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Theorizing Modernity and Technology

1. Introduction: The Need for Integrated Studies of Modernity and Technology

Technology made modernity possible. It has been the engine of modernity, shaping it and propelling it forward. The renaissance was made possible by major 14th and 15th-century inventions like the mechanical clock, the full-rigged ship, fixed-viewpoint perspective and global maps, and the printing press. The emergence of industrial society in the 18th century was the result of an industrial revolution that was made possible by technological innovations in metallurgy, chemical technology and mechanical engineering. The recent emergence of an information society is also the product of a largely technological revolution, in information technology. Technology has catalyzed the transition to modernity and catalyzed major transitions within it. More than that, technologies are and continue to be an integral part of the infrastructure of modernity, being deeply implicated in its institutions, organizing and reorganizing the industrial system of production, the capitalist economic system, surveillance and military power, and shaping cultural symbols, categories and practices (see Edwards and Lyon, this volume).

If modernity is shaped by technology, then the converse also holds: technology is a creation of modernity. The common wisdom of technology studies, that technology is socially shaped or even socially constructed, that it is 'society made durable,' implies that a full understanding of modern technology and its evolution requires a conception of modernity within which modern technology can be explained as one of its products. If this holds for technology at large, it certainly also holds for particular technologies, technical artifacts, and systems. These are also products of modernity, and bear the imprint not only of the behaviors of actors immediately involved in their construction, but also of the larger sociocultural and economic conditions within which they are developed. To miss out on this larger context is to miss out on

part of the story that can be told about that technology. It would be like a staging of Wagner's Parsifal with only the actors on stage, without any settings, costumes and props.

In the current specialized academic landscape, modernity is the object of study of modernity theory, and technology is studied in technology studies. Few works exist that bridge these two fields and that study technology with extensive reference to modernity, or modernity with extensive reference to technology, or that concentrate on both by studying the way in which evolutions within modernity intersect with technological changes. In modernity theory, technology is often treated as a 'black box' that is discussed, if at all, in abstract and often essentialist and technological determinist terms. In technology studies, the black box of technology is opened, and technologies and their development are studied in great empirical detail, yet technology studies generates its own black box, which is society. The larger sociocultural and economic context in which actors operate is either treated as a background phenomenon to which some hand-waving references are made, or it is not treated at all - a black box returned to sender, address unknown.

Undoubtedly, part of the reason for modernity theory not adequately coming to grips with technology has been the lack of empirically informed accounts of technology. It is only in the past few decades that major progress has been made in our understanding of technology and technological change, with the establishment of technology studies as a mature field of study. The same argument cannot be given for the lack of reference to modernity theory in technology studies, as modernity theory has been around a lot longer than technology studies. Here, this lack of reference is more likely explained by the abstract and totalizing character of many theories of modernity, their often inadequate accounts of technology, the speculative, untested character of many of their claims, and the difficulty of connecting the micro-level concepts of technology studies to the macro-level categories of modernity theory. These criticisms do not apply equally to all theories of modernity. There is a world of difference between the abstract, totalizing theories of modernity of classical critical theory, Marxism and phenomenology, and many recent theories of modernity, like those of David Harvey and Manuel Castells, that are empirically rich and mindful of heterogeneity and difference. So if the sociocultural and economic context that is modernity ought to be considered in technology studies, then technology studies should work to appropriate more adequate theories of modernity, or start developing its own.[1]

It is time, then, to bridge the disciplinary gaps that now separate modernity theory and technology studies, and to work at empirically informed and theoretically sophisticated accounts of technology, modernity, and their mutual shaping. In this essay, I will contribute to this task through an analysis of the problems and misunderstanding that now beset modernity theory and technology studies in their respective treatment (or non-treatment) of technology and of modernity (section 4). A key conclusion of this section is that the major obstacle to a future synthesis of modernity theory and technology studies is that technology studies mostly operates at the micro- (and meso-) level, whereas modernity theory operates at the macro-level, and it is difficult to link the two. In section 5, I will analyze the micro-macro problem and ways in which it may be overcome in technology studies and modernity theory. Preceding these sections, sections 2 and 3 provide basic expositions of concepts, themes and approaches in modernity theory and technology studies. These sections aim to introduce these fields to readers insufficiently familiar with them, as well as to set the stage for analysis in sections 4 and 5.

2. Modernity Theory: Understanding the Modern Condition

The Structure and Aims of Theories of Modernity

Modernity is the historical condition that characterizes modern societies, cultures and human agents. Theories of modernity aim to describe and analyze this historical condition. A distinction can be made between cultural and epistemological theories of modernity, most of which are found in the humanities, and institutional theories, which are common in social theory – although in both traditions many theories of modernity can be found that blend cultural, institutional and epistemological aspects.

Cultural and epistemological theories of modernity focus on the distinction between premodern and modern cultural forms and modes of knowledge. These theories usually place the transition from traditional society to modernity in the Renaissance period, in 15th and 16th century Europe. The transition to modernity, on this conception, is characterized by the emergence of the notion of an autonomous subject, the transition from an organic to a mechanistic world picture, and the embrace of humanistic values and objective scientific inquiry. Some theories locate the transition to modernity later than this, as late as the 18th century, during

which Enlightenment thought had culminated into a genuine project of modernity, with universalistic pretensions to progress, and with fully developed conceptions of objective science, universal morality and law, and autonomous art (e.g., Habermas, 1983). The cultural-epistemological approach to modernity dominates in philosophy, with Hegel, Nietzsche and Heidegger as early icons, and is also well represented in cultural history and cultural studies.

Many studies in the humanities that analyze modernity as a cultural phenomenon also focus on *modernism*, which is a phenomenon distinct from modernity. Modernism, or aesthetic modernism, as it is also called, was a cultural movement that initiated in the mid-19th century as a reaction against the European realist tradition, in which works of art intend to 'mirror' external nature or society, without any additions or subtractions by the artist. Modernist artists, in often quite different ways, rejected this realism and held that it is the *form* of works of art, rather than their contingent content, that guarantees authenticity and liberates art from tradition. Modernism has been very influential in literature, in the visual arts, and in architecture, with movements as diverse as naturalism, expressionism, surrealism and functionalism being counted under it. The emergence of modernism has often been explained by reference to major social transformations in 19th and early 20th century modernity. David Harvey, for instance, has argued that modernism was a cultural response to an crisis in the experience of space and time, which was the result of processes of time-space compression under late 19th century capitalism.[2] The label 'modernism' is also used in a broader sense, in which it does not refer to an aesthetic movement, but to the culture and ideology of modernity at large (e.g., Bell, 1976). 'Modernism', in this sense, stands for positivism, rationalism, the belief in linear progress and universal truth, the rational planning of ideal social orders, and the standardization of knowledge and production. When used in this latter sense, the notion of modernism becomes almost interchangeable with the notion of modernity construed as a cultural or epistemological condition (cf. Berman, 1983).

Institutional theories of modernity focus on the social and institutional structure of modern societies, and tend to locate the transition to modernity in the 18th century, with the rise of industrial society in Europe. Institutional theories of modernity are as old as social theory itself, with early proponents like Weber, Marx and Durkheim outlining key structural features of modern societies and theorizing major transitions from traditional to modern society. Modernity, on the institutional conception, is a mode of social life or organization rather than a cultural or epistemological condition. It is characterized by institutional structures and processes like

industrialism, capitalism, rationalization and reflexivity. It is with this institutional meaning of 'modernity' that one can correlate the notion of *modernization*, which is the transformation of traditional societies to industrial societies. 'Modernity' used to be a condition emerging in 18th century European societies, but nowadays characterizes industrial societies around the globe.[3]

In my discussion of modernity theory, I will give special emphasis to the social theory tradition, with the understanding that much of this work analyzes not only institutional aspects of modernity, but cultural and epistemological dimensions as well. Indeed, it is quite common to see these aspects combined in social theories of modernity, even if institutional features receive the most emphasis. This blending of traditions has been particularly strong in critical theory, with authors like Habermas, Marcuse and Adorno referring to Hegel and Heidegger as liberally as to Marx and Weber. But it is also quite visible in more recent theories of modernity, such as those of Giddens, Harvey, Wagner and Castells, as well as in the early institutional theories of modernity developed by Weber and Marx.

Theories of modernity in the social theory tradition present an account of the distinct structural features that characterize modern societies and the way these features came into being. Typically, they contain most or all of the following elements:

- They draw the boundaries of modernity as a historical period, contrasting it with a premodern period and sometimes also with a postmodern period.
- They describe and analyze the special features of modernity, with an emphasis on institutional, cultural or epistemological dimensions. They almost invariably do this through macro-level or 'abstract' analysis. However, they may contain various elaborations, case studies or illustrations of the macro-theory.
- They (optionally) describe the dynamics of modernity, delineating (a) the historic changes that led to modern society, (b) various epochs within modernity (e.g., early, high and late modernity; classical and reflexive modernity), and (c) the transitions between these epochs.
- Some theories of modernity also contain normative evaluations or critiques of the condition of modernity. Some propose visions of an alternative society or speculate how present modernity may transform itself into another type of social formation.

Next to grand theories of modernity, such as those of Marx, Weber, Habermas and Giddens, one can find studies of particular eras within modernity, of major transitions and developments within the modern era, and of particular features or structures of modernity. Theories of particular eras within modernity attempt to characterize a particular historical epoch within modernity and to analyze the transitions that led to it. Many contemporary social theorists focus on *late modernity*, as a historical epoch emerging in the second half of the twentieth century, and attempt to characterize its special features. Thus, one finds theories of reflexive modernity (Beck, Giddens & Lash, 1994), 'the risk society' (Beck, 1992), 'postindustrial society' (Bell, 1976; Touraine, 1971), 'the information age' and 'the information society' (Castells, 1996; Schiller, 1981), 'the global age' (Albrow, 1996), and many others. Akin to these theories, one finds theories of *postmodernity*, that hypothesize that we have already left (late) modernity and have recently entered a new postmodern era (e.g., Jameson, 1991; Harvey, 1989).

Besides theories of particular eras in modernity, there are many studies of major sociocultural, technological or economic transitions within modernity. These range from studies of the scientific revolution and the industrial revolution to studies of the control revolution (a revolution in technologies of control that is claimed by Beniger (1989) to have paved the way for the information society) or the emergence of Fordism, to theories of the historical development of the modern subject and of new modern forms of power (e.g., Foucault, 1979). Not all these works explicitly situate the developments they analyze within the wider context of modern social institutions and culture. Finally, one can find studies that are concerned with particular aspects or structures of modernity, such as modern identity (Lash & Friedman, 1993; Giddens, 1991), capitalism (Sayer, 1991), pornography (Hunt, 1993), consumer culture (Slater, 1997) and gender (Marshall, 1994; Felski, 1995).

Not every work in social theory is a work in modernity theory. For it to qualify as such, it would have to be centrally concerned with major institutional, cultural or epistemological aspects of or transformations within modernity, such as capitalism, the autonomous self, modern technology and the Enlightenment. Alternately, for phenomena that are not inherently tied to modernity or at least not defining of it, such as pornography, adolescence, or the automobile, it would study these in relation to the larger institutional, cultural and epistemological context of modernity. Thus, an analysis of adolescence would be a study in modernity theory if it would explicitly consider the historical, cultural, and institutional constructions of adolescence in the

modern era and changes in its construction over time, but not if it would treat adolescence in a largely ahistorical way (e.g., as a set of locally enacted constructions with little historical continuity), or if it would study its historical treatment in a particular country or setting without reference to its relation to modern social institutions and culture.[4]

Modernity and Social Theory

Theories of modernity have always held a prominent position in social theory. What follows is a brief review. Any such review will have to start with Karl Marx and Max Weber, who are often identified as the fathers of modernity theory. They are both known for their theory of the transition between feudal and industrial society, and their theories of (capitalist) industrial society. They are hence early proponents of institutional theories of modernity and of the transition of the premodern to the modern period. In Marx's historical materialist conception of modernity, the difference between the modern and the premodern era is characterized by qualitative differences in the economic structure. The economic structure of a society is made up of production relations, and changes when the development of the productive forces (means of production and labor power) results in greater productive power. According to Marx, the transition from feudal to capitalist society was caused by large increases in productive power in feudal society. These increases caused changes in production relations, and hence in the economic structure. The resulting economic structure was capitalist in late 19th century modernity, but Marx of course envisioned a transition to a post-class socialist society, a transition that would occur when further increases in production power make a socialist state possible. He hence envisioned an early, capitalist, and a late, socialist state of modernity. Both are characterized by an industrial system of production, but their social form and culture are significantly different.

Weber (1958[1905]) did not see the transition from feudal to industrial society as caused by the development of productive power. Instead, he held that the capitalist economic system that made industrial society possible was an outgrowth of the Protestant work ethic, which demanded hard work and the accumulation of wealth. Because capitalism is profit-based, it demanded *rationalization* so that results could be calculated and so that efficiency and effectiveness could be increased. In this way, rationalization became the distinguishing characteristic of modern industrial societies. The rationalization of society is the widespread

acceptance of rules, efficiency, and practical results as the right way to approach human affairs, and the construction of a mode of social organization around this notion. According to Weber, rationalization has a dual face. On the one hand, it has enabled a liberation of humanity from traditional constraints and the has led to a progress of reason and freedom. But on the other hand, it has produced a new oppression, the "iron cage" of modern bureaucratic organizational forms that limits human potential.[5]

Weber's notion of rationalization as the hallmark of modernity has been very influential in modernity theory. It has been particularly influential in critical theory, particularly with members of the Frankfurt school such as Adorno, Horkheimer, Marcuse and Habermas, who built on Weberian notions, as well as Marxist ideas, in formulating their sweeping critiques of modern society.[6] Jürgen Habermas, without doubt the most influential scholar in the critical theory tradition, has advanced a theory of modernity with strong Weberian and Marxist influences, in which he analyzes modernity as an 'unfinished project' (Habermas, 1983). He theorizes an early phase of modernity and a later phase. Early modernity witnessed the rise of the 'bourgeois public sphere,' which mediated between the state and the public sphere. In late modernity, the state and private corporations took over vital functions of the public sphere, as a result of which it became a sphere of domination (Habermas, 1989).

Although critical of late modernity, Habermas sees an emancipatory potential in early modernity, with its still intact bourgeois public sphere. He hence sees modernity as an 'unfinished project' and has attempted to redeem some elements of modernity (the Enlightenment ideal of a rational society, the modern differentiation of cultural spheres with autonomous criteria of value, the ideal of democracy) while criticizing others (the dominant role of scientific-technological rationality, the culture of experts and specialists). Central in this undertaking has been his distinction between two types of rationality: purposive or instrumental rationality, which is a means for exchange and control, and which is based on a subject-object relationship, and communicative or social rationality, which is geared towards understanding and based on a subject-subject relationship, and which is the basis for communicative action. Habermas claims that there has been an one-sided emphasis since the Enlightenment on instrumental, scientific-technological rationality, which has stifled possibilities for expression. The result has been a colonization of the lifeworld by a amalgamated system of economy and state, technology and science, that carries out its functional laws in all spheres of life. Habermas

regards communicative action as a means to put boundaries on this system, and to develop the lifeworld as a sphere of enlightened social integration and cultural expression.

Looking beyond critical theory, one cannot escape the powerful analysis of modernity in the work of Anthony Giddens (1990; 1991; 1994). Giddens analyzes modernity as resting on four major institutions: industrialism, capitalism, surveillance, and military power. These and other institutions in modernity moreover exhibit an extreme dynamism and globalizing scope. To account for this dynamism, Giddens identifies three developments. The first is the separation of time and space, through new time and space-organizing devices and techniques, from both each other and from the contextual features of local places to which they were tied, to become separate, 'empty' parameters that can be used as structuring principles for large-scale social and technical systems. The second development is the disembedding of social life, which is the lifting out of local contexts of social relations and institutions by disembedding mechanisms, which are media like money, time-tables, organization charts, and systems of expert knowledge. Disembedding mechanisms define social relations and guide social interactions without reference to the peculiarities of place. The third development is the reflexive appropriation of knowledge, which is the production of systematic knowledge about social life, which is then reflexively applied to social activity. Jointly, these developments create a social dynamic of displacement, impersonality and risk, which can be overcome through reembedding (the manufacture of familiarity), trust (in the abstract systems that disembed social relations) and intimacy (the establishment of relationships of trust with others based on mutual processes of self-disclosure).

Risk, trust and the reflexive appropriation of knowledge are also a central themes in Ulrich Beck's theory of (late) modernity (Beck, 1992). Beck distinguishes two stages of modernization, the first of which is simple modernization: the transformation of agrarian society into industrial society. The second stage, which began in the second half of the twentieth century, is that of reflexive modernization. This is a process in which modern society confronts itself with the negative consequences of (simple) modernization, and moves from a conflict structure based around the distribution of goods to a model based on the distribution of risks. Current society is the risk society, in which risks are manufactured by institutions and can be distributed in different ways. The distribution of risk occurs at the backdrop of major social transformations, in which traditional social forms such as family and gender roles, that continued

to play an important role in industrial society, are moreover undergoing radical change in the risk society, which has led to a progressive 'individualization of inequality.'

The idea that modernity has recently entered a new phase is pervasive in contemporary social theory, even among those authors that stop short of claiming that we have entered or are entering a phase of postmodernity. Intensifying globalization, the expansion and intensification of social reflexivity, the proliferation of nontraditional social forms, the fragmentation of authority, the fusion of political power and expertise, the transition to a post-Fordist economy that is no longer focused on mass production and consumption and in which the production of signs and spaces becomes paramount -- all have been mentioned as recent developments that point to a new stage of reflexive or radicalized modernity (e.g., Lash and Urry, 1994; Beck, Giddens and Lash, 1994; Giddens, 1990, 1994; Albrow, 1996; Lipietz, 1987), with most authors identifying the late 1970s as a transition period. Many authors point specifically to the information technology revolution in claiming that we have entered an information age (or, equivalently, a postindustrial age), in which not an economy of goods but an information economy has become the organizing principle of society (e.g., Bell, 1996; see Webster, 1995 for an overview). In the transition from industrial society to the information society, the economic system is transformed, and along with it the occupational structure, the structure of organizations, and social structure and culture at large. According to Manuel Castells, who has presented the most comprehensive theory of the information society to date, the basic unit of economic organization in the information age is the network, made up of subjects and organizations, and continually modified as networks adapt to their (market) environments. Castells argues that contemporary society is characterized by a bipolar opposition between the Net (the abstract universalism of global networks) and the Self (the strategies by which people try to affirm their identities), an which is the source of new forms of social struggle (Castells, 1996, 1997, 1998).

Modernity and Postmodernity

Not all scholars agree that modernity is still the condition that we are in. Theorists of postmodernity claim that we have recently entered an era of postmodernity, which follows modernity. Postmodernity is usually considered, like modernity, to be a historical condition. Most postmodern theorists who consider postmodernity in this way place the transition from

modern to postmodern society somewhere in the 1960s or 1970s, although some hold that we are still in the middle of a transition phase. They hold that changes in society over the last century have accumulated during these decades to arrive at a society whose institutional, cultural or epistemological condition is sufficiently different from that of modern society to warrant the new label.

Many postmodern theorists point only to cultural changes to support this claim. Some, however, emphasize technological and economic changes and see changes in cultural and social forms as resulting from them. David Harvey emphasizes the 1970s transition from a Fordist economy of mass production and consumption to a global post-Fordist regime characterized by greater product differentiation, intensified rates of technological and organizational innovation, and more flexible use of labor power (Harvey, 1989). Frederick Jameson has theorized a transition to 'late capitalism,' which is global, and in which all realms of personal and social life, and spheres of knowledge, are commodified. He claims that late capitalism comes with its own cultural logic, which is postmodernism (Jameson, 1991). Lash and Urry (1994) point to the shift from an economy of goods to an economy of signs and spaces, as does Jean Baudrillard (1995), who claims that information technology, media, and cybernetics have yielded a transition from an era of industrial production to an era of simulation, in which models, signs and codes determine new social orders. The culture of postmodernity is often characterized by consumerism, commodification, the simulation of knowledge and experience, and the blurring if not disappearance of the distinction between representation and reality, a temporal present that both erases past history and a sense of a significantly different future. The cultural shifts also include a decline in epistemic and political authority, the fragmentation of experience and personal identity, and the emergence of a disorienting postmodern hyperspace.

Not all postmodern theorists hold postmodernity to be a historical condition, however. For some, like Jean-François Lyotard, postmodernity is rather a cultural or epistemological form that is not essentially tied to a particular historical period. Lyotard holds that within contemporary society, one can find both modern and postmodern forms existing together.[7] The characteristic of postmoderns like Lyotard is that they resist the modern form. For Lyotard, modernity is equivalent to reason, Enlightenment, totalizing and universalizing thought, and grand historical narratives; it is equivalent to what I identified earlier as modernism in a broad sense, that is, the culture and ideology of modernity. Lyotard criticizes the modern form of

knowledge and calls for new knowledges, that do not impose a grid on reality but that emphasize difference. Lyotard's cultural critique is also a critique of scholarly method. He argues that postmodern scholars should not do theory. They are also not to produce new grand narratives of society, but should deconstruct and criticize modernist claims for universalistic knowledge, by doing local, micro-level studies that emphasize heterogeneity and plurality (Lyotard, 1984a). He rejects the old methodology of social theory, along with any and all of its theoretical claims. This call for a postmodernization of the social sciences and humanities has been echoed by Richard Rorty, Jaques Derrida and Zygmund Bauman, and can be seen in the profusion of postmodern case-studies and analyses that uncover difference and heterogeneity and celebrate cultural Others.

Postmodern theorists hence range from those like Jameson and Harvey who study postmodernity as a historical era, to those, like Lyotard and Rorty, who criticize modernist ideology and develop and employ postmodern methodologies for the humanities and social sciences. Postmodernism, as a critique of modernist thought, is moreover an intellectual orientation that is different from, even if overlapping with, *aesthetic* postmodernism, which has emerged in literature, architecture and the visual arts since the 1960s and 70s as a response to aesthetic modernism. Critics of (academic) postmodernism, which include Habermas and Giddens, criticize both the hypothesized transition from modernity to postmodernity, and the intellectual attitude of postmodern scholars. Giddens, for example, claims that in spite of the discontinuities cited by postmodernists, the major institutions of modernity as it existed in the 19th and early 20th century, industrialism, capitalism, surveillance, and military power, are still in place, and he therefore only wants to go as far as to theorize a late, or 'radicalized' stage of modernity (Giddens, 1990). He and Habermas have both criticized postmodernism's anti-theoretical attitude, its epistemological and moral relativism, its irrationalism, and its laissez-faire attitude to politics (Giddens, 1990; Habermas, 1987). Similar debates exist within postmodern theory, with Harvey (1989) theorizing a transition to postmodernity while criticizing postmodernist thought, and Lyotard (1984b) criticizing Jameson's 'totalizing dogmas' and defense of master narratives.[8]

3. Technology Studies: New Visions of Technology

Technology Studies as a Field

'Technology studies' is the name for a loosely knit multidisciplinary field, with a wide variety of contributing disciplines, such as sociology, history, cultural studies, anthropology, policy studies, urban studies and economics. Technology studies is concerned with the empirical study of the development of technical artifacts, systems and techniques, and their relation to society. Technology studies is part of science and technology studies, or STS, a larger field that emerged in the 1970s and that is concerned with studies of science and technology, and their relations to society that are both empirically informed and on sound theoretical footing. STS is nowadays an established discipline, with departments and programs around the world, as well as specialized conferences and journals.[9] A full review of theories and approaches in technology studies is well beyond the scope of this paper, and is complicated because of the relative youth of the field and the diversity of its topics and approaches. In what follows, I will focus on two subfields of technology studies that are at the core of many STS departments and programs. They are *social studies of technology*, which studies social and cultural aspects of technology, and *history of technology*, which studies the historical development of technologies and their relation to society.[10] In discussing the history of technology, moreover, I will focus on contextual approaches, which are dominant in STS, and which study the historical development of technologies in relation to their social context, instead of taking an internalist approach which focuses on purely scientific and technological contexts only.[11] This selective choice means that I will ignore, amongst other work, the important work that has been done in the economics of technology and philosophy of technology.[12]

Contemporary technology studies, with its focus on social, cultural and historical dimensions of technology, covers a wide variety of topics. Scholars rarely consider 'Technology-with-a-capital-T'. Instead, they examine specific technologies such as genetic engineering or nuclear technology, specific engineering fields and approaches such as mechanical engineering or cold fusion research, specific techniques such as rapid prototyping or cerebral angiography, and technical artifacts, machines, materials and built structures such as ceramic vases, Van de Graaff generators, polystyrene, and the Eiffel tower. Additionally, many scholars study large technological *systems* such as railroad systems or early warning systems in missile defense, and

processes of technological change such as the development of the bicycle in the 19th century or the invention and development of electric lighting.

Technology studies analyzes these technological entities in their relation to their social context. Roughly, this is done in one of three ways. In one set of studies, the focus is on the shaping of the technology itself and the role of societal processes therein: how did the technology come into existence, what (social) factors played a role in this process, what modifications has it undergone since its first came into being, and why did these occur? In other studies, the focus is on the shaping of society by technology, or, alternatively, on the social changes that accompany the introduction and use of the technology. In yet other studies, these processes are considered together, emphasizing how a technology and its social context co-evolve, or co-construct each other. A significant proportion of work that takes up this co-construction theme even denies that there is a meaningful distinction between technology and society, and attempts to study 'sociotechnology,' which consists of dynamic seamless webs of entities that are only labeled 'technological' or 'social' after they have fully evolved (Bijker & Law, 1992; Latour, 1987; Callon, 1987). There is also a fourth category of studies in technology studies, which historian John Staudenmaier (1985) calls 'externalist,' that do not focus on technology *per se* but only on contextual aspects, such as engineering communities, technological support networks, or public images of technology.[13]

The core of contemporary technology studies is constituted by social studies of technology and the history of technology, both of which have been influenced by New Left critiques of science and technology. I will now discuss these two subfields in order. In *social studies of technology*, the research focus is on the social contexts in which technologies are developed and used, such as engineering labs, factories and homes, and it is examined how elements in these contexts interact with each other and with the technology in question. Such elements include individual agents and social groups, along with their behaviors, interactions, identities and statuses (gender, race, class), as well as organizational structures, institutional settings and cultural contexts.

Contemporary social studies of technology are in large part an outgrowth of social studies of science. The specific tradition of social studies of science of which it is an outgrowth is sometimes called Social Studies of Knowledge (SSK). The SSK-approach in sociology of science, which is the dominant approach nowadays, is distinguished by the fact that it holds that

scientific knowledge itself, and not just the social and institutional context of scientific inquiry, ought to be the key focus of the sociology of science. SSK holds that scientific knowledge is not a 'rational' process exempt from social influences but a social process, and that scientific truth is not objectively given but socially constructed. The SSK-approach in this way deviates from the dominant approach in sociology of science until the late 1970s, the Mertonian approach named after Robert K. Merton, which only focused on the institutional context of scientific inquiry while assuming that scientific inquiry itself is by and large rational and objective. It also distinguishes itself from traditional (positivist) philosophy of science and epistemology, which also holds scientific inquiry and truth to be rational and objective. Instead, it takes inspiration from the work of philosopher of science Thomas Kuhn's work on the structure of scientific revolutions, which is critical of images of science as a rational and cumulative process.[14]

It was a founding principle of SSK that 'nature' and 'rationality' and 'truth' in science are not explanatory of the process of scientific inquiry but are themselves contingent social constructs that must be explained. This central principle is extended in the early eighties, when some SSK'ers start to publish work in social studies of technology. The principle is modified to read: the working of machines does not provide an explanation of technological and social change, but is itself something that must be explained, at least in part by investigating social agents, their interactions and their beliefs about technology.[15] Technology is regarded, in part or wholly, as a social construction that must be explained at least in part by reference to social processes, and within which no appeal can be made to objective standards of truth, efficiency of technological rationality.

Although some contemporary work in (contextual) *history of technology* finds inspiration in social studies of technology, the history of technology is itself a much older field (Westrum, 1991; Staudenmaier, 1985). Yet, although there has always been an interest in the social context of technology in history of technology, contextual approaches that put this social context at center stage have only recently come to dominate. A typical study in contextual history of technology considers how a particular technology, such as mechanical power transmission, the internal combustion engine or the personal computer, evolved historically, and considers how the technology came to reflect the contexts in which it has been developed and used. The investigation is often bounded in time (a particular historical era or development stage of the technology) and space (a particular geographical area or setting). Contextual elements that

historians consider may include organizational, policy, and legal settings, including relevant individual actors, social groups, and organizations (engineers, firms, industries, governmental bodies, activist groups) and their discourses and behaviors. In *sociohistorical studies of technology*, in which social studies of technology intersect with the history of technology, the development of technologies is studied with special reference to its social contexts and uses.[16]

Most studies in social studies and history of technology are case studies that consider particular settings or events in which technologies are developed are used.[17] Other studies are what John Staudenmaier calls 'expanded studies,' which look more broadly at several types of technologies or several types of settings or historical episodes.[18] Yet other studies are primarily theoretical or methodological, focusing on issues like technological determinism or the interpretive flexibility of technological artifacts, or on methodological issues within technology studies. Most studies operate at a micro- or meso-level of analysis, focusing on individual actors, social groups and organizations, and their interactions, rather than on the macro-level of institutions and cultural frameworks. Research methods are diverse, and include textual analysis, discourse analysis, participant observation, ethnomethodology, and quantitative analysis.

Theoretical Claims of Technology Studies

The strong empirical orientation of most work in social studies and history of technology is visible not only in its case analyses, but also in its theoretical and methodological assumptions, which have often been inspired by, or modified as a result of, these case studies. As a consequence of this, there has been a fair amount of agreement on a number of theoretical assumptions. I will try to characterize some of these assumptions, along with some others that are also salient but more controversial.

One of the most central theoretical assumptions in technology studies is the assumption that *technology is socially shaped.* Technological change is conditioned by social factors, and technological designs and functions are the outcome of social processes rather than of internal standards of scientific-technological rationality; technology is society made durable.[19] The social shaping thesis denies the technological determinist idea that technological change follows a fixed, linear path, which can be explained by reference to some inner technological 'logic,' or perhaps through economic laws. Instead, technological change is radically underdetermined by such constraint, and involves technological controversies, disagreements and difficulties, that

involve different actors or relevant social groups that engage in strategies to shape technology according to their own insights.

Some scholars may discern technological or scientific constraints on technological change, but others point out that such constraints, if they exist at all, are themselves also socially shaped -- for example, expectations of growth within the business, engineering or user communities. Also, while some scholars recognize separate stages in the development of technology (e.g. invention, development, innovation), others, particularly in social studies of technology, analyze technological change as an entirely contingent and messy process, in which heterogeneous factors affect technological outcomes, and in which the process of invention continues after technologies leave the laboratory or factory. These scholars emphasize that users, regulators, and others also affect the design and operation of technologies, and the way in which technologies are interpreted and used (Bijker, 1992; Lie and Sørenson, 1996; Oudshoorn and Pinch forthcoming). Against a linear path model of technological change, proposals have been made for a *variation and selection model*, according to which technological change is multidirectional: there are always multiple varieties of particular design concepts, of which some die, and others, which have a good fit with social context, survive (e.g., Pinch and Bijker, 1987; Ziman, 2000).

The social shaping thesis implies a *weak constructivist* claim that technological configurations are variable and strongly conditioned by social factors. *Social constructivist* approaches go beyond this claim to arrive at the *strong constructivist* claim that technological change can be entirely analyzed as the result of processes of social negotiation and interpretation, and that properties of technologies are not objective, but are effectively read into them by social groups. Social constructivism is hence a contemporary form of idealism, denying the possibility or desirability of a reference to any 'real' structures or forces beyond the representations of social groups. Whether a certain technology 'works' or is 'efficient' or 'user-friendly,' and what are its functions, powers and effects is not a pregiven, but the outcome of social processes or negotiation and interpretation.[20]

That the meaning or use of technologies is not pre-given is also recognized by those social shaping theorists who do not embrace social constructivism. They mostly agree that technology has *interpretive flexibility*, meaning that technologies can be interpreted and used in different ways (Pinch and Bijker, 1987). When social negotiations surrounding technological

change come to a close, interpretive flexibility is held to diminish because the technology *stabilizes*, along with concomitant ('co-produced') meanings and social relations. Stabilization implies the embedding of the technology in a stable network consisting of humans and other technologies, and the acceptance of a dominant framework on how to interpret and use the technology. Stabilization of a technology implies that its contents are 'black-boxed,' and are no longer a site for controversy. Its stabilized properties come to determine the way that the technology functions in society. Yet, black boxes can be reopened at any time. The history of technology shows how technologies such as the telephone, the Internet or the automobile take on particular functions or societal roles that may vary from time to time and place to place.

The flipside of the claim that technology is socially shaped is the claim that *society is technologically shaped*, meaning that technologies shape their social contexts. This claim goes considerably beyond the claim that new technologies may open up new possibilities that change society, or that technologies may have side-effects. Obviously, the steam engine changed society by making new types of industrial production possible, and the printing press effected change by making written information more available and easier to distribute. Obviously, also, technologies may have side-effects such as environmental pollution or unemployment. The technological shaping thesis does not just refer to such recognized functions and side-effects of technologies, but to the multiplicity of functions, meanings and effects that always, often quite subtly, accompany the use of a technology. Technologies become part of the fabric of society, part of its social structure and culture, transforming it in the process. The idea of society as a network of social relations is false, because society is made up of sociotechnical networks, consisting of arrangements of human and nonhuman actors linked together.

The notion of a sociotechnical network is a central notion in *actor-network theory* (ANT), which is a third influential approach technology studies next to the social shaping and social-construction approaches. It studies stabilization processes of technical and scientific objects as these result from the building of actor networks, which are networks of human actors and natural and technical phenomena. Actor-network theorists employ a principle of generalized symmetry, according to which any element ('social', 'natural', or 'technical') in a heterogeneous network of entities that participate in the stabilization of a technology has a similar explanatory role (Callon, 1987; Latour, 1987; Callon and Latour, 1992). Social constructivism is criticized by ANT for giving special preference to social elements, such as social groups and interpretation processes,

on which its explanations are based, whereas 'natural' or 'technical' elements, such as natural forces and technical devices are prohibited from being explanatory elements in explanations. Actor-network theory allows for technical devices and natural forces to be actors (or 'actants') in networks through which technical or scientific objects are stabilized. By an analysis of actor networks, any entity can be shown to be a post hoc construction, but entities are not normally socially constructed, because stabilization is not only the result of social factors.

The notion that society is technologically shaped means, according to most scholars in technology studies, that technology seriously affects social roles and relations, political arrangements, organizational structures and cultural beliefs, symbols, and experiences. Technology scholars have claimed that technical artifacts sometimes have built-in political consequences (Winner 1980), that they may contain gender biases (Wajcman, 1991), that they may subtly guide the behavior of their users (Sclove, 1995; Latour, 1992), that they may presuppose certain types of users and may fail to accommodate non-standard users (Akrich, 1992) and that they may modify fundamental cultural categories used in human thought (Akrich, 1992; Turkle, 1984, 1995). Latour (1992), for example, discusses how mundane artifacts, like seat belts and hotel keys, may induce their users towards certain behaviors. A hotel key, for example, has heavy weights attached them in an attempt to compel hotel guests to bring their key to the reception desk upon leaving their room. Winner (1980) argues that nuclear power plants require centralized, hierarchical managerial control for their proper operation. They cannot be safely operated in an egalitarian manner, unlike, for example, solar energy technology. In this way, nuclear plants shape society by requiring or suggesting a particular mode of social organization for their operation. Sclove (1995) points out that modern sofas with two or three separate seat cushions define distinct personal spaces, and thus work to both respect and perpetuate modern Western culture's emphasis on individuality and privacy, in contrast to e.g. Japanese futon sofa-beds. Turkle (1984), finally, discusses how computers and computer toys affect conceptions of life. Because computer toys are capable of behaviors that inanimate objects are not normally capable of, they lead children to reassess the traditional dividing lines between 'alive' and 'not alive' and hence to develop a different concept of 'alive'. Most authors would not want to claim that technologies have inherent powers to affect such changes. Rather, it is technologies-in-use, technologies that are already embedded in a social context and been assigned an interpretation, that may generate such consequences.

To conclude, the major insights of technology studies have been that technologies are socially shaped and society is shaped by technology, or, alternatively, society and technology co-construct each other. They are not separate structures or forces but are deeply implicated in each other. Technological change is moreover not a linear process but proceeds by variation and selection, and technologies have interpretive flexibility, implying that their meanings and functions and even (according to social constructivists) their technological content are constantly open to renegotiation by users and others.

4. Technology Studies and Modernity Theory: Mutual Criticism

The Treatment of Technology in Modernity Theory

It is difficult to overlook the pervasive role of technology in the making of modernity. As argued in section 1, technology is a central means by which modernity is made possible. It is a catalyst for change and a necessary condition for the functioning of modern institutions. But it is more than that. What can be learned from technology studies is that the institutions and culture of modernity are not just *shaped* or *influenced* by technology, they are also *constituted* by it. The social systems of modernity are sociotechnical systems, with technology an integral part of the workings of social institutions. Social institutions are societal structures that regulate and coordinate behavior and in this way determine how certain societal needs are met. In the modern age, however, their regulative functions are no longer a direct outcome of collective actions, since most collective actions have become thoroughly mediated and shaped by modern technologies, which function as co-actors. For example, collective acts of voting are nowadays thoroughly mediated by voting technologies that help determine whether people get to vote at all, how votes are defined, and whether votes are counted. Modern culture is, likewise, a technological culture, in which technologies are not just means by which cultural symbols and artifacts are realized, but have become constitutive of their meaning or content. Information technology, for example, is transforming basic cultural concepts and experiences like those of time, space, reality, privacy and community, and is also affecting fundamental shifts in cultural practices.

If this analysis of the role of technology in modernity is anywhere near correct, then it is surprising, to say the least, to find that technology is not a central topic in the vast literature in modernity theory. Indeed, of the many hundreds of books that bear the word 'modernity' in the title, less than a handful also refer to 'technology' or one of its major synonyms or metonyms (e.g., 'technological,' 'computers,' 'biotechnology,' 'industrial,' etc.).[21] Many of the major works in modernity theory only make passing reference to technology. For example, technology is only referenced once in the recent edited volume *Theories of Modernity and Postmodernity*, it is not mentioned at all in Zygmunt Bauman's *Intimations of Postmodernity*, and there are only four or five brief references to it in Alain Touraine's *Critique of Modernity*.[22]

What can explain this apparent neglect of technology in modernity theory? It is not the denial that technology has an important role in the constitution of modernity, for most authors would agree that its role is pivotal. A better explanation is that the dominant dimensions along which modernity has traditionally been analyzed (institutional, cultural and epistemological) have not allowed technology to play a major identifiable role, but have instead assigned to it the status of a background condition. Technology is often analyzed as a mere catalyst of institutional, cultural and epistemological change, or as a mere means through which institutions, cultural forms and knowledge structures are realized. In institutional analyses of modernity, modernity is analyzed as constituted by institutions and their transformations. Technology is not usually recognized as an institution itself; it is not seen as a separate regulative framework like capitalism, government, or the family, but rather as one of the means through which these frameworks operate. More often than not, institutions like capitalism, industrialism or military power are discussed without specific reference to the technologies that sustain them. The role of technology in transforming these institutions (e.g., in the transition to an information society) is more difficult to ignore. But here one often finds technology subsumed to a broader phenomenon, such as rationalization (Weber), productive forces (Marx) or disembedding mechanisms (Giddens), of which technology is only a part. Even in Marxist theory, which assigns an important role to production technology in the making of modernity, production technology still only serves as an external constraint on economic structure, which ultimately determines the social forms of society.

In most cultural and epistemological theories of modernity, technology is either analyzed as a mere catalyst of cultural and epistemological changes, or it is robbed of its materiality and

reduced to knowledge, language or ideas. In Heidegger's critique of modernity, in which technology 'enframes' us and turns the world into 'standing reserves,' technology turns out not to be defined a material process or as a mode of action, but as a particular mode of thinking (Heidegger, 1977). The same idealism is also visible in much of Critical Theory, in spite of its greater emphasis on social institutions. There, technology is often identified with technological or formal rationality, which is a mode of thinking that does not just characterize modern technology but also modern thought and economic and social processes. Habermas, moreover, has defined technology as 'technological knowledge and ideas about technology' (Habermas 1987). In postmodern theory, finally, technology is often reduced to language, signs, or modes of knowledge, along with everything else.

When technology is referred to in modernity theory without being reduced to something else, still other problems emerge. One is the *level of abstraction* at which technology is discussed. Technology is usually treated as a monolith, as a macroscopic entity, Technology-with-a-capital-T, over which broad generalizations are made that are supposed to apply equally to nuclear technology and dental technology, to vacuum cleaners and gene splicers. This abstract, undifferentiated treatment leads to vagueness, obscures differences between technologies, and fails to distinguish the different ingredients that make up technology (knowledges, artifacts, systems, actions) and the way these relate to their context. Giddens, for example, employs the notion of an 'expert system,' which is a key mechanism for the decontextualizing of social relations. He defines expert systems as "systems of technical accomplishment or professional expertise that organize large areas of the material and social environments in which we live today".[23] He discusses few examples of expert systems, but makes clear that virtually any system in which the knowledge of experts is integrated and that contains relevant safety measures qualifies as an expert system, including automobiles, intersections, buildings, and railroad systems. Giddens moreover hardly goes into any detail on the way in which expert systems decontextualize social relations.

A monolithic treatment of technology easily leads to *essentialism* and *reification*. On an essentialist conception, technology has fixed, context-independent properties that apply to all technologies. As Andrew Feenberg has argued, technological essentialism usually construes technology's essence as its instrumental rationality and its functionalism which reduces everything to functions and raw materials.[24] This essentialism often correlates with a reified

conception of technology, according to which it is a 'thing,' with static properties, that interacts with other 'things' like the economy and the state. Essentialism and reification, in turn, have a tendency to promote *technological determinism*, according to which technology develops according to an internal logic, uninfluenced by social factors, and operates as an autonomous force in society, generating social consequences that are unavoidable.[25] Technological determinism is evident in dystopian critiques of modernity, such as those of Heidegger, Marcuse, and Ellul, in which technology engulfs humanity and rationalizes society and culture. In many other theories of modernity, it is also present, albeit in a more subtle way. Marx's thesis that the productive forces determine or constrain production relations has often been interpreted as a form of technological determinism. Daniel Bell (1976) presents a similar view in characterizing the transition to a postindustrial society as the result of economic changes due to increased productivity, which is conditioned by information technology. Baudrillard (1995) construes the transition from modernity to postmodernity in technological determinist terms by analyzing it as the result of information technology and media, whose models and codes yield a new social order. In James Beniger's (1989) detailed historical study of the making of the information society is also built on technological determinist principles, with technological change being a cause of social change, while itself relatively independent of social influences.

In conclusion, the treatment of technology in modernity theory is problematic in several respects. Technology is often not assigned a major role in modernity, it is often subsumed to broader or narrower phenomena or one-dimensional phenomena, its treatment is often abstract, leading to vagueness, over-generalization, detachment from context and a failure to discern detailed mechanisms of change. In addition, technology is often reified and essentialized, and the conceptions of technology are often deterministic. There is also the problem that modernity theory's sweeping generalizations over technologies do not normally rest on micro-level elaborations of the macro theory, or on case-studies. Modernity theory's generalizations, it will be clear by now, tend to go against many key ideas of technology studies (the social character of technology and its interpretive flexibility, the path-dependency of technological change, etc.). Moreover, when theories of modernity provide inadequate accounts of technology and its role in modernity, their accounts of social institutions, culture and the dynamics of modernity suffer as well. There are theories that avoid many of the listed problems (e.g., Castells, 1996), but they are exceptions against the rule.

The Treatment of Modernity in Technology Studies

Modernity theory must provide an account of technology, because of its major role in the shaping of modernity. Technology studies, on the contrary, does not seem to require a consideration of modernity in its analyses of technology. It is not obvious that a historical study of the telephone or an analysis of the development and advertisement of fluorescent lighting *must* refer to macroscopic structures and events like disembedding mechanisms and changes in capitalist production modes. And in fact, most work in technology studies does not refer to such macro-structures but instead remains at the micro- (and meso-) level. It studies actors (individuals, social groups, organizational units), their values, beliefs and interests, their relations and (inter)actions, and the way in which these shape or are shaped by specific technologies. Case-studies and extended studies based on this approach contain rich descriptions of complex dynamics that lead to social and technological outcomes. However, the aim of many of these studies is not just to *describe* what happens, but also to *explain* why it happened. For example, in analyzing the history of the Penny Farthing bicycle, Pinch and Bijker (1987) do not just want to write a description of various bicycle models and various social groups involved in their manufacture and use; they want to understand the factors that determine what models are successful and the reasons why social groups assign certain meanings to a model.[26] I will argue that micro-level accounts cannot be sufficiently explanatory of technological and social change unless they are linked up with macro-level accounts.

The main reason for this is that a sufficiently rich account of actors and their relationships, beliefs and behaviors requires an analysis of the wider sociocultural and economic context in which these actors are operating. This broader analysis is required to explain why actors have certain attitudes, values, beliefs or relationships, and may even be necessary to infer their very existence. For example, an understanding of why certain types of men were are attracted to high-wheeled bicycles in late 19th century England, and perhaps also the identification of social groups with this attraction, is likely to require an account of masculine culture in late 19th century England. Failure to look at this cultural context would result in superficial and possibly also unreliable actor descriptions. More generally, to base explanations of technological and social change merely on observations of actors and their behaviors would be to subscribe to a form of *methodological individualism*, a questionable form of reductionism

which holds that social explanations are reducible to facts about individuals and hence that no reference to supra-individual social structures is required (Lukes, 1994).

Granted, the actors in technology studies also include more complex actors, such as social groups and organizations, and nonhuman actors like machines, but these are still particular actors to which agency is attributed, frequently along with beliefs and attitudes. If the actions, beliefs and attitudes of these actors are not related to wider sociocultural contexts, then explanation is likely to fall short. This is a recurring problem in most approaches in technology studies that emphasize an actor perspective, including social-shaping and social-constructivist approaches and the actor-network approach of Bruno Latour, Michel Callon, John Law and their associates. This latter approach does relate the properties of individual actors to a wider context, which is the network of actors in which they are operating, and holds that this network defines these properties. However, the networks are limited in scope, usually comprising only the actors thought to have a direct role in the development or functioning of a particular technology. Actor-network studies rarely provide sufficiently complete accounts of the networks that shape the behaviors or attitudes of the other actors in the network (e.g., engineers, corporations or politicians), who therefore tend to be analyzed in a methodological individualist way.[27]

There is also another reason why micro-level approaches have only limited explanatory power. As Paul Edwards points out (this volume), a major distinguishing feature of modern societies is their reliance on infrastructures, large sociotechnical systems like information and communications networks, energy infrastructures, and banking and finance institutions. As Edwards argues, these infrastructures mediate between the actors that are studied in micro-level analysis. In this sense they function as disembedding mechanisms (Giddens), defining social relations and guiding social interactions over large time and space distances (see also Brey, 1998). But these infrastructures themselves are best studied at the macro-level. Micro-level approaches that ignore infrastructures hence run the risk that they provide insufficient account of the relations between actors in modernity (whereas accounts of social relations in premodern societies can more easily remain at the micro-level because they are not usually mediated by infrastructures). The recent transition to a post-Fordist, global economy has imposed further limitations on micro-level analyses by fragmenting industrial production and marketing and reorganizing it at a global scale (Rosen, 1993).

Social constructivists, while acknowledging the need to consider the societal context in which actors operate, have sometimes objected to an appeal to social theory because of its 'realism,' which would be incompatible with (strong) social constructivism.[28] However, there is no inconsistency in invoking categories of social theory in social constructivist analyses. Social constructivist explanations proceed by 'deconstructing' entities in terms of the activity of other entities, specifically social groups. These entities are often not deconstructed themselves, for pragmatic reasons, because deconstruction has to stop somewhere. For instance, Bijker's (1992) social constructivist analysis of fluorescent lamps refers to the involvement of General Electric, as a 'real' entity. As Bijker (1993) later explained, his primary interest had been the social construction of fluorescent lamps, and not the social construction of General Electric. Because of this specific interest, it was excusable to present 'some parts of the sociotechnical world' as 'fixed' and as undeconstructed entities that function in the explanation of the development of fluorescent lamps, even though these entities are social constructions as well. But if reference can be made to General Electric in social explanation, then surely reference can be make to Fordism, disembedding mechanisms, and other 'socially constructed' entities of social theory.[29]

Another criticism of modernity theories, and a reason cited for avoiding them, is their alleged tendency to totalization, universalization, functionalism, rationalism, panopticism and determinism, not just in their treatment of technology, but in their treatment of society as a whole. This mirrors the criticism of postmodernists of macro-level metanarratives. Tom Misa has argued, for instance, that macro-level theories tend to "impute rationality on actors' behalfs or posit functionality for their actions, and to be order-driven," and that these tendencies quickly lead to "technological, economic or ecological determinism." Micro-level studies, instead, focus on "historical contingency and variety of experience" and are "disorder-respecting".[30] While the former tendencies are clearly visible in the majority of theories of modernity, I hold that they are not inherent to macro-theorizing. The macro-structures postulated in macro-theories inevitably impose constrains on individual action, but this does not mean that they must also determine it. Macro-structures can moreover be defined as contingent, heterogeneous, and context-dependent, such as Castells' 'networks'.

A final objection to macro-theories is that they are often speculative and not elaborated or tested empirically. While there are good exceptions (again, Castells), these virtuoso performances confirm the general rule. My point is not that this category of theorizing should be

rejected, but instead that these theories should be developed, tested, and refined. I conclude, tentatively, that there are no good reasons for scholars in technology studies to avoid macro-theories of modernity, and that there are good reasons to employ them. Working towards integrated studies of modernity and technology involves, then, developing and testing macro-theories and working to bridge the micro-macro gap that now often separates modernity theory from technology studies. These two tasks will be the topic of my next section.

5. Modernity, Technology and Micro-Macro Linkages

The problem of micro and macro

In large part, the problem of connecting the topics of modernity and technology, and of connecting modernity theory with technology studies, is the problem of connecting the macro with the micro. Modernity theory typically employs a macro-level of analysis, analyzing macro-level phenomena like "late modernity" and "globalization" in terms of other macro-level phenomena such as " time-space disembedding" and "the gradual decline in Western global hegemony". Much work in technology studies operates at the micro level, analyzing micro-level entities such as "fluorescent lighting" or "the advertising of a new daylight fluorescent lamp" by reference to other micro-level entities such as "the influence of Ward Harrison of the incandescent lamp department of General Electric" or "the writing of a report on daylight lighting by the Electrical Testing Committees". Additionally, one could claim that modernity theory typically employs a *structure-perspective*, focusing on social structures and their properties, whereas technology studies often employs an *actor-perspective*.

I will assume that there is a mutual need, in technology studies and modernity theory, to bridge the gap between the micro and the macro, and between a structure- and an actor-perspective. Yet, the problem of micro and the macro (not to mention the problem of structure and agency) remains still one of the great unsolved problems in social science. In spite of the attention this problem has generated, there is still no recipe, no method, and few inspiring exemplars on how to connect macro-level and micro-level analyses. In what follows, I will try to advance this general issue by looking more analytically at the problem. I will argue that progress on the micro-macro problem has been hampered by a failure to recognize the

multiplicity of levels of analysis ('micro' and 'macro' being coarse distinctions only) and a failure to distinguish two distinct dimensions within the micro-macro distinction: size and level of abstraction. I will then outline four principal ways in which levels of analysis may map onto each other, and will conclude by drawing implications for an integration of modernity theory with technology studies.

Size and level of abstraction

What makes a phenomenon studied in the social sciences or humanities a macro-phenomenon? And what makes a concept a micro-level concept? Considerable confusion exists over this matter. Sometimes, it is held that macro-analysis is distinct from micro-analysis because it focuses on *larger* things. Social systems are large, and individuals and their actions are small, and therefore social systems are the subject of macro-analysis and individuals the subject of micro-analysis. Another claim sometimes made about the micro-macro distinction is that macro-level phenomena and the concepts that refer to them are abstract and general, whereas micro-level phenomena tend to be concrete and specific.

Thus there are at least two parameters along which macro-analyses are distinguished from micro-analyses: the *size* of the units of analysis, and their *level of abstraction*.[31] Very few attempts exist in the literature to further define or operationalize these parameters, or to study their interrelationships. It is usually assumed that they tend to interrelate: that the units of macro-level analysis are typically, if not invariably, large, abstract, and general, whereas things in micro-level analysis tend to be small, concrete, and specific. Yet, there are many exceptions to this rule. For example, 'the modern self' is both smaller and more abstract than 'protest marches during the inauguration of George W. Bush'. The modern self is a smaller unit of analysis, because protest marches involve many 'modern selves'. Yet, it is more abstract because it refers to a general type of phenomenon, whereas the protest marches denote a specific type of phenomenon. Other units of analysis do not seem to have a definite size at all. For example, 'reflexivity' is a property that can apply both to large things (e.g., social systems) and small things (e.g. knowledge processes of organizational units).

To understand the connections between the micro and the macro, we must therefore first better understand the parameters by which these notions are defined, being the notions of level of abstraction and size. I will now discuss these in order.

Level of abstraction

What does it mean to say that a phenomenon is more abstract than another? Principally, I want to argue, this means that the phenomenon is more *general*. For example, 'rationalization' is a more general process than 'the standardization of testing in aviation schools' (a form of rationalization), and that is why it is more abstract. Starting from an abstract phenomenon, one can arrive at more concrete phenomena by introducing additional properties that bound it. Conversely, when one starts with a concrete phenomenon one can arrive at a more abstract one by abstracting properties from it. For example, starting with the abstract phenomenon of "industrial society" one can arrive at the more specific and therefore more concrete phenomenon of "late nineteenth century British industrial society" by adding additional properties that specify time period and nationhood. Likewise, starting from the notion of a parent, one can arrive at the somewhat more concrete notion of a mother (a female parent) by adding a gender property ('female'). Conversely, one can go abstract from "late nineteenth century British industrial society" to "industrial society" and from "mother" to "parent" by subtracting properties, that is, by generalising.

In this way, it is possible to construct hierarchies of entities that range from abstract to concrete, with the more concrete entities being species (subtypes or instances) of the more abstract entities. For example, one can construct a hierarchy going from transportation vehicle to bicycle to Penny Farthing bicycle to the Bayliss-Thomson Ordinary Penny Farthing bicycle to the specific Bayliss-Thomson Ordinary Penny Farthing bicycle of which I have a picture. Notice, however, that concretization is not just a matter of adding adjectives (and abstraction a matter of substracting them). The relation between more abstract and more concrete phenomena is not always linguistically transparent, and conceptual analysis, if not empirical investigation, may be needed to observe the relation (e.g., that a mother is a type of parent, or that a standard-setting body in health care is a type of bureaucratic organization).

Size

Units of analysis can often be ordered according to their size. For example, a social system is obviously larger than a social group in that system, and a social group is larger than an individual in that group. The reference to size here does not imply a reference to absolute metric or

numerical properties. Rather, size is here used in a *relative* or *comparative* sense. A phenomenon *a* is larger than a phenomenon *b* if a can *contain b*, or *b* is a *part* of *a*. For example, there are part-whole relations between the economy and individuals participating in it, because analysis of economic processes ultimately reveal individuals engaged in economic behavior. This is why economic systems are larger than individuals. Large units of analysis are hence larger than small units of analysis because they are able to stand in a *part-whole* relation or a relation of (partial) *containment* to these smaller units.[32] Because parts may have parts themselves, hierarchies can be constructed of units of analysis that range from large to small. For example, a social system may include a market system that includes organizations that include organizational units that include divisions that include employees. Likewise, the British railway system includes train stations that include platforms and station staff. Also, items may be parts of multiple wholes. For example, pay-per-view virtual musea may be part of the post-Fordist economy, but also part of postmodern culture. Notice that part-whole relations between units of analysis, which refer to their size, are clearly different from the types of genus-species relations discussed earlier, which refer to level of abstraction. For instance, Internet advertising is a *species* of advertising but a *part* of the post-Fordist economy.

Levels of analysis and their interrelationships

What the distinction between size and level of abstraction shows is that the micro-macro distinction encompasses at least two distinct hierarchies: a hiearchy from abstract to concrete and one from large to small. Things can be simultaneously small and abstract ("the modern self") or large and concrete ("the locations of capital cities across the globe in the year 2001"). In practice, however, there are correlations between these two hierarchies. What should also be clear from the discussion of these two hierarchies is that the distinction between two levels of analysis (macro and micro) or even three levels (macro, meso and micro) is a gross oversimplification. Going from abstract to concrete or from large to small, many levels may be encountered in between. So what is commonly called the 'macro-level' in fact relates to multiple levels of analysis that may range from very large or abstact phenomena like "modernity," "Western culture" and "industrial society" to significantly smaller or more concrete entities like "the Internet economy," "gender in late 19th century France" and "the Kansai region in Japan". Similarly, micro-level phenomena may range from larger and more abstract entities like

"advertising agencies," "hackers" and "local area networks" to smaller or more concrete entitis like "Bill Gates," "Mary's filing of a petition" and "the software error in Fred's computer".

The terminology of 'micro' and 'macro' is therefore too coarse, because it does not distinguish between size and level of abstraction, and it does not discriminate the different levels and hierarchies that exist within macro- and micro-level analysis. The consequence of this is that it becomes difficult to see how various kinds of micro- and macro-level analysis may be integrated with each other. Yet, arriving at an adequate integration of levels of analysis is the major problem faced by theories of modernity and technology. How do you get from a discussion of late modernity, rationalization and the state to a consideration of the development and use of specific technologies? And conversely, how do you get from talk about Pentium computers, hacker culture and virtual communities to talk about globalization, the modern self and post-Fordist economies? Any adequate study of modernity and technology requires such a bridging of the micro and the macro, of the abstract and general and the concrete and empirical, of the large and diffuse and the small and singular.

The major question, then, for theories of modernity and technology is how the gaps that exist between different levels of analysis can be breached. My distinction between size and level of abstraction indicates that gaps between levels occur in two ways: because the higher level refers to more abstract phenomena than the lower level (e.g., bureaucratic organizations vs. standard-setting bodies in health care), or because it refers to larger phenomena (e.g., social systems vs. markets). But my discussion also suggests on how these gaps may be breached: by identifying genus-species relationships (for phenomena at different levels of abstraction) and part-whole relationships (for phenomena of different sizes). For instance, an analysis of standard-setting bodies in health care may be linked to an analysis of bureaucratic organizations by identifying standard-setting bodies as species or instances of bureaucratic organizations. Similarly, an analysis of markets may be linked to an analysis of social systems by identifying markets as subunits within social systems. Such 'matches' provide the conceptual links that are necessary to connect discourses that would otherwise remain disconnected.

However, in most studies in the social sciences and humanities that involve the linking of levels of analysis, the aim of such linking is not merely to connect disparate discourses. Most studies have a more specific aim, for instance to explain events at the micro-level, or to analyze the structure of macro-level phenomena. Most studies center on a specific analysandum, a

macro- or micro-level phenomenon that the study aims to analyze (e.g., "late industrial society," or "changes in the design of the bicycle in the late twentieth century"). Links to created to levels of analyses that are either higher or lower than that of the analysandum are hence asymmetrical: the higher- or lower level entities are invoked to explain or analyze the analysandum.

Four Types of Interlevel Analysis

When something is analyzed in terms of phenomena at another level, these phenomena may be from a lower or a higher level, and may differ in their level of abstraction and in their size. This implies that there are four ways in which analysis may bridge levels. I will name these *decomposition* (the analysis of a larger unit in terms of smaller units), *subsumption* (the analysis of a smaller unit by reference to larger units), *deduction* (the analysis of a more concrete unit by analyzing it as a subclass of a more general phenomenon) and *specification* (concretization; analyzing a more abstract unit by analyzing one or more of its more concrete forms). I will now discuss these in order.

- In *decompositional analysis* (or reductive analysis) a large phenomenon is analyzed in terms of (much) smaller phenomena. For example, the behavior of markets (at the macrolevel) is analyzed as the product of the behavior of individuals (at the microlevel).

- *Subsumptive analysis* is the opposite of decompositional analysis. With it, one tries to account for smaller phenomena by (partially) subsuming then under a larger (structural, functional or causal) pattern of which they are a part. For example, given the macro-event of a transition from Fordism to post-Fordism, in which the bicycle firm Raleigh (a micro-entity) is one of the players, there is a modest expectation that Raleigh will invest in product differentiation, since firms engaging in product differentiation is part of the transition to post-Fordism (cf. Rosen, 1993).

- In *deductive analysis*, a phenomenon is identified as a species or token of a more general phenomenon, and knowledge about this more general phenomenon is subsequently applied to the more specific phenomenon. That is, one deduces features from the general to the specific. E.g., a regulative agency in health care is identified as a

bureaucratic organization, and one's theory of bureaucratic organizations is subsequently applied to it.

- In *specificatory analysis*, finally, a phenomenon is studied by identifying and studying one or more subtypes or tokens of it. Case-analysis, when used to elaborate a more abstract analysis, is one type of specificatory analysis, one that makes reference to tokens. An example of specificatory analysis is Castells' analysis of East Asian business networks (a meso-unit). Castells analyzes them by distinguishing various kinds (at meso- and micro-levels of analysis) and studying their similarities and differences.[33]

Implications for Studies of Technology and Modernity

The above perspective on levels of analysis can be used to show both how modernity theory can incorporate lower-level analyses in technology studies, and how technology studies can make better use of higher-level analyses in modernity theory. To begin with the former, macro-level modernity theory can benefit from micro-level work in technology studies by using such work to *elaborate* its macro-level descriptions in a way that makes the overall account more concrete and empirical. Such elaboration can proceed through a process of decomposition and specification in which macro-units are decomposed into smaller parts and concretized through the identification of species or subtypes. For example, in an elaboration of the notion of the bureaucratic organization, decomposition would specify the components of bureaucratic organizations, and specification would aim to distinguish various sorts of bureaucratic organizations. Both types of analysis may be repeated to arrive at levels of analysis that refer to ever smaller and more concrete phenomena. Such elaboration makes macro-theories both more easily testable and more capable of informing micro-level analyses. Such elaboration ultimately makes it easy to link up with the lower-level analysis of technology studies.

The incorporation of modernity theory into studies of technology can be similarly clarified. Here, the required types of analysis are subsumption and deduction. To illustrate, Paul Rosen has attempted to use David Harvey's theory of the shift from a Fordist mode of production to flexible accumulation in the late 1960s and early 1970s in an explanation of the constant shifts in the design of mountain bikes. Connecting this latter fact to Harvey's theory requires deduction (e.g., identifying it as a species of product differentiation, a process mentioned in

Harvey's theory, and) and subsumption (e.g., identifying accompanying advertisements as part of the dialectic of fashion and function in post-Fordist economies). To make an adequate connection, Rosen has to do a good deal of level-building, analyzing the cycle industry and advertising at various levels. This does not only involve bottom-up construction (building up levels from his micro-level analyses of mountain bike design, firms and advertisements) but also top-down construction (elaborating Harvey's theory). This makes it possible for him to have the two analyses meet halfway in between.

I conclude that integrated analyses of technology and modernity, that build on macro-theories of modernity and micro-theories of technology, are possible, though requiring hard work. Analysts have to engage in level-building, often engaging in both decomposition, subsumption, deduction and specification. This, I believe, is the responsibility of both modernity theorists and scholars in technology studies. It is a joint project, that can begin to blur the boundaries between two now all-too-separate fields.

FOOTNOTES

[1] For some recent attempts in technology studies to appropriate (and update) existing theories of modernity, see Feenberg (1995; 1999a), Rosen (1993), and Slevin (2000). For attempts at a theory of modernity from within technology studies, see Latour (1993) and Law (1994).

[2] Harvey (1989), chapter 8.

[3] For further discussion of the notions of "modernity," "modernism" and "modernization" see Featherstone, 1991; Turner, 1990; and Harvey, 1989.

[4] What is, and is not, a defining aspect of modernity is, of course, a matter of debate. Thus, whereas some would consider gender to be just a social form "within" modernity, others have argued that it a major constitutive force, and that our very conceptions of "the modern" are the result of a deeply gendered ontology (e.g., Felski, 1995; Marshall, this volume).

[5] For an account of Marx's theory of modernity, see Antonio (2001). For Weber, see Scaff (1989) and Turner (1993). Sayer (1991) and Giddens (1973) treat Marx's and Weber's accounts jointly.

[6] See, e.g., Marcuse (1964) and Horkheimer and Adorno (1972).

[7] Cf. Lyotard and Thébaud, 1985, p. 9: "Postmodern is not to be taken in a periodizing sense." At other times, Lyotard seems to endorse an epochal conception of postmodernity in which postmodernity is the cultural condition that has result from the information technology revolution. Cf. Lyotard, 1984, p. 3.

[8] For reviews of postmodern theory, see Best and Kellner (1991) and Smart (2000).

[9] For surveys of STS as an academic field, see Jasanoff et al. (1995), Cutcliffe and Mitcham (2001) and Cutliffe (2000).

[10] See MacKenzie and Wajcman (1999) for a representative anthology of social studies of technology, and see its introduction for a survey. See Fox (1999) for a review of themes and approaches in the history of technology.

[11] See Staudenmaier (1985) for a review of the contextual approach and its history.

[12] See the respective reviews by Dosi et al. (1988) and Mitcham (1994). Achterhuis (2001) surveys contemporary American philosophy of technology.

[13] Staudenmaier (1985), p. 17.

[14] See Kuhn (1962). Bloor (1976) is a seminal work in SSK. Other important works include Latour & Woolgar (1979) and Latour (1987).

[15] See Woolgar (1998) and Bijker (1993) for accounts of the turn to technology in social studies of science. The early classic that marked the beginning of contemporary social studies of technology is still Bijker and Pinch (1984).

[16] Bijker (1995) provides a review.

[17] Staudenmaier (1985) has surveyed this for the history of technology (p. 201). My own review of issues from the year 2000 of the journals *Social Studies of Science* and *Science, Technology and Human Values* confirms that the same is true for social studies of technology.

[18] Staudenmaier (1985), p. 206.

[19] For one of the original statements of this position, see MacKenzie and Wajcman (1985).

[20] Pinch and Bijker (1987) is a classical statement of social constructivism in technology studies, specifically of the influential social construction of technology (SCOT) approach. For a recent review of social constructivist approaches, see Pinch (1999).

[21] Based on a search on title words at Amazon.com, January 2001.

[22] See Turner (1990), Bauman (1992) and Touraine (1995).

[23]Giddens, 1990, p. 27.

[24] Feenberg, 1999, pp. viii-xv.

[25] See Smith and Marx (1994) for a historical and Winner (1977) for a philosophical critique of technological determinism.

[26] Pinch and Bijker (1987), p. 24.

[27] For critiques of the lack of attention of (constructivist) technology studies to sociocultural contexts, see Rosen (1993) and Winner (1993).

[28] See, e.g., Pickering (1995) and Elam (1994).

[29] Along the same lines, the rejection by actor network theory of social theory because it maintains artificial distinctions between ‘society,’ ‘nature’ and ‘technology’ is also overstated, because these distinctions are not evident in many concepts in social theory. Notions like ‘disembedding mechanisms’ (Giddens), ‘rationalization’ (Weber) and ‘the Net’ (Castells) are all defined as sociotechnical phenomena.

[30] Misa 1994, 119.

[31] Time scale is an often mentioned third parameter: it is often claimed that macro-analysis typically analyzes processes stretching over years or even centuries, whereas micro-analysis covers shorter timespans, ranging from minutes to months.

[32] My claim that large units of analysis may have smaller units of analysis as parts does not imply the *reductionist* claim that larger units of analysis are wholly composed of smaller units of analysis and therefore can be analyzed without remainder in terms of these smaller units and their to one another. I am skeptical about this.

[33] Castells, 1996, p. 174-9.

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