Like democracy, development is an essentially contested concept, with too much tied up in its meaning to allow it ever to settle into one form. The word invokes process and direction, and invites the question: development toward what? For a peasant in India, development may mean steady food, the assurance of staying on the land, and fewer children dying young. For a World Bank official, the peasant’s dream would appear in statistics on poverty alleviation and reduction in child mortality. To an industrialist, development may mean business survival and personal wealth; to an economist, growth in gross domestic product; and to a politician, jobs, popularity, and power.

Amartya Sen (2000) defines development as freedom. Freedom is central to the process of development, he argues, both because “achievement of development is thoroughly dependent on the free agency of people” (freedom as means) and because it provides a yardstick for measuring progress (freedom as end). Development as freedom means human beings gaining the capability to achieve their own goals in their own contexts.

The substantive freedoms include elementary capabilities like being able to avoid such deprivations as starvation, undernourishment, escapable morbidity, and premature mortality, as well as the freedoms that are associated with being literate and numerate, enjoying political participation and uncensored speech, and so on (Sen, 2000: 3).

For freedom in this sense, the fundamental difference between the global North\(^1\) and the global South is that many more people in the South are poor. Nearly a third of the population of developing countries lives in absolute poverty on less than $1 per day (Chen & Ravallion, 2004). Life spans in the poorest nations are half those in affluent ones, and developing countries bear the main burden of such major diseases as AIDS, tuberculosis, and malaria (Task Force on HIV/AIDS, 2004). Environmental conditions contribute to poor health, for example, through lack of clean water and adequate sanitation, and poverty contributes to environmental degradation as the rural poor strain natural resources such as forests and land in an attempt to eke out a living (Vosti & Reardon, 1997). Part of the literature on science, technology, and development focuses on ways research and innovation can contribute to the solutions
to these problems of everyday life, an approach we can call the human development project.

Another part of the development discussion focuses on providing the resources to address the human development challenge through economic growth. National mastery of new technologies, and in particular information technology, is often seen as the key. In this view, the flow of information on a global basis is the lifeblood of the new economy. The worst economic fate is not to be at the periphery of the global network, but to be irrelevant to it, in what Castells (1996) calls the “black holes of the Information Economy.” The knowledge industries—in those emerging areas that hold a temporary monopoly position by being at the cutting edge—are portrayed as the main sources of wealth today and in the future. In this view, whole geographic regions (e.g., Europe versus North America) vie to win the competition in the churn and change of the contemporary industrial scene. Indeed, contemporary theories of economic growth place technological innovation right in the heart of the growth process. The strong role of technology in maintaining markets for national industries, both domestically and internationally, is thus often seen as a second main challenge in using science and technology for development, the competitiveness project.

Immersed in the second project, many observers find it easy to lose sight of the first; yet making lives better is the essence of development as freedom. Whether poor, comfortable, or wealthy, most citizens of the global South do not think about “science” or “technology” in the abstract, although they use or buy electricity, water, medicine, televisions, and mobile phones that are part of what STS would call sociotechnical systems. Living technology rather than analyzing it, most people in the South ask primarily how it helps them, their families, their regions, and their countries.

What do the published literatures on science and technology for development have to offer to actors in the global South who are seeking to use science or technology to achieve development as freedom? This chapter does not present a comprehensive view—the literature is too vast for that, even when we focus our attention on what has been published since the last edition of this Handbook (Shrum & Shenhav, 1994). But we at least try to raise research questions grounded in the concepts alive today at the intersection of science and technology studies, economic growth theory, and innovation systems research.

The first section of the chapter introduces these three perspectives. The second section applies them to interpret examples of practical development problems: education, innovation policies, and learning firms. The final section outlines some key questions for an actor-centered, knowledge–pluralistic research agenda on science and technology in the development process.

THREE PERSPECTIVES

Science and Technology Studies

Over the decade since the last edition of this Handbook, the social sciences have been flooded with analysis of processes of change in the world system, often under the
rubric of globalization (Worthington, 1993). Globalization has many meanings, but the predominant approach defines it as the distribution of productive processes across countries on a global scale, a process that is transforming livelihoods in some developing countries while leaving others untouched. Comparisons abound between the current wave of globalization and earlier ones, including the epic migrations of the turn of the century. In this wave, it is capital, not labor, which is moving. For the first time in world history, there is mutual trade in manufactured goods between the core and the up and coming semiperiphery (Ghose, 2003).

Two changes identified as technological are often portrayed as the drivers of the current dynamic: the falling cost of transportation and the rising capability of computer-mediated communication (Ghose, 2003). Some observers attribute fundamental importance to the spread of communication networks (Castells, 1996). Sociologists have examined patterns of urbanization in this newly connected world (Sassen, 2002), and political scientists, while not abandoning the study of change in national governance patterns, have begun to analyze such emerging institutions of global governance as the World Trade Organization and the new set of rules it is negotiating in the global knowledge economy.

The STS literature includes stories that take place in the global South but does not try to add them up into an account of changing macro structures in the world economy or a coherent theory of development. Instead, the stories highlight particular actors and the forms of knowledge they bring into particular interactions, shedding light on the dynamics that create new patterns. The STS literature is not monolithic in approach: methods range from standard survey research (Campion & Shrum, 2004) to network studies (Shrum, 2000) to discourse analysis (Hecht, 2002), but the dominant approach is narrative. Yet there are some themes that appear across the various writings that may constitute an STS approach to the topic.

Most often, the actors portrayed in the STS stories belong to the global scientific community. So, for example, we find studies of women scientists (Campion & Shrum, 2004; Gupta & Sharma, 2002) and universities (Sutz, 2003) in the South. Sometimes the stories confirm conventional trajectories. For example, Velho and Pessoa (1998) describe Brazil’s ambitions in international research, leading to the decision to invest in a synchrotron light source. Lomnitz and Cházaro (1999) lament the lack of understanding of the roles of computer scientists in the basic research-oriented reward system of Mexican universities. Others describe new configurations, like Shrum’s account (2000) of nongovernmental agricultural research organizations.

The relationships between scholars in the North and South receive attention in the STS literature, for example, in Solovey’s work (2001) on Project Camelot. Some articles reflexively consider the knowledge status of scholars from the North in their observer roles in the South, or as Shrum (2005) puts it, “reagent” roles (see also Verran, 2001). Similarly, in their “love” for the Zimbabwean bush pump, de Laet and Mol (2000) explore “new ways of ‘doing’ normativity.”

The juxtaposition and conflict between different forms of knowledge is the most common theme in STS stories set in the global South. For example, Lei (1999) describes
the exclusion of Chinese traditional medicine from emerging networks of "Western-style" doctors in China in the 1920s and 1930s. Postcolonial science carries the echoes of previous power relationships into the present (e.g., Adams, 2002; see also Dubow, 2000). Traditional and local are not always overcome by "modern" and Northern, however. In Verran's (2002) account, environmental scientists eventually come to respect aboriginal regimes of burning in the Australian bush. And farmers, engineers, and social activists jointly design the Baliraja Memorial Dam in India (Phadke, 2002).

Given these themes, the STS literature implicitly portrays globalization as a process of knowledge confrontations. “Professional” or “scientific” knowledge carries the privilege of the North into the definitions that shape life in the South. It tangles with other ways of framing and addressing issues, particularly those rooted in the knowledge of poor or indigenous people. By treating the various forms of knowledge symmetrically, the STS approach draws attention to the asymmetries in power that privilege one form of knowledge over another. STS stories include a broad set of actors, especially highlighting civil society and marginalized groups, and features their categories and knowledge. The STS literature thus highlights certain questions with regard to development projects: Whose project is it? What knowledge do the various actors bring to the interaction? Whose knowledge gets respect and deference? What are the outcomes of the project for the everyday lives of the people involved?

In the background of the STS stories are the practical problems of development as freedom, for example, AIDS (Karnik, 2001), rural energy (Gorman & Mehalik, 2002), fertility (Oudshoorn, 1997), and Chagas disease (Coutinho, 1999). The STS contribution to development is the freedom to envision both problems and solutions in local ways, without the imposition of the categories used in the sciences or technologies of the North.

**New Growth Theory**

Economics provides another strand of thinking about science and technology in the global South. Unlike STS, where Southern stories are not set apart, economics has a subfield for “development” and a branch of theory, growth theory, that gives a particular account of the process. In that account, nations are the central actors, with governments (usually called “the State”) playing the central role. Like STS scholars, the economists themselves also play roles, since they provide analysis and advice to both national governments and the international banks, but they pay less attention to their own roles and seldom subject them to scrutiny in their work, except in autobiographical mode [e.g., Stiglitz’s *Globalization and Its Discontents* (2002) on his experiences at the World Bank and Sachs’s *End of Poverty* (2005)].

Growth theory traces its roots back to Adam Smith and his analysis of the role of division of labor in expanding economic activity, and to Karl Marx, who saw capitalists and production technology (“the means of production”) as the driving forces of change in the economy. Classical growth theory attributes economic expansion to the accumulation of land, labor, and capital. Examining this claim in light of emerging data, scholars in the 1950s noted that the combination of these three did not explain
all the variance in growth, and Solow added the hypothesis that the rest of the variation (the “residual”) was due to technological change. Neoclassical growth theory, as this hypothesis came to be called, did not delve into the sources of technological change, but rather treated its result as a public good that was available to all nations and businesses alike (Solow 1956, 1957). Technology was “exogenous” in this theory. The creative capitalist had disappeared, replaced by a faceless process of technological change. Neoclassical growth theory was compatible with traditional modernization theories; countries that were “behind” could “catch up,” since technology acquisition costs much less than technology development.

The most influential family of contemporary growth theories changes this picture by treating technology as endogenous, that is, as the result of deliberate economic choice, on the part of either private firms or the State (Romer, 1990). Those who invest in developing new technology earn economic rewards, because they hold a temporary monopoly over the means of doing something new and more productive. Economic growth results from the increasing returns associated with new knowledge. As a result, while returns diminish in the physical economy, they increase in the newly named knowledge economy (Cortright, 2001).

This new growth theory observes that knowledge-based economies tend toward monopolistic competition (Cortright, 2001). Because knowledge has increasing returns (continuously declining marginal costs), leading firms tend to build up insurmountable advantages and new entrants face the difficult prospect of starting out with much higher costs than their established competitors. History matters: once a technology is locked in, it is harder for competitors to replace it. Institutions matter: dynamic organization adjustment to changing circumstances is required for continuing progress. Place matters: local institutions and cultures shape knowledge flows, and tacit knowledge is important.

All these factors suggest that once a country or region has a significant knowledge advantage, it will be difficult for another country or region to catch up. A country that has almost no technical base now might easily conclude that it will never get into the game. New growth theory’s primary recommendation for such a country is to increase human capital, that is, increase its total knowledge and creativity through education. Another endogenous approach to growth, evolutionary economics (Nelson & Winter 1982), calls attention to still other opportunities inherent in the knowledge economy. The creative destruction of the market, that is, the continual appearance of new industries that supersede previous ones, opens up possibilities for countries to concentrate their resources in specific areas and leapfrog over competitors in old industries, finding places for themselves in new ones (Schumpeter, 1942). Technological change is at the root of this process, and it is thus worthwhile for countries to invest in the capabilities necessary to ride the next wave when it comes. Some of the most prominent examples of technology-based growth success have followed this path, including the Asian “tigers” such as Korea, Taiwan, and Singapore.

The actors in these accounts of science and technology in development are quite distinct from those in the STS literature on the same topic. Private firms ultimately
produce the growth, but the theorists provide advice primarily to governments, urging them to create the conditions for firms to act. Knowledge is again an object of conflict, but this time it is the new knowledge embodied in innovations that forms the basis of competition, with various institutions contending over the ground rules for ownership and profits. Development is not freedom in Sen’s sense for these theorists. Industrial growth can coexist with persistent poverty in the absence of redistributational mechanisms for the wealth generated. New growth theory concerns itself with the accumulation of wealth in a country or region; use of that wealth for human development is someone else’s project.

Innovation Systems

A third line of recent research on science, technology, and development draws on the concepts of evolutionary economics and traces them concretely into networks of actors and the relations among them in developing countries. This is the burgeoning work on innovation systems, which has three main types: national, regional (subnational), and sectoral (product-specific). The concepts were introduced and developed by Freeman (1982), Nelson (1993), and Lundvall (1992) and have been developed by Edquist (1997) at the national level, by Braczyk et al. (2003) at the regional level, and by Malerba (2004) at the sectoral level. Several recent volumes explore applications specifically in the context of developing countries (Cassiolato et al., 2003; Muchie et al., 2004; Baskaran & Muchie, 2006).

An innovation system consists of elements and their relationships (Edquist, 1997); it is a network of actors, like the ones found in actor-network theory in STS (Callon, 1999; Latour, 1987). The three usual categories of actors discussed are firms, government, and research institutions, including public sector laboratories and universities. The concept has no problem accommodating new forms of actors, for example, the nongovernmental research organizations Shrum (2000) describes, or hybrid forms such as university-associated research parks. Likewise, in principle, civil society organizations could be included, but in practice they seldom appear in the stories innovation systems researchers tell (their “case studies”). Nonetheless, firms are at the center of the networks, and a healthy innovation system is one in which firms are in the lead. Many forms of relationships appear in the stories, from competition through exchange and collaboration. The network can have multiple levels or subnetworks. For example, it can incorporate governmental actors at regional, national, and supranational levels (e.g., the European Union). Sectors could form subareas of a regional network.

As in the previous two perspectives, knowledge plays a central role in the concept of the innovation system. The life process of an innovation system is learning, which involves accessing, accumulating, and applying knowledge (single-loop learning), reacting to changes in the environment (double-loop learning), and using internally generated knowledge to transform the environment (triple-loop learning) (OECD, 2002). The value of the network in the system is that it increases learning through interaction and sharing. Everyone is supposed to learn in an innovation system: indi-
viduals, firms, other institutions, and the system itself. In principle, the sources of knowledge can be as heterogeneous as the actors involved in the network, although again in practice, organizational, business, and technical knowledge are privileged in innovation system accounts.

What is the project of an innovation system? Implicitly, the goal is growth. This focus is clear in the central role given to firms. While the centrality of learning might seem to create an affinity with the development-as-freedom approach, and although the founders claim to be analyzing societal learning processes (Johnson & Lundvall, 2003), the innovation systems literature devotes little concrete attention to whether learning extends beyond the network of firms, government agencies, and laboratories. Innovation systems could easily be elite in composition; the concept does not require otherwise. Likewise, the concept is neutral on whether the systems are oriented toward socially constructive or destructive technologies (e.g., vaccines or weapons systems). The literature on regional innovation systems has a geographically redistributive slant, exploring the ways that less wealthy regions could become wealthier. Likewise, the application of the concept to countries in the global South also supports an economic catch-up agenda (Johnson & Lundvall, 2003). But very few scholars of innovation systems have emphasized the importance of innovation for social productivity or poverty alleviation (for exceptions, see Arocena & Senkar, 2003; Arocena & Sutz, 2001, 2003; Sutz, 2003).

Summary
Each of these three literatures, then, peers into life in the South through a different lens, with some version of knowledge playing a key role in each. New growth theory focuses on the role of the State in assuring the conditions for economic growth through monopoly over new commercially important knowledge (we call this angle knowledge as growth). The innovation systems approach focuses on firms and their learning processes, asking how these can be enhanced by incentives and interactions with other institutions (knowledge as learning). The STS literature follows the science and technology institutions of the North as they encounter and engage knowledge produced in other contexts in the South, with a focus on the empowerment of civil society organizations and marginalized groups (knowledge as confrontation). None of the perspectives explicitly takes development-as-freedom as its goal nor explores concretely how the approach would contribute to meeting the basic needs of the world’s population.

APPLICATIONS
The various development paradigms that have appeared in succession over the past half-century (Gore, 2000) have shared an assumption of strategy and action: some set of actors in the context of a poor country should take a specified set of steps toward “development.” The paradigms direct various policy prescriptions to this assumed, but often unnamed, set of actors. But the three perspectives we have outlined above
identify a multi-actor space, one in which the interests of civil society, the State, and private firms may not coincide, and surely do not necessarily add up to development as freedom. This section examines three common development tasks assigned by the current paradigm to these various actors and analyzes the prospects for the contribution of each to development as freedom.

**Education as Freedom**

Standing at the civil society corner of figure 31.1, we examine the process of education. The importance of education, in particular, science and technology education, as a means of augmenting productivity, increasing innovation, and solving social problems is a recurrent theme in the literature on education and on development (Lewin, 2000a,b; UNESCO, 2004; Watson et al., 2003). The economic success of Japan and more recently the East Asian tigers are cited as examples in which the emphasis on education has paid great dividends in the countries’ development efforts (Mingat, 1998). Scientific and technological education in developing countries faces constraints, such as insufficient teachers, inadequate skills, lack of equipment (Sane, 1999) and inadequate access due to poverty and poor student interest in study and careers in science or engineering (UNESCO, 2004). Education policy, observers point out, needs to take other factors into account, such as macroeconomic and trade policies, institutions (legal and political systems), factor endowments, and sociocultural environment (Banerjee, 1998; Hunter & Brown, 2000).

Education is central to the concept of development as freedom. The application of the concept goes well beyond programs that address basic needs, such as training in cleaner production (Huhtala et al., 2003) and strengthening the research capability in reproductive health problems (Benagiano & Diczfalusy, 1995). The world’s citizens

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**Figure 31.1**
The development triangle.
need education to achieve both stable livelihoods and political voice; education is thus seen as a significant contributor to increasing democracy, social justice, and individual empowerment (Kyle, 1999; Zahur et al., 2002). Since literacy is fundamental to achieving these goals, the policy directions of international agencies have often suggested that developing countries should increase the share of their public expenditure on primary education (Curtin & Nelson, 1999).

New growth theory, in contrast, puts more emphasis on higher education and technical skills to feed the innovation process. Viewed from the angle of State action, resources allocated to education become “investments in human capital” rather than Sen’s means and ends of freedom. Economists struggle with the difficulties in identifying the true social returns across primary, secondary, and tertiary levels of education (Birdsall, 1996; Heyneman, 2003; Vlaardingerbroek, 1998), and views on the efficacy and relevance of recommended programs are mixed (Curtin & Nelson, 1999; Heyneman, 2003). Nonetheless, investments in higher education appear to economists to be at least as crucial as those at the primary level, setting up difficult trade-offs for policy makers.

The “human capital” terminology suggests that government policies should not only address the direct provision of education and training but should also facilitate and encourage the private sector to play active roles, as several model economies in Asia have done. The educational strategies of the Asian tigers provide valuable insights for other developing countries, but the contextual underpinnings have to be taken into consideration (Kuruvilla et al., 2002). The role of government cannot be static, as illustrated by the changing role of the Korean government with respect to R&D and training (Hee & Soo, 1997).

Like the STS approach, the literature on science education acknowledges the confrontation between forms of knowledge shaped in the North and those shaped in the South. The literature often describes developing countries as facing “challenges” resulting from the conceptualization of science from a Western European perspective, which imposes changes in the worldview, culture, and behavior of students including cognitive learning and the use of language (Gray, 1999; Jegede, 1997; Lewin, 2000b). Some authors note that developing countries need to adapt Northern learning to make science education relevant to local culture and context (Bajracharya & Brouwer, 1997; Brown-Acquaye, 2001; Gray, 1999). Others point out that formal and informal science education both contribute to the popularization of science and to building a “scientific culture,” and urge public/private partnerships in the establishment of science centers are though to play an important role (Tan & Subramaniam, 2003). A symmetrical approach to knowledge would take each of these activities as a site for neutral epistemological research, but such studies are rare while the rush to adopt Northern approaches is common.

STS researchers following “big science” into the global South would find it being put to use in attracting young people to technical careers. The regional Centres for Space Science and Technology Education in Africa (Abiodun, 1993; Balogun, 2002) are described as contributing to human capital and the process of development.
Supporters anticipate that the regions will not only reap direct benefits of education in space science and technology but will also derive benefits from research associated with curriculum development, pedagogy, and delivery methods in space education (Andreescu et al., 1997; Hsiao et al., 1997; Kasturirangan, 1997; Lang, 2004). “Whose projects are such centers?” STS analysts would be likely to ask. The same question could be asked of institutions such as the Third World Academy of Science (TWAS) and of efforts to establish national academies of science (Guinnessy, 2003). These activities promote the exchange of information through networks of cooperation and scientific excellence while at the same time extending the power and prestige of Northern science into Southern institutions.

A broader concept of societal learning, more akin to the innovation systems approach, is implied in the literature on training strategies that encompass building skills for design and development (Alic, 1995), management and technical know-how related to the technology acquisition (Alp et al., 1997), as well as technical skills for using advanced equipment and machinery. Economists point out that threshold levels of absorptive capacity are needed to maximize the benefits of technological investments and capital flows (Borensztein et al., 1998; Eicher, 1999; Keller, 1996), which impact skills building and knowledge flows (Lall, 2002; Reddy, 1997). In studies of education in Malaysia and Korea, Snodgrass notes that while education may be seen as a necessary condition for economic growth, it is not a sufficient condition. For education to boost growth, the demand for educated or skilled labor must also increase (Snodgrass, 1998). In addition to building lower level skills for increasing productivity and efficiency, higher level skills in management, political leadership, and bureaucracy are required (Rodrigo, 2001). In this view, skills are built not only in the formal education system but also through on-the-job experience, or learning by doing; however, higher level skills are more difficult to acquire in this way (Rodrigo, 2001).

In summary, education is valued from all three corners of the triangle, but it does not necessarily bring freedom at the core. If education is a top-down process of infusing Northern science and its concepts into more and more people in the South, its contributions to freedom are important but limited. If education is undertaken as part of a societal learning process, however, weaving together new and old insights into a locally defined and controlled process of change, both innovation and freedom could be strengthened.

**Innovation Policies**

For developing countries, the creative destruction of a global, knowledge-based economy has created an unstable and uncontrollable environment (Hipkin, 2004). New growth theory stresses that technological innovation may be the only way to survive and prosper in today’s world (Sikka, 1997). Toward this end, commonly recommended State actions include investing in research and development (R&D), creating the conditions for foreign direct investment, and strengthening intellectual property policies. All these steps are problematic, however, from the viewpoints of civil society, learning firms, and development as freedom.
Investment in National R&D  As with the tradeoff between primary and tertiary education, public investments in R&D are the site of conflict between the human development and competitiveness projects. The resources available are modest: at the aggregate level, R&D expenditure as a percentage of gross national product (GNP) in developing countries is still much lower than that observed in industrialized countries (Bowonder & Satish, 2003). Additionally, national R&D intensity tends to increase in line with per capita income (Mitchell, 1999). In developing countries, R&D expenditures by higher education institutions and government agencies are far higher than R&D spent by private firms. In theory, this could be an advantage for engaging civil society and developing a capacity for learning with regard to local problems. But in practice, these groups are seldom included in the discussion about research agenda, and the effort is continually undermined by the pull of research agendas from the North (Sutz, 2003).

According to the literature, the prospects are not much better for using national R&D spending to stimulate the learning process in industry. Particularly in the area of biotechnology, governments in developing countries have played major roles in pursuing R&D because the private sector is too weak to lead the way in accessing the new tools and technologies (Byerlee & Fischer, 2002). R&D activities in many developing countries address local needs that are not of broad international significance (Albuquerque, 2000). As seen in a study of domestic patent data in Brazil, there is a higher share of individual patents rather than of company patents. University R&D in Latin America has not been particularly relevant to the needs of industries (Arocena & Sutz, 2001), partly because the connection between industries and universities is usually weak.

Foreign Direct Investment (FDI)  Foreign direct investment has been seen by most developing countries as a shortcut not only to economic benefits but also to acquiring capacity for technological innovation (Sjoholm, 1999). Arze and Svensson (1997) claim that over time technology from FDI and domestic innovative capacities are interdependent. As an example, in Indonesia, spillovers from FDI can be found in certain manufacturing sectors, as reflected by the increasing productivity of locally owned firms. Moreover, the larger the technology gaps between domestic and foreign firms, the larger the spillovers. Nonetheless, the literature notes that the positive effects of FDI are not automatic. Host country characteristics and supporting policies including fiscal incentives, available skilled workers, and competitive environment are important factors in facilitating spillovers to local domestic firms (Blomstrom & Kokko, 2001; Lall, 1995).

The effects of FDI in developing countries are far from proved. The study of Uruguay by Kokko and Zejan (2001) has shown some evidence that the presence of FDI has no apparent impact on local productivity except for increasing the chances of exporting by local firms. On the contrary, instead of benefiting local firms in terms of technology transfer, FDI can create a competitive environment, resulting in pressure on local firms to increase their efficiency (Okamoto, 1999). Furthermore, clustered FDI is significantly
better than dispersed FDI, particularly in terms of transferring technology (Thompson, 2002). Developing countries also need to be concerned about the issue of higher unemployment when adopting new technologies (Diwan & Walton, 1997).

Studies of firms and industries that are considering locating in developing countries have shown that several aspects of local contexts are competitive priorities for them, including labor availability, level of local competition, government laws and regulation, and market dynamism (Badri, 2000). However, local firms in some developing countries have a hard time coping with these new entrants into the domestic market. For example, there is decreasing room for locally owned companies in automobile industries in South Africa (Barnes & Kaplinsky, 2000). In other cases, emerging multinationals based in developing countries enjoy global success by fostering continual cross-border learning to help them move up the value chain (Barlett & Ghosal, 2000). In the absence of competition from foreign firms, it was difficult for local firms in India to develop their technological capabilities to penetrate the global market, with the result that most stayed inefficient (Bowonder, 1998).

The literature stresses that globalized competition has transformed production systems for both developed and developing countries (Fleury, 1999). In particular, multinational corporations have not only invested in manufacturing plants for the production of their product but also in R&D in places they consider appropriate. Studies have indicated the positive influence of such remote R&D facilities in many developing countries like Brazil, China, and Taiwan (Bowonder, 2001). On the other hand, if developing countries rely excessively on high-tech industry outsourced from foreign firms, they might discourage domestic firms from taking on more complex projects or moving up to higher levels of the product value chain, as illustrated in India by the success of software industry (D’Costa, 2002) and the failure of the hardware industry (Khan, 2001).

**Intellectual Property Policies** A third example of a recommended policy that is likely to have mixed results is the new agreement on Trade-Related Intellectual Property Rights (TRIPS), negotiated through the World Trade Organization. The literature on the implications of TRIPS for developing countries has been negative or cautiously neutral at best (Correa, 1998, 2000; Hoekman et al., 2002; South Centre, 1997; UNCTAD, 1996). Some analysts maintain that stronger intellectual property rights (IPRs) will ultimately help developing countries through increased technological activities domestically and enhanced technological inflows from abroad. Critics say this claim is merely in the interests of developed countries and assert that stronger IPR protection would benefit only industrialized countries and the companies that export IPR-based technologies (Bronckers, 1994; Dealmeida, 1995).

The debate over TRIPS raises explicitly the issue of “voice” for the South—the national-level version of the STS issue of voice for marginalized groups within developing countries. For example, some observers have criticized TRIPS for excessive representation of private business interests of developed countries (Sell & Prakash, 2004), for additional bilateral pressure for heightened IPR protection beyond what is required
under the TRIPs agreement (Drahos, 2001), for structural weakness in the ability of developing countries to participate in the WTO judicial process (Shaffer, 2004), and for ineffective measures for developing countries to sanction developed countries under the WTO system (Bronckers & van den Broek, 2005; Subramanian & Watal, 2000).

TRIPs creates another direct tradeoff between the human development and competitiveness projects. Drug prices are expected to rise under TRIPs because of increased requirements for patenting pharmaceuticals. This price rise could have far-reaching implications for global public health by exacerbating limited access to essential drugs to treat major diseases in poor countries, diseases that account for a millions of deaths (Attaran, 2004; Perez-Casas et al., 2001; Scherer & Watal, 2002; Subramanian, 1995; Wagner & McCarthy, 2004). A fierce conflict has erupted over HIV/AIDS medications. On the one side are developed countries, backed by their multinational pharmaceutical companies, and on the other, some developing countries such as South Africa, Brazil, and Thailand, (Bond, 1999; Schuklenk & Ashcroft, 2002; Sell & Prakash, 2004). The TRIPs agreement will hurt the pharmaceutical industry in some countries (including India) by prohibiting their manufacturing generic drugs as inexpensively as in the pre-TRIPs era (Watal, 2000). Many developing countries are also concerned about the lack of research on drugs for diseases prevalent in their countries (Grabowski, 2002; Kremer, 2002; Lanjouw & Cockburn, 2001; Mahoney et al., 2004).

Since many developing countries heavily rely on their agricultural sector, the TRIPs requirements regarding plant varieties and plant breeders’ rights have also been controversial (Macilwain, 1998; Srinivasan, 2003, 2004). Several problematic post-TRIPs developments in biotechnology have intensified the concerns of many developing countries about theft of traditional knowledge, a problem that particularly affects indigenous communities. Local knowledge that has been held for centuries by indigenous communities and general public may end up as part of the intellectual property of developed countries. This new phenomenon, dubbed “biopiracy,” has generated its own literature with regard to pharmaceuticals (Hamilton, 2004; Timmermans, 2003), plant varieties (Macilwain, 1998; Srinivasan & Thirtle, 2003), and biodiversity (Bhat, 1996; Brechin et al., 2002; Kate & Laird, 1999; Posey & Dutfield, 1996). This topic is rife with knowledge confrontation, and it is surprising that not more STS literature has been devoted to this topic.

The TRIPS agreement has also come under criticism for its negative impact on global public goods (Maskus & Reichman, 2004). Any incursion of private knowledge into public knowledge reduces the global capacity to learn and therefore to innovate, so from the viewpoint of innovation systems, the incentives IPRs provide for innovation are at least partially outweighed by the costs in loss of available information.

Summary Overall, then, the growth prescriptions for the State corner of the development triangle hold little that is helpful in the other two corners. The stunning absence of attention to development as freedom in these prescriptions speaks volumes
about the disconnect between currently fashionable national poverty reduction strategy papers and the dominant ideas about overall economic growth.

Learning Firms

In the literature on innovation processes in private industry, the landscape of development as viewed from the corner of private firms is crowded with networks and alliances with other firms, either inside or outside the country in question. The occasional publicly supported research institution appears, but the State is off in the distance as a network facilitator, and civil society appears only as “markets” or “customers” for goods and services. Employment and labor issues are invisible.

As suggested by Ernst et al. (1998) and Arnold et al. (2000), to obtain technology, firms face the choice of *creating their own technology* or *acquiring technology from outside*. To create technology of their own, firms need the capacities ranging from adapting and reverse engineering to developing their own prototype technology by performing their own R&D. In acquiring technology from outside, the firm faces further choices in selecting, adopting, and implementing technologies. The adoption/adaptation process must be a knowledge confrontation but again one that the STS literature has not studied.

In fact, according to innovation theory, firms are not inclined to innovate on their own without receiving any knowledge, skills, technical support, methods, and instruments from outside. Rather, innovative firms are thought to be embedded in a complex network of relationships with customers, suppliers, research institutes, industry associations, and so on. Some scholars (Porter, 1990) refer to this interdependence as a “cluster.” The new-tech agglomeration in Beijing, for example, seems to contain all the necessary elements of entrepreneurship: small firms, new firm formation, and innovativeness. Nonetheless, there are also weaknesses in that cluster, including limited direct global linkages with multinational firms and restraints on networking with state-owned institutions and firms (Wang & Wang, 1998). As this example illustrates, the literature on clusters tends to focus on learning from other firms rather than from local communities.

The literature in this area often identifies the State in the South as too weak to sustain the diffusion process (see, e.g., Conceicao & Gibson, 2001; Di Benedetto & Calantone, 2003). In a weak State, decentralized decision-making leads to duplication of efforts and hence reduces learning opportunities. The steel industry in India illustrates the effects of this fragmentation (D’Costa, 1998). Likewise, some firms in the auto industry in India failed to adopt best practices, resulting in poor performance (Diwan & Walton, 1997).

For firms in developing countries, both learning and imitating are primary capabilities affecting technological progress (Gao & Xu, 2001), as illustrated by the video/compact disk industry in China. Moreover, the learning processes of small and large firms in the same industry of the same country can be quite different. The case of color television manufacturers in China has shown that the one that focused on the local market was less successful than the one concentrating on the export market.
In addition, the study of a Chinese firm originally spun off from a government-supported research institute indicates an evolutionary pattern of path-dependency, from sales to distribution and service activities, to manufacturing product, process design, and finally R&D (Xie & White, 2004).

Studies reveal that clustering and networking help small and medium entrepreneurs (SMEs) improve their competitiveness. In short, Humphrey and Schmitz (1996) have offered the “triple C” concept—customer-oriented, collective, and cumulative. Despite suffering from competition with their counterparts in developed countries, high-tech manufacturing firms in developing country need to identify proper technical strategies to flourish in times of national growth. These strategies include (1) using market opportunities or growth consistent with the firm’s capacity and competitive advantage, (2) continually expanding the business to acquire expertise and capital enabling increasingly sophisticated processes, and (3) cooperating with technical forerunners (Wang & Pollard, 2002).

Governments in developing countries can facilitate networking in many ways. For example, China’s Shanghai-Volkswagen (SVW) developed vertical networks among its suppliers because the Shanghai government encouraged it to promote outsourcing and extend supplier networks across the entire country. On the contrary, in the case of Proton in Malaysia, vertical networks did not occur among suppliers because the government limited the networking range (Yoshimatsu, 2000).

Summary The literature on firm-level innovation in developing countries is rather narrowly focused on issues of company survival in a global competitive environment. Company survival is necessary for growth, and growth is helpful in human development, but neither assures that development as freedom will be reached. There is plenty of discussion of dynamics along the State–private firm edge of the development triangle but virtually none on dynamics along the civil society–private firm edge. Given the analysis in the previous section of the weakness of the State in mediating between the human development and competitiveness agendas, dynamics on the third edge (between civil society and the State) do not provide any immediate hope for uniting knowledge and learning with development as freedom, unless a broader concept of innovation and learning is adopted. We turn now to this possibility.

RESEARCH AGENDA

This review has deliberately juxtaposed three literatures that are not usually brought together. The mostly economic literatures on knowledge as growth and knowledge as learning conventionally overlap and complement one another. But they are both mutually invisible to the literature on knowledge as confrontation, that is, the writings in the field of science and technology studies on developing countries. The development triangle (see figure 31.1) therefore may not unite the three themes but rather capture their mutual neglect. The STS literature neglects business; the literature on the developmental State neglects civil society, at least when it deals with innovation.
policies; and the literature on learning and competence building systems by and large neglects the contributions of civil society. They all neglect development as freedom.

So are these three topics irrelevant to reaching development as freedom? Surely not. Economic growth is a necessary if not sufficient condition for improving everyday lives for the world’s poor, although as Sen himself shows, it is not the accumulation of wealth that matters for health and education but rather how wealth is used. Learning is certainly a crucial process for human beings to free themselves from disease and illiteracy and to achieve open speech and participation. Part of that learning must take place in the workplace. Likewise, no matter how seemingly abstract the categories used to analyze them, knowledge confrontations have real consequences.

To increase its contributions to development as freedom, however, each of these three literatures must move its intellectual agenda closer to the center of the development triangle (figure 31.2). The literature on knowledge as growth has a close cousin in the literature on growth and inequality, and growth and human development. It needs to pay attention to these concepts and break loose from the narrow confines of the competitiveness project to embrace a broader concept of social productivity. How much more quality of life will the citizens of a country gain from a particular public investment? The answer is not captured in standard economic measurement, but it should be. The literature on learning and competence building systems needs to live up to its own ambitions to consider societal learning processes, not just those in private firms. Innovation can move in many directions. Rather than remaining silent on direction of technological change, this literature needs to articulate the kinds of learning that would orient private industry toward businesses with wider social benefits.

Finally, the STS literature needs to engage with the real world of knowledge in development. It is not enough to follow the actors from research institutions in the North
to those of the South, and in particular to follow oneself in that role. Standing on the side of marginalized communities is an excellent vantage point for analyzing knowledge confrontations that matter. STS needs to actively look for and carefully study success stories in the transfer of power through knowledge, with the goal of informing the practice of those at the bottom.

In this chapter, we have tried, like Sen, “to present, analyze and defend a particular approach to development, seen as a process of expanding substantive freedoms that people have” (Sen, 2000: 297). We have viewed science and technology as forms of knowledge and learning and explored several ways that they contribute to the process of achieving development as freedom. We hope that the next chapter on this topic in the next Handbook will be able to celebrate progress toward that goal.

Note

1. We define the global South as the middle- and low-income countries of Africa, Asia, and Latin America, and the global North as the high-income nations of the world. For the former group, we also sometimes use the terms developing world or developing countries. The transition countries of Eastern Europe and the former Soviet Union offer a different set of development experiences, which are not discussed here.

References


