked out more than a century ago (Swedberg 1998; Wright 2005).

To the Marxian-Weberian model of capitalism, Schumpeter added attention to the role of the entrepreneur, and Polanyi added the notion of modern capitalism as a radical utopian project. Schumpeter's (1934) idea that entrepreneurship can be conceptualized as a new combination of already existing elements is easily wedded to the idea that materiality is important and to changing relations between people and objects. Similarly, Polanyi's (1944) notion of modern capitalism as a peculiarly utopian project that is against nature through its peculiarly abstract and radical quality can be recast in material terms.

Contemporary economic sociology has continued the tradition from Marx onwards of trying to theorize the capitalist machine, and it has done so in a way that can be linked to the insights of STS. In theories of contemporary capitalism, the point of departure for economic sociology is in the conventional definition of the economy as consisting of production, distribution, and consumption (Swedberg 2005). It is usually also assumed in mainstream economics that what is being produced is distributed via the market, and then consumed. It is, however, clear that the assumption that distribution takes the form of exchange in the market is by no means obvious, even in a society with a market or capitalist economy. Different forms of distribution besides that of exchange exist, such as distribution via the state (what Polanyi termed 'redistribution') and distribution according to certain norms of reciprocity (Polanyi 1957).

The link between production and consumption may, by way of summing up the argument so far, be constituted in different ways—via exchange, redistribution, or reciprocity, to use Polanyi's terminology. Early preindustrial societies organized their economies with the help of redistribution and reciprocity, according to Polanyi, while capitalist society relies mainly on exchange. It is also clear that the capitalist type of society uses not only exchange but also redistribution and reciprocity. In today's OECD countries, for example, the state channels some 30–50 percent of GNP. And reciprocity (in other words, exchanges based on preexisting social roles, such as between family members, with no attempt to gain

a direct advantage) remains the main principle governing individual households.

Finally, there exists an interesting difference between economies in which distribution mainly takes place via the market (exchange), on the one hand, and those where it mainly takes place via the state (redistribution) or the household (reciprocity). While the former tends to be dynamic, economies organized on the basis of redistribution and reciprocity do not. The reason for this has to do with the fact that exchange is entered into not only because of a desire to consume, but also to make a profit. This is not the case with redistribution and reciprocity; both of which are modeled on the idea of a household and the desirability of being able to satisfy the needs of its members rather than to make a profit (as in the individual household, the medieval manor, or the socialist state). This means that, although there definitely exists a necessity for reproduction in redistributive systems and systems based on reciprocity, there is usually not a push to constantly expand. Exchange is also a form of distribution that tends to mobilize both parties to a transaction, while redistribution and reciprocity typically only mobilize the actor who initiates the distributive process, not the one who receives the service or the good. In the former case, both parties have to go to the market, whereas in the latter case one party assumes a passive role. (See figure I.1.)

What roles do technology and materiality play in these different types of the economic process? It is clear that materiality is absolutely central to all of them, for the simple reason that all individuals have to reproduce themselves, and this is also a need that each of our three processes can accommodate. Also, in each of the three systems of distribution materiality is present at each of the three stages (production, distribution, and exchange).

The last statement deserves to be explicated, since we have now reached the point in our account of economic sociology where it is appropriate to bring STS and its concern with materiality back into the discussion. The apparently stable boxes in figure I.1 are perhaps better understood as networks making up the collectivities of individuals and objects to which we referred earlier. These networks exist not only in production (the part of the economic process to which technology is usually assigned) but also in distribution and consumption. The market, for example, is not just some abstract structure of social relations or an institution consisting of rules and regulations; it also involves material objects, be it in the form of balances, coins, tickers, telephones, or computers. Similarly, consumption involves objects, and not only objects to be consumed, but also other

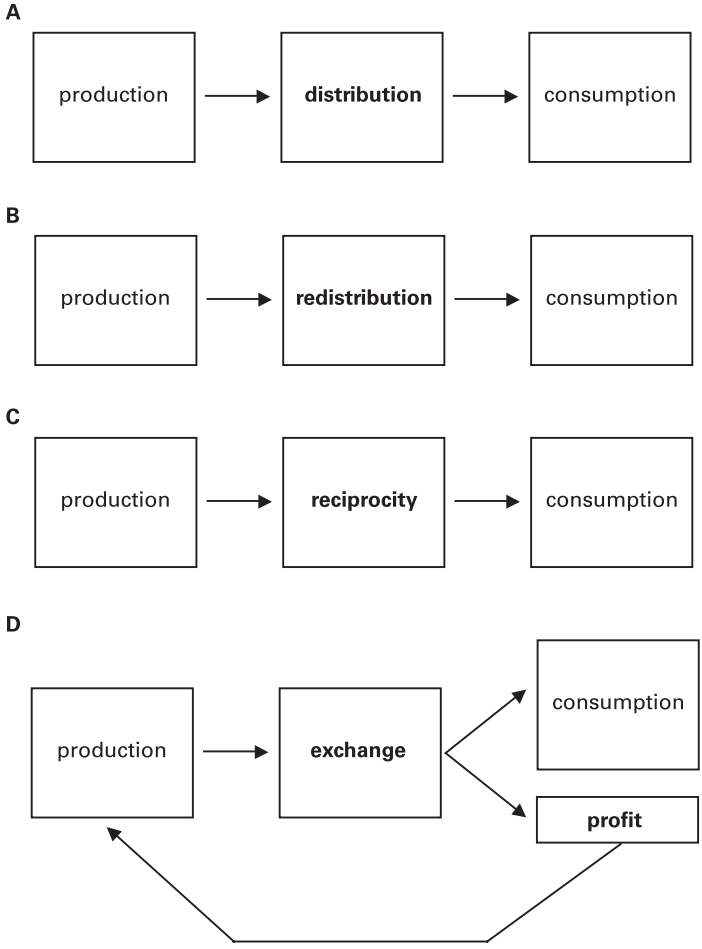

Figure I.1
The economic process and how it can be organized. (A) The economic process in general. (B) The economic process when "redistribution" (Polanyi) is predominant. (C) The economic process when "reciprocity" (Polanyi) is predominant. (D) The economic process when "exchange" (Polanyi) is predominant. The economic process in any society can be defined as consisting of production, distribution, and consumption. Exchange characterizes the capitalist organization of the economy; this type of economy derives its dynamic from the fact that the end goal of the economic process is not exclusively consumption, but also profit. The more this profit is reinvested into production, the more dynamic the economy will be. The two main mechanisms in capitalism, in other words, are organized exchange (the market) and the feedback loop of profit into production. It is the use of these two that makes the organization of economic interests in the form of capitalism an effective machine for transforming economic reality.

objects—including such ''means of consumption'' as advertisement, packaging, stores, malls, and parking lots (Ritzer 1999). Consider frozen orange juice. The widespread consumption of orange juice, and indeed much of the food-distribution system in the United States, depends crucially on the development of the technology of mobile refrigeration units on trucks, the existence of interstate highways, and the establishment since World War II of an independent trucking industry (Hamilton 2003).

There is also, again, the fact that consumers often use the objects they buy in ways that are unforeseen by the producers, and in this sense become ''co-constructors'' of many new objects (Oudshoorn and Pinch 2003). Even if it can be analytically instructive in some cases to assume that there are distinct boundaries between production, distribution, and consumption, these boundaries are often ambiguous in reality and shot through with links to objects and people (in the other boxes in figure I.1, so to speak).

If technology and materiality have been neglected thus far, how come economics is such a successful science without them? One way to answer this question is to simply point out that, although neoclassical economics no doubt is a great academic success and has its very own Nobel Prize, it has also shown itself to be singularly unable to produce the kind of knowledge that translates into predictions of what will happen in reality (McCloskey 1985, 1990). Macroeconomic forecasting, as Evans (1997) points out, has a particularly dismal record. Nevertheless, economists still offer a veneer of understanding, some nuggets of real wisdom, and legitimation for policies. Economic techniques such as cost-benefit analysis, as Porter (1995) has shown, originated in the world of politics as a numerical way of displacing and resolving political disputes. The application of such techniques involves a constant set of translations back and forth between calculative practices and politics (Ashmore, Mulkay, and Pinch 1989). ''Trust in numbers'' enables the state to use suites of calculative tools, practices, and techniques to help maintain political and social order and stability (Porter 1995). These calculative practices are, as Mirowski (2002) has shown, increasingly part and parcel of the technologies (e.g., computers) that are indispensable to forecasting. Economic assumptions are themselves sometimes built into the ''laws of the market,'' as Callon has persuasively demonstrated, thereby providing a reflexive circle of verification that enables the market to be understood as an economic phenomenon. (For Callon, economic activity is not strictly that of economists but would include auditors, accountants, and policy makers.) Materiality and technology are everywhere, and once technologies move from interpretative flexibility to stability they enable assemblages of humans and non-humans to work together in the choreography of any modern economy. It is this

"glue," this stability in the entanglements, that provides the illusion of the iron hand of the market.

A classical question is whether technology drives economic development or whether the profit motive is the driving force. In capitalism it is clearly the latter, even if technology is an integral part of all three ways in which an economy can be organized. But this does not mean that the technology that exists in a capitalist society is directly shaped by the profit motive alone. All that can be said at this general level is that technology can be used to accelerate profit. This is a very broad formulation that allows for a multitude of ways of conceptualizing how technology develops.

One may, however, also ask whether the materiality perspective that we are advocating does not invite a new and different conceptualization of the problem of how profit and economic development are related. At some level it makes sense to conceptualize technology in terms of the entanglement of objects and people, and this is true for all three forms of organizing the economy (reciprocity, redistribution, and exchange). The more technology there is, it would appear, the more entanglement; and as objects are shaped by people, these are transformed in their turn. A dynamic capitalist system could, from this perspective, be understood as a system that has the capacity to speed up this interaction considerably, and with this comes an increased capacity for the reproduction of people. Entanglement of this type would seem to be related to the concept of productivity in economics, even if it is broader in nature and even if it also takes human meanings and social relations into account.

These ideas also bear on how we understand the specific role of information technologies in the economy. Though information may seem "non-material," in reality this type of technology permits new forms of entanglements between people and objects and can crucially change the material circumstances whereby exchange of goods and knowledge occurs and where things and ideas circulate. The changing material arrangements and social organization of exchange are highlighted in chapters 5, 7, and 8 of this book. Similarly, several chapters deal with the material and social changes brought about by computer software in the arena of consumption (chapter 10), in new "open-source" systems for allocating value to items during exchange (chapter 11), and in new online systems for managing human resources (chapter 12). In all these chapters we see that the details of changing material arrangements underpin the social and economic understanding of the new information economy.

This book is a first exploration of how the idea of materiality may be used as a bridge between STS and economic sociology for two-way traffic be-

tween these two fields. The individual chapters can be grouped according to whether they raise general questions in this respect (part I), questions relating to infrastructure (part II), questions about the material arrangements of the market (part III), or questions about the use of technology (part IV).

In chapter 1, Michel Callon ponders one of the fundamental issues in economics: the role of the individual and the reality of the famed *homo economicus*. Many commentators agree that the actor assumed in *homo economicus* is a pale shadow of real human actors, but Callon accepts neither of the standard responses to this recognition. Whereas economic sociology argues that the way forward is to embed the too thinly endowed actor with human characteristics (in short, to embed the actor in a real social and cultural context), neoclassical economists try to free *homo economicus* from the institutional ties and make the actor even more rational. Callon's position is to reject the debate and to instead focus on how and under what circumstances individuals can have agency. Drawing on the notion of agency earlier developed by Callon and Latour within the well-known Actor-Network Theory, Callon argues that agency is configured within a network of both human and non-human actors. Drawing on examples such as buying decisions by consumers at supermarkets and studies of people with disabilities, Callon investigates what social policy options there are for dealing with individual actors in the changed world of network economies. He argues that with ''prosthetic'' policies the individual is endowed with new competencies to deal with the network, in the same way that disabled people are equipped with prosthetic devices to help them manage their handicap. ''Habilitation'' policies, on the other hand, construct new socio-technical arrangements, such that that they facilitate new forms of individual agency within networks, rather in the way that the world can be restructured better to suit the needs of a handicapped person by allowing handicapped access to all buildings. In terms of economic networks, by changing labor regulations firms can tailor training directly to their employees' career plans and thus enable employees to engage in the running of organizations in new ways. It is clear that Callon favors the latter sorts of policies and thus offers a normative prescription for dealing with some of the socioeconomic issues raised by the new economy.

In chapter 2, Richard Swedberg brings the discussion firmly back to the material realm—from *homo economicus* to home economics. He notes that, although people live in houses, eat food, interact with machines, and produce and use objects, economics at best acknowledges this materiality in an indirect way. He argues that the ambitious goal the authors in this volume

have set themselves—the goal of building a new form of economic analysis that attempts to theorize the economy in terms of entanglement and interpenetration of things and people—will also require us to mine the history of economic thought for leads. Swedberg makes a start as to how to do this by recovering the concern of early economics with the material theory of the household. He locates the origins of this approach in ancient Greece in the often-neglected economic writings of Aristotle and Xenophon. He then shows how in the classical period of political economy (1600s–late 1800s) the material realm of the household began to vanish in the writings of Adam Smith and Karl Marx, who, although paying attention to the body and technology, focused more on production and exchange outside the household. For example, women's work, emphasized by the ancient Greeks, is almost completely absent from the accounts of Smith and Marx, where women (and children) are mentioned only when they enter the labor market. Swedberg concludes his survey by looking at one modern institutional context for economics: Cornell University in the early twentieth century, where in 1916 Frank Knight famously gave the theory of *homo economicus* a classical formulation. Interestingly, the discipline of "home economics," with its material vision of the household, emerged at Cornell at the same time—a development largely ignored by and outside the mainstream of economic thought.

In chapter 3, Phillip Mirowski and Edward Nik-Khah use the case of the 1994 public auction by the Federal Communications Commission of spectrum licenses to the highest bidder as a way of examining Callon's ideas about the performativity of the economy. Callon (1998: 30) argues in his well-known book *The Laws of the Market* that "the economy is embedded not in society but in economics." By this Callon means that economists and economic thinking and methods have played a role in the way that markets are built. This shifts the traditional economic sociology problem of studying the embedding of economy in society or the social explanation of economics to studying how the economy in a sense must work according to economic laws because economists have built an "economic machine" that made it that way. *Prima facie*, the case of FCC spectrum auctions seems to fit Callon's performativity argument, because many leading game theorists were involved in the design of the auction and have claimed credit for it. Mirowski and Nik-Khah provide a much more detailed account of the different groups of game-theory and experimental economists involved in the auctions. They show a diversity of aims and understandings amongst the different players in the auction and the power played by the telecom corporations in redefining the government's goals for the auction.

In the end they claim that a more traditional science studies analysis which includes power among social groups better explains the outcome—an outcome that was deliberately masked such that one influential group of economists—game theorists—could ''bask in the limelight and take the credit.'' Mirowski and Nik-Khah offer a different view of how STS analysis can be taken into the realm of economics. Their view is ''not at all isomorphic to the performativity thesis,'' but it does grant more rigid and hence constraining roles to nature and society than Callon and Latour are prepared to grant.

Part II of the volume is titled Infrastructure, a term that is sometimes used in STS and by which is meant not only the traditional types of infrastructure (such as electrical networks and railroad systems; see Chandler 1977) but also laws, organizational forms, systems of filing, administration classification, and the like (Star 1999; Star and Bowker 1999; Yates 2005). This part opens with a chapter on one particular form of infrastructure that is very important in the modern economy, namely accounting. David Hatherly, David Leung, and Donald MacKenzie argue that some areas of ''economic reality'' are constituted via the classification of economic transactions in the form of accounting. This is especially the case with profit and loss, which are both of utmost importance to investors, governments (e.g. for taxation purposes), and employees (e.g. for the determination of bonuses). Accounting is often manipulated, as evidenced by recent corporate scandals in the United States involving Enron and WorldCom. New financial instruments, such as derivatives, also present special problems when it comes to accounting, sometimes because of their complexity. Hatherly, Leung, and MacKenzie argue that accounting rules can be interpreted and used in a potentially unlimited number of ways. The reason for this is that rules of any kind cannot be locked into place once and for all. According to finitism (a Wittgensteinian approach developed within the sociology of scientific knowledge), rules can always be interpreted in new and unpredictable ways, even if they cannot be used in just any way. According to Hatherly et al., this quality makes the approach of finitism well suited to deal with the many complexities that an empirical study of accounting entails.

The next chapter moves on to the topic of global configurations of trading and information technologies. Karin Knorr Cetina and Barbara Grimpe focus their attention on two such systems: FOREX (used in the foreign exchange market) and DMFAS (a debt management and financial analysis system) first developed in 1979 after a United Nations Conference on Trade and Development and now used internationally to monitor and control

countries' debt levels and debt repayments. Knorr Cetina and Grimpe argue that these technologies not only network the world together, as Manuel Castells and others have argued, but introduce a specific "scopic mechanism" of coordination. By this they mean a mechanism that collects and focuses activities, interests, and events on one surface (in the case of foreign exchange markets, a computer screen), from whence the results may then be projected again in different directions. They identify what they call a Global Scoping System (GSS) as the configuration of screens, capabilities, and contents that traders in financial markets confront all over the world. The goal of the chapter is to examine how the material architecture of global financial markets leads to this new form of "scoping" coordination. They trace the origins and development of FOREX and DMFAS and show that, although both infrastructures provide scoping, FOREX provides a continual instantaneous scoping of the market whereas DMFAS depends on International Monetary Fund and World Bank schedules for producing reports and inputs on fixed time scales. Despite these temporal differences, both technological systems provide for reflexive scoping in that traders (in the case of FOREX) and national debt officers (in the case of DMFAS) participate reflexively in creating and participating in a standard global representation to which they and other actors in turn respond. Knorr Cetina and Grimpe conclude that FOREX and DMFAS embody different strategies of globalization. FOREX follows the strategy of global exclusivity and maintains a separate province of the global world, co-existing with the rest of the planet rather than integrating it. DMFAS, on the other hand, is tied in with the nation state and thus helps sustain the global character of world economic institutions and an emerging global governance.

In chapter 6, Elizabeth Popp Berman analyzes a different type of infrastructure: that of law and the various institutions in which legal rules are embedded—courts, police, lawyers, and so on. Patent law, Popp Berman argues, is an institution that mediates between technology and economic forces in modern society, and it can do so in a number of ways. One alternative would be for the state to pay for the research and make it available for free; another would be to assign to the inventor the exclusive right to an invention for a specified period of time. Which way is preferable is largely unknown, according to Popp Berman, and some of the confusion involved is mirrored in the largely accidental passage of the Bayh-Dole Act of 1980, which opened up the rapid commercialization of academic inventions in the United States. While economists have very firm opinions about what type of patent law is needed and why, Popp Berman suggests that economic sociologists as well as people working in the STS tradition are

needed to disentangle the complex social, technological, and economic issues involved. Economic sociologists may, for example, explore the different ways in which scientists and investors react to different types of patent law. The issues may also differ depending on what scientific field and what industry are involved. Input from STS scholars is also needed in this effort, since their expertise is in scientific and technical issues. The fact that STS scholars have a very broad and social approach to science and technology is a particularly important asset in this regard.

The chapters in part III (Technology and the Material Arrangements of the Market) examine particular technologies and their roles in financial markets. Alex Preda examines the history of the first technology specifically designed to be used in financial markets: the stock ticker. This device, invented in 1867, was initially a printing telegraph that printed out a security's name, price quote, and traded volume. It soon became ubiquitous on stock markets, and it remained so until it was replaced in 1960 with an electronic ticker. Preda examines the context from which the ticker emerged, how it was first used, and how it affected stock markets. He shows that the stock ticker was adopted because it enabled official stockbrokers to maintain their monopoly over credible, authoritative price data.

There is much concern in economic sociology with how prices in markets are determined not only by economic efficiency and computational rules but also by social networks, interests, and status. Preda shows that what must be added to the economic sociology account is the part played by technological systems in how price data are generated and observed. In capturing the new forms of agency which the stock ticker enables in financial markets, Preda introduces the notion of a ''generator''—a concept that captures temporal structures, representational languages, and cognitive tools. The price ticker made market exchanges visible as they happened, transforming them into more abstract and visible forms available to everybody at once. The paper strips of the stock ticker were a forerunner of financial charts that today make market exchanges visible in real time. In short, the stock ticker enabled the transformation of multiple, unsystematic, discontinuous, and unrecorded heterogeneous price information into the single, continuous, homogeneous nearly real-time price variations on which traders have come to rely.

In chapter 8, Daniel Beunza and David Stark take us into the heart of the modern trading room. They present the results of an extensive ethnography of a Wall Street trading room in a major international investment bank. The traders they examine are concerned with arbitrage, which involves essentially the construction of comparability across different assets.

In arbitrage small differences in these comparative valuations are exploited to make a profit on the deal. In the process of calculating these values equivalencies are established and the process of recognizing these equivalencies and how they offer opportunities depends crucially on the ''tools of the trade.'' Like Preda, Beunza and Stark demonstrate the importance of instrumentation (in this case, assemblages of instrumentation) in understanding how the socio-technical, the socio-cognitive, and the socio-economic are intertwined. Just as Latour and others have argued that the scientific laboratory gains its strength as a place where diverse instruments are gathered together, Beunza and Stark argue that traders turn their trading rooms into laboratories in which they experiment and deploy an array of instruments, including networked computers, mathematical formulas, and ''robots'' capable of automated trading. Their ethnography shows also the importance of spatial layout and physical proximity—in terms of our earlier discussion, the materiality of local arrangements really counts. They succeed in showing that in order to understand the sophisticated instruments of quantitative finance we need to analyze the entanglements of actors and instruments in the ''sociotechnology of the trading room laboratory.''

In chapter 9, Fabian Muniesa focuses on the role of a rather old technology—the telephone—in the trading room. Although computers and electronic networks were expected to make the telephone redundant in financial markets, Muniesa shows that this is far from the case. Rather as Beunza and Stark found that face-to-face communication between proximal actors in a trading room was crucial, so too it turns out to be the case that telephone communications can still facilitate trading operations. Just as the stock ticker has been updated, the technology of the telephone has changed such that current market operators obtain greater diversity and flexibility than ever before with the use of a special box that permits as many as 24 telephone conversations to be accessed in a variety of ways at the touch of a button. A microphone even permits some conversations to be relayed on and over heard by a variety of other listeners. All conversations are recorded ''back room'' and if need be can serve as a legal record of transactions. Muniesa's research, rather than treating the telephone as a passive device, an instrument serving human interaction, shows how the materiality of the device (its technical features) shapes action and enables its users to perform functions crucial to the operation of markets. He examines the use of the telephone in three different empirical locations: in market making, in a stockbroking environment where orders are largely being filled, and in a sales environment where the particular needs of clients must be met. He shows how the telephone serves a crucial function in all these

environments, enabling counterparts (defined by Muniesa as a ''client,'' a ''trader,'' and a ''broker'') for trades to be identified and providing a means of negotiating and trust building amongst actors in social networks—aspects not available with anonymous electronic trades. He shows how in some circumstances telephony practices are transformed by the other new market technologies (such as computer screens) and how these enable reconfigurations of social networks. The overall goal is to explore the correspondence between ''social networks'' in the traditional economic sociology sense and material networks of communication that allows for ''ties'' to be articulated and expressed in a particular code and manner.

In the first chapter in part IV (Technology, Economy, Use), Christian Licoppe addresses how e-commerce is changing modern life. Licoppe argues that before e-commerce existed, consumers were used to viewing shopping as either a kind of planned activity (as when one brings a list to a shop) or as a form of impulsive buying. E-commerce lends itself much more easily to planned shopping, according to Licoppe, while browsing and spontaneous purchases are harder. One type of purchasing behavior, in brief, is typical for stores and supermarkets, and another for the consumer sitting in front of his or her computer.

Electronic shopping also differs from traditional shopping in the way its sequences are timed. When you buy on the Internet there is especially a significant time gap that does not exist when you shop in a store or a supermarket, namely between the expressed intention to buy and the actual delivery of the goods. From an economic viewpoint, e-commerce adds little to the traditional view of exchange, since you still have to first hand over the money before you get what you want. From the perspective of buying as a social type of activity, in contrast, buying on the Internet represents a novel experience; and the customer often reacts with anxiety to the time gap between the display of intention to buy and the delivery of the goods.

How the technology that is used in e-commerce has led to many changes in the ways that people interact with one another is also at the center of the second chapter in part IV. What interests Shay David and Trevor Pinch is that, whereas a few years ago it was common for books and other cultural goods to be reviewed only by expert reviewers, the new technology has led to the emergence of a new type of reviewers, who may be called amateur reviewers or user reviewers. Their activities, according to David and Pinch, are reshaping the operation of ''the reputation economy.'' Taking as their point of departure the fact that some amateur or user reviewers duplicate the product reviews that they post on websites such as Amazon.com, David and Pinch raise a series of general issues concerning new technology and how it is used in predictable and unpredictable ways. ''Interpretive flexi-

bility'' and ''technological affordance'' are seen as particularly helpful in explaining why electronic product reviews have come to serve a number of purposes besides providing information about the item that is being sold, such as the construction of identity and the promotion of one's own books and CDs. They do so, according to David and Pinch, by emphasizing that the use of an item is not somehow inherent in its essence but instead is decided by the social, historical, and economic context of the item.

That mainstream economic analysis is not particularly well suited to explain what happens when technology is transferred, and that alternative types of explanations from the STS literature are better at this, is the main theme of chapter 12. By 'transfer' Nicholas Rowland and Tom Gieryn do not mean the process of moving some piece of technology from one place to another, but something that involves the social setting—more precisely, the organizational processes that accompany the transfer of some technology from one organizational setting to another. The example Rowland and Gieryn use to make their point is the trouble that has resulted from the recent decision by the Indiana University Business School to switch to a standardized IT system produced by PeopleSoft. If one analyzes this situation with the transaction-cost approach that is associated with the work of Oliver Williamson, Rowland and Gieryn argue, it is very difficult to make sense of the difficulties that ensued at the Indiana University Business School. If instead one uses the STS idea that it is not possible simply to replicate an experiment, since this does not take tacit knowledge into account, one is in a much better position to address ''transfer problems.''

Notes

1. We are not the first to suggest this linkage. Michel Callon's 1998 book *The Laws of the Market* has been highly influential. Callon's approach has also been taken forward (and critiqued) in a special issue of *Economy and Society* edited by Andrew Barry and Don Slater (2002). Important studies also have been conducted by Knorr Cetina and Bruegger (2002), MacKenzie and Millo (2003), and Callon and Muniesa (2003). See also MacKenzie, Muniesa, and Siu 2007.

2. Both fields have produced handbooks of their main themes and approaches. For STS, see Jasanoff, Markel, Petersen, and Pinch 1996 and Hackett, Amsterdamska, Lynch, and Wajcman 2007; for economic sociology, see Smelser and Swedberg 1994, 2005.

3. There are other ways of bringing STS and economics together. For example, the role of numbers, figures and calculative practices and their use in economics has been investigated from an STS perspective (Ashmore, Mulkay, and Pinch 1989; Porter 1995; Kalthoff, Rottenburg, and Wagener 2000). Calculative practices are at the heart

of Callon's (1998) approach, which we discuss in more detail in the text and which Callon elaborates upon in his own contribution. A related body of work draws parallels between accountancy practices and the increasing prevalence of what might be called an ''audit society'' (Miller 2001; Power 1990; Strathern 2000). McCloskey's (1985) influential work on the rhetoric of economics offers another approach to the practice of economics as an academic discipline (see also McCloskey 1990). The history and philosophy of economics is also a rapidly developing area; see, e.g., Morgan 1990; Mirowski 1998; Weintraub 2002.

4. ''[T]he boy with the cold hard cash / is always mister right / 'cause we are living in a material world / and I am a material girl''—Madonna, ''Material Girl'' (1984). Andrew Pickering (1989) deserves credit for being the first person to use Madonna's catchy song title in an academic context.

5. Their German reader was eventually published in English as *Materialities of Communication* (Gumbrecht and Pfeiffer 1994).

6. For another attempt to take materiality seriously within science studies, see Mukerji 1997.

7. For another such collection, see Buchli 2002.

8. The cultural analysis of television was famously discussed by the cultural critic Raymond Williams in *Television, Technology and Cultural Forms* (1974).

9. See also Akrich 1992.

10. The feminist approach to technology has also been extremely influential in STS. The focus upon bodies and the gendered meanings and practices built around technologies provides another important route into the issue of materiality. See, e.g., Cockburn and Ormrod 1993; Oudshoorn 1994; Wajcman 1991; Haraway 1991; Oldenzeil 1999. For a very recent bringing together of feminism with materiality, see Alaimo and Hekman, 2008.

11. ''Closure'' and ''stabilization'' are given slightly different meanings in Bijker 1995a.

12. For overviews of economic sociology, see Smelser and Swedberg 2005; for some often used anthologies Granovetter and Swedberg 2001; Biggart 2002; Dobbin 2004. Michel Callon, Karin Knorr Cetina, Donald MacKenzie, Alex Preda, David Stark, and a few other scholars span the two areas of STS and economic sociology.

References

Akrich, M. 1992. The de-scription of technological objects. In *Shaping Technology/Building Society*, ed. W. Bijker and J. Law. MIT Press.

Alaimo, S. and S. Hekman eds. 2008. *Material Feminisms*. Indiana University Press.

Alder, K. 2007. Thick things: Introduction. *Isis* 98: 80–83.

Appadurai, A., ed. 1986. *The Social Life of Things: Commodities in Cultural Perspective*. Cambridge University Press.

Ashmore, M., M. Mulkay, and T. Pinch. 1989. *Health and Efficiency: A Sociology of Health Economics*. Open University Press.

Baker, W. 1984. The social structure of a national securities market. *American Journal of Sociology* 89: 775–811.

Barry, A., and D. Slater. 2002. Introduction: The technological economy. *Economy and Society* 31, no. 2: 175–193.

Biggart, N., ed. 2002. *Readings in Economic Sociology*. Blackwell.

Bijker, W. 1995a. *Of Bicycles, Bakelites and Bulbs: Toward a Theory of Sociotechnical Change*. MIT Press.

Bijker, W. 1995b. Sociohistorical Technical Studies. In *Handbook of Science and Technology Studies*, ed. S. Jasanoff et al. Sage.

Bijker, W. 2007. Dikes and dams, thick with politics. *Isis* 98: 109–123.

Bijker, W., T. Hughes, and T. Pinch, eds. 1987. *The Social Construction of Technological Systems: New Directions in the Sociology and History of Technology*. MIT Press.

Bourdieu, P., and L. Wacquant. 1992. *An Invitation to Reflexive Sociology*. University of Chicago Press.

Buchli, V., ed. 2002. *The Material Culture Reader*. Berg.

Burt, R. 1992. *Structural Holes: The Social Structure of Competition*. Harvard University Press.

Callon, M., ed. 1998. *The Laws of the Markets*. Blackwell.

Castells, M. 2000. *The Rise of the Network Society*, second edition. Blackwell.

Chandler, Alfred D. 1977. *The Visible Hand: The Managerial Revolution in American Business*. Belknap.

Cockburn, C., and S. Ormrod. 1993. *Gender and Technology in the Making*. Sage.

Collins, H., and M. Kusch. 1998. *The Shape of Actions: What Humans and Machines Can Do*. MIT Press.

Collins, H., and T. Pinch. 1998. *The Golem at Large: What You Should Know about Technology*. Canto.

DiMaggio, P. 1988. Interest and agency in institutional theory. In *Institutional Patterns and Organizations*, ed. L. Zucker. Ballinger.

DiMaggio, P., and H. Louch. 1998. Socially embedded consumer transactions: For what kind of purchases do people most often use networks? *American Sociological Review* 63: 619–637.

Dobbin, F., ed. 2004. *The New Economic Sociology: A Reader*. Princeton University Press.

Dosi, G. 2000. *Innovation, Organization and Economic Dynamics: Selected Essays*. Elgar.

Fischer, C. 1994. *America Calling: A Social History of the Telephone to 1940*. University of California Press.

Fligstein, N. 1990. *The Transformation of Corporate Control*. Harvard University Press.

Freeman, C. 1982. *The Economics of Industrial Innovation*. MIT Press.

Granovetter, M. 1985. Economic action and social structure: The problem of embeddedness. *American Journal of Sociology* 91: 481–510.

Granovetter, M. 2005. Business groups and social organization. In *The Handbook of Economic Sociology*, second edition, ed. N. Smelser and R. Swedberg. Princeton University Press.

Granovetter, M., and P. McGuire. 1998. The making of an industry: Electricity in the United States. In *The Laws of the Market*, ed. M. Callon. Blackwell.

Granovetter, M., and R. Swedberg, eds. 2001. *The Sociology of Economic Life*. Westview.

Gumbrecht, H., and K. Pfeiffer, eds. 1994. *Materialities of Communication*. Stanford University Press.

Hackett, E. J., O. Amsterdamska, M. Lynch, and J. Wajcman, eds. 2008. *The Handbook of Science and Technology Studies*, third edition. MIT Press.

Hamilton, S. 2003. Cold capitalism: The political economy of frozen orange juice. *Agricultural History* 77: 557–581.

Haraway, D. 1991. *Simians, Cyborgs and Women: The Reinvention of Nature*. Routledge.

Hutchins, E. 1995. *Cognition in the Wild*. MIT Press.

Jasanoff, S., G. Markel, J. Petersen, and T. Pinch, eds. 2004. *The Handbook of Science and Technology Studies*. Sage.

Kalthoff, H., R. Rottenburg, and H.-J. Wagner, eds. 2000. Facts and Figures: Economic Representations and Practices. *Oekonomie und Gesellschaft Jahrbuch* 16. Metropolis.

Kline, R., and T. Pinch. 1996. Users as agents of technological change: The social construction of the automobile in the rural United States. *Technology and Culture* 37: 763–795.

Knorr Cetina, K., and U. Bruegger. 2002. Global microstructures: The virtual societies of financial markets. *American Journal of Sociology* 107, no. 4: 905–950.

Knorr Cetina, K., and A. Preda, eds. 2004. *The Sociology of Financial Markets*. Oxford University Press.

Latour, B. 1996. *Aramis: or, The Love of Technology*. Harvard University Press.

Latour, B. 1999. *Pandora's Hope: Essays on the Reality of Science Studies*. Harvard University Press.

Latour, B. 2005. *Reassembling the Social: An Introduction to Actor-Network Theory*. Oxford University Press.

Latour, B. 2007. Can we get our materialism back, please? *Isis* 98: 138–142.

Latour, B. Forthcoming. *Gabriel Tarde and Economics*.

Lave, G., and E. Wegner. 1991. *Situated Learning: Legitimate Peripheral Participation*. Cambridge University Press.

MacKenzie, D. 1991. *Inventing Accuracy: A Historical Sociology of Nuclear Missile Guidance*. MIT Press.

MacKenzie, D., and Y. Millo. 2003. Negotiating a market, performing theory: The historical sociology of a financial derivatives exchange. *American Journal of Sociology* 109, no. 1: 107–146.

MacKenzie, D., F. Muniesa, and L. Siu, eds. 2007. *Do Economists Make Markets? On the Performativity of Economics*. Princeton University Press.

Martin, M. 1991. *"Hello Central?" Gender, Technology and Culture in the Formation of Telephone Systems*. McGill–Queens University Press.

Marx, K. 1999. *Capital: A Critique of Political Economy*. Penguin.

McCloskey, D. 1985. *The Rhetoric of Economics*. University of Wisconsin Press.

McCloskey, D. 1990. *If You're So Smart: The Narrative of Economic Expertise*. University of Chicago Press.

McKelvey, M. 2000. *Evolutionary Innovations: The Business of Biotechnology*. Oxford University Press.

Miller, D., ed. 1998. *Material Cultures: Why Some Things Matter*. University of Chicago Press.

Miller, D., ed. 2005. *Materiality*. Duke University Press.

Miller, P. 2001. Governing by numbers: Why calculative practices matter. *Social Research* 68, no. 2: 379–395.

Mirowski, P. 1998. *Against Mechanism: Protecting Economics from Science*. Rowman and Littlefield.

Mirowksi, P. 2002. *Machine Dreams: Economics Becomes a Cyborg Science*. Cambridge University Press.

Morgan, M. 1990. *The History of Econometric Ideas*. Cambridge University Press.

Mukerji, C. 1997. *Territorial Ambitions and the Gardens of Versailles*. Cambridge University Press.

Muniesa, F. 2003. Des Marchés commes algorithmes: Sociologie de la cotation électronique à la Bourse de Paris. Ph.D. dissertation, Ecole des Mines, Paris.

Nelson, R., and S. Winter. 1982. *An Evolutionary Theory of Economic Change*. Harvard University Press.

Oldenzeil, R. 1999. *Making Technology Masculine: Men, Women and Modern Machines in America, 1870–1945*. Amsterdam University Press.

Oudshoorn, N. 1994. *Beyond the Natural Body: An Archaeology of Sex Hormones*. Routledge.

Oudshoorn, N., and T. Pinch. 2003. *How Users Matter: The Co-Construction of Users and Technologies*. MIT Press.

Pickering, A. 1989. Living in the material world: On realism and experimental practice. In *The Uses of Experiment*, ed. D. Gooding et al. Cambridge University Press.

Pinch, T. 2006. The sociology of science and technology: a review.'' In *21st Century Sociology: A Reference Handbook*, volume 2, ed. C. Bryant and D. Peck. Sage.

Pinch, T. 2008. Technology and institutions: Living in a material world. *Theory and Society*.

Pinch, T., and W. Bijker. [1984] 1987. The social construction of facts and artifacts: or how the sociology of science and the sociology of technology might benefit each other. In *The Social Construction of Technological Systems*, ed. W. Bijker et al. MIT Press.

Polanyi, K. 1944. *The Great Transformation*. Farrar & Rinehart.

Polanyi, K. 1957. The economy as instituted process. In *Trade and Market in the Early Empires*, ed. K. Polanyi et al. Regnery.

Porter, T. 1995. *Trust in Numbers: The Pursuit of Objectivity in Science and Public Life*. Princeton University Press.

Powell, W. 1990. Neither market nor hierarchy: Network forms of organization. *Research in Organizational Behavior* 12: 295–336.

Power, M. 1990. *The Audit Society: Rituals of Verification*. Oxford University Press.

Ritzer, G. 1999. *Enchanting a Disenchanted World: Revolutionizing the Means of Consumption*. Pine Forge.

Rosen, P. 1993. The social construction of mountain bikes: Technology and postmodernity in the cycle industry. *Social Studies of Science* 23: 479–513.

Rosen, P. 2002. *Framing Production: Technology, Culture, and Change in the British Bicycle Industry*. MIT Press.

Rosenberg, N. 1994. *Exploring the Blackbox: Technology, Economics, History*. Cambridge University Press.

Schumpeter, J. 1934. *The Theory of Economic Development*. Harvard University Press.

Simmel, G. 1978. *The Philosophy of Money*. Routledge.

Smelser, N., and R. Swedberg, eds. 1994, 2005. *The Handbook of Economic Sociology*. 1st and 2nd rev ed. Russell Sage Foundation and Princeton University Press.

Star, S. 1999. The ethnography of infrastructure. *American Behavioral Scientist* 43: 377–391.

Star, S., and G. Bowker. 1999. *Classification and Its Consequences*. MIT Press.

Strathern, M., ed. 2000. *Audit Cultures: Anthropological Studies in Accountability, Ethics and Academy*. Routledge.

Suchman, L. 1998. *Plans and Situated Actions*. Cambridge University Press.

Swedberg, R. 1998. *Max Weber and the Idea of Economic Sociology*. Princeton University Press.

Swedberg, R. 2005. The economic sociology of capitalism: An introduction and agenda. In *The Economic Sociology of Capitalism*, ed. V. Nee and R. Swedberg. Princeton University Press.

Vaughan, D. 1996. *The* Challenger *Launch Decision: Risky Technology, Culture and Deviance at NASA*. University of Chicago Press.

Wajcman, J. 1991. *Feminism Confronts Technology*. Pennsylvania State University Press.

Weber, M. 1988. *The Protestant Ethic and the Spirit of Capitalism*. Peter Smith.

Weintraub, E. 2002. *How Economics Became a Mathematical Science*. Duke University Press.

Williams, R. 1974. *Television, Technology and Cultural Forms*. Technosphere Books.

Woolgar, S. 1991. Configuring the user: The case of usability trials. In *A Sociology of Monsters*, ed. J. Law. Routledge.

Wright, E., ed. 2005. *Approaches to Class Analysis*. Cambridge University Press.

Yates, J. 2005. *Structuring the Information Age: Life Insurance and Information Technology in the 20th Century*. Johns Hopkins University Press.