

Philosophy of Technology and the Question of Development: Articles for the China E-Business Monthly

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With two exceptions, these articles were published in translation in 2006 in the China E-Business Monthly and posted to www.sina.com. The author notes that he is not a China expert and has never lived for an extended period in China. Whatever interest these articles may have must be owing to his outsider's point of view as an observer who looks at China through the lens of Western research on technology and development.

Technology Studies and Development in China

Marx wrote *Das Capital* in England, inspired by the industrial revolution which first took off in that country. But he wrote the book in German. In the preface he explained the relevance of the English experience to still agrarian Germany with a Latin phrase: “De te fabula narratur,” which translates “Of you the tale is told.” By this Marx meant that the future of Germany was already visible across the water in England. And so it was. Germany industrialized too toward the end of the 19th Century.

Soon thereafter Russia and Japan entered the race to industrialize and later social theorists adopted Marx's prophetic confidence that late modernizers would recapitulate the experience of the early forerunners such as England. However, national particularities and the consequences of earlier developments made for significant differences in the “tale” of modernization in Russia and Japan. Today it is China of whom the old tale is supposed to be told. But in this case too the similarities begin to recede before the differences.

The models for China's rapid economic advance are the US, Europe, and Japan, and the obstacles are usually said to be inheritances from Chinese history and culture. But there is an enormous problem with this way of telling the story of progress: China's large and diverse population. Russia is also big, but it has its own vast resources. When Japan entered world resource markets its purchases represented a small increment in demand. Exploration and exploitation of new resources could easily match anything Japan required.

In the case of China imitation of the very wasteful consumption models of the existing industrial societies threatens huge disequilibriums in resource markets, especially in energy. The waste, furthermore, appears to be incompatible with effective strategies for dealing with the increasing inequalities that threaten social order.

The world will not “run out” of oil all of a sudden because millions of Chinese buy Toyotas. But the price of energy can rise to the point where a social and economic model based on automobiles is impractical, leaving China stranded with enormous investments in an outmoded transportation system. Although cars and trucks will no doubt continue to be used where they are most appropriate, it seems unlikely that most people will drive to work or to the store to shop in a foreseeable future.

Apart from the question of whether, or rather how soon, the shift away from private automobiles may occur, there is a larger issue which has to do with the imitative basis of Chinese

modernization. Imitation of technical knowledge, know-how and design can speed up development enormously. Transfers of technology and the knowledge on which it is based have been going on for thousands of years, including of course transfers from China to the West in earlier times. Without the possibility of drawing on the intellectual resources of the whole planet, development would slow to a crawl.

But imitation of technical knowledge is quite different from imitation of the model of consumption of the advanced countries. By a “model of consumption” I mean a specific basket of consumer goods and associated infrastructures that includes necessities and also the typical luxuries identified with prosperity in a given society. Technical knowledge is practically the same from one place to another, but what people prefer to consume varies widely and there is no criterion by which a best model of consumption can be distinguished. This is not a matter of the accumulated knowledge of the human race but a local cultural phenomenon.

What it signifies to be rich and successful at any given point in history is relative to cultural factors that call into existence the corresponding technologies to the extent the prevailing level of technical knowledge and resources permit. Different times and places, different ideas of wealth. But China is importing a model of consumption along with the technologies designed to serve it. The deep question of what model of consumption might emerge from indigenous cultural roots and local resources is not addressed.

But is such a nativist variation in consumption models possible when a modernizing country such as China must depend on knowledge and technology imported from abroad? Western scholars do not all answer this question the way they used to 30 years ago and Chinese development experts need to be aware of this change.

The idea of technological determinism was very influential after World War II. The most popular expositions of modernization theory, such as Walt Rostow’s theory of the five stages of development, described the path of poor agricultural societies toward something very much like the American Way of Life. The theoretical certainty that America represented the future rested on the assumption that technology developed along a fixed track from lower to higher stages, determining social life in accordance with its requirements at each stage. If this is true then the most advanced country does indeed show the future to its less advanced neighbors, just as Marx claimed in the preface to *Das Capital*.

Since the 1980s this deterministic understanding of technology has come under increasingly effective attack by alternative theories such as social constructivism. These new theories argue that there is no one necessary line of technological development but many branches that correspond to different interests, cultures, and political forces. Of course there may be inventions so fundamental that all lines of development draw on them, such as electric power or the wheel, but many very different devices can make use of such basic discoveries. They do not determine a restricted panoply of devices with a single set of consequences at the social level. This is why it is possible for societies to adapt technology to their own needs rather than simply remaining backward where they lack certain resources or potentials exploited in more advanced countries.

Practically speaking, what is the significance of these new ideas? Recent scholarship in technology studies emphasizes the transformations technologies undergo as they are transferred and adapted from one institution to another and one nation to another. The extent of the change varies greatly. There is no rule or law of adaptation from which one could predict outcomes. In some cases, for example, early German industrialization, the changes may have been small enough to say that England truly represented the future. In other cases, for example, the Asian

“Tigers” it is far from clear that the societies are becoming Americanized. In the case of China’s future, even more radical departures from existing models will become necessary as the full weight of its huge population influences its developmental path.

Note that none of this means China will have to remain poor if by poor we mean a lack of access to basic necessities, a wide variety of consumer goods, education, and opportunities for many individuals to develop and apply their talents. The point is rather that what it means to be rich is subject to social definition and redefinition. Korea has a level of computerization and computer usage unrivalled in the world today but fewer cars per capita than the United States. Which society is more prosperous? French people eat far better food than Americans, but live in smaller lodgings. Who is better off? There are no final answers to such questions.

Furthermore, objective constraints and subjective desires do not always stand opposed. Rather, culture shifts in response to reality in interesting and complex ways. What people want and what they can realistically expect often change together. For example, when in the first big OPEC oil shock multiplied the price of gasoline many times over, Americans (temporarily) discovered the joys of owning smaller, more efficient, and more manoeuvrable automobiles. We can hope that constraints on Chinese development will be internalized as part of the culture and influence preferences, rather than simply experienced as obstacles to prosperity.

In conclusion, here is a foreigner’s impression: a critical appropriation of Western ideas and technologies is indicated for China with a realistic sense that Chinese interventions into world markets will change those markets profoundly. China must anticipate the changes and plan its future accordingly. It will not find its future told in the tale of the US, Japan, or any other country but must make up its own story from out of its own culture, resources, and dreams.

Which Modernization for China?

With 4.5% of world population the United States consumes 25% of world resources. It also emits a corresponding percentage of world pollution. This is the result of several centuries of industrial development in the world’s most dynamic economy.

China still trails far behind in total wealth. Its population is a bit more than four times that of the US but its share of world wealth is about one eighth the US share. Per capita income in the US is some 35 times that of China.

But China is catching up. It is growing four or five times as fast as the US. Extrapolating the trend, China too becomes a moderately wealthy country in the not too distant future, and this seems likely to happen if no great disaster arrests its progress.

This is the premise of the *China Modernization Report 2006* published by the Chinese Academy of Sciences. The report’s optimistic scenario projects growth at current rates until 2050, at which time China will be 10 times as rich as it is at present. Poverty will have been abolished, five hundred million peasants will have moved to the cities, six hundred million urbanites will have moved to suburbs, and half the population will own cars. The author admits that this will be difficult to achieve but he believes it possible.

Of course the projection may be falsified by all sorts of contingencies. Forty five years is far too distant a future for anyone to foresee with confidence. But the significance of this document has less to do with the future than the present. The *China Modernization Report 2006* reveals contemporary aspirations. It is intended to inspire efforts rather than to guarantee results.

This is precisely what is most disturbing about the report. China today aspires to a future

that bears a startling resemblance to the American present. The US is the country of car ownership and suburbanization. This is the model of wealth that has driven development in our economy since World War II. The report adopts this model uncritically for China and presumably this reflects the image of wealth in the minds of many Chinese citizens for whom modernization is Americanization. This is the image of modernity that has been most effectively transmitted by films and books that present the US as a utopia, an ideal of prosperity.

But there are two problems with this ideal: it is both unrealizable and undesirable.

Why can't China be rich in the same way as the US? The answer is simple. The American model consumes a quarter of the world's resources with a population a fourth the size of China's. The other 75% of the world's resources must be shared by 96% of the world's population. Multiply China's wealth 10 times over and where will it find the resources to sustain an American level of consumption? The problem of pollution is just as severe. America contributes about one quarter of all greenhouse gases. If China catches up it will flood the atmosphere with carbon dioxide, accelerating climatic trends fatal to its own agricultural productivity. This is clearly an economic and environmental dead end.

Can minor tinkering with the technology of American modernity solve the problem? That seems unlikely. The gas mileage of automobiles can certainly be doubled, but if the report's predictions are realized, China alone would double the number of automobiles during an era of declining oil production and expanding world demand for energy. This makes no sense.

What about really radical technological transformation? Will fuel cells or some similar technology save the American post-war model and enable China to emulate it? This is possible but now we are in the realm of science fiction. In this realm anything and everything is possible. Gambling the global future on as yet uninvented technology also makes no sense.

The *China Modernization Report 2006* has more to offer than these implausible predictions of American style development. The author imagines a wealthy China providing everyone with full medical insurance and access to 17 years of education; life expectancy would rise to 80 years, and the percentage of skilled knowledge workers would rise from the current 10% to 50%. These social goals are independent of the projected suburbanization and automobilization of Chinese society. In fact, they may well contradict it.

For all its wealth the United States has not achieved these goals. Approximately 45 million Americans are without adequate health insurance and educational levels are nowhere near as high as in other developed countries. Infant mortality rates are comparable with Costa Rica, not France or Japan. Poverty is still widespread in the US, as hurricane Katrina revealed, and America's rapidly growing prisons contain over two million people for a population of about 300 million, nearly one percent. The gap between rich and poor continues to grow and race is still destiny for millions of Americans. Social policy appears to have very little effect on these well known problems. It is hard to escape the conclusion that American society has misallocated its resources in an environmentally and socially disastrous way.

Countries are held together by their dreams. So long as Russians believed communism was the path of prosperity the regime was stable. When doubt crept in collapse occurred. China has avoided collapse by harnessing the dream of prosperity with its successful economic reforms. Unfortunately, the image of prosperity that sustains the regime is ambiguous. Universal health care belongs on any list of important achievements of a rich society. Universal automobile ownership is specific to a temporary stage in the development of American society and has little prospect of realization elsewhere, certainly not in China.

There is something terribly unfair about this state of affairs. Whether one approves of the

American model or not, why shouldn't China have a crack at it if it so desires? Consider the fact that the US and Europe have been polluting the atmosphere with their greenhouse gases for 150 years and those gases are still up there. In all fairness China should also get to pollute the atmosphere for at least a century. But the consequences of a fair distribution of opportunities to pollute would be catastrophic and China would suffer as much or more than other countries from such a policy.

Unfair it may be, but there is also an opportunity not to be missed in the obstacles to Americanization. The alternative is to innovate a different model of wealth, focusing on the social goals China can hope to achieve and devoting far more wealth to improving health, education, and the quality of work and urban life than to automobiles and suburban homes. Rather than America's sprawling suburbs where every move depends on the car, China can build inspiring and exciting cities in which it is enjoyable to live and easy to get around on public transportation. Chinese experts should be sent out to study small and vibrant European cities rather than Japanese and Korean auto plants.

This is a realizable ideal that will have unsuspected rewards for a world that knows more about American achievements than about American problems. The first priority of every developing country should be to avoid the tremendous inequalities of wealth, health care, and education that characterize the American model. No study of American modernity is complete that sees only the joys of big suburban homes and not the boredom of suburban life. Take the good but leave behind the bad! That should be the motto for the next China Modernization Report.

Momentum: A Concept in Technology Studies

Until fairly recently, it was widely believed that technical development was determined by the advance of scientific knowledge and in turn determined the organization of social life. Technology, like fate, was a product of human action beyond human control. This "deterministic" theory of technology was supposed to explain why all developed societies gradually come to resemble each other: since science is everywhere the same, so must be technology and the society that depends on it. But this view is no longer widely held by contemporary researchers. We now believe that technology is not determining but that social, political and cultural factors influence the direction of development. In sum, technology is not fate but depends on our choices.

Nevertheless, human beings are clearly not free to make whatever they please. There seem to be great forces steering development. Some if not all of these forces do emerge from technology itself. These latter are of special interest and relevance to policy makers for reasons I will explain.

The American historian of technology, Thomas Hughes, has proposed an interesting theory of technical development focussed on large scale systems such as the electrical system or the airline industry. These systems are composed of networks of people and devices in complex combinations. Although their components each have a separate existence, they are designed or ordered to work together like the parts of a single huge machine. The subordination of each element to the whole is essential to the efficient functioning of the system. Thus the airline industry requires not just planes but airports designed for them, pilots and mechanics trained to operate them, strategies for sharing airspace, and so on and so forth, all combined by managers

to work together harmoniously.

Hierarchical management is the preferred strategy of system builders in most industries such as this one because of the complexity of the network.

Systems are bounded by environments which they do not control. The airport is part of a city, the airlines must buy food for the passengers, their pilots belong to a union, and air travel depends on the weather. But systems have a way of incorporating important parts of the environment as they expand. In this way they guarantee their functioning against accidents and enemies. Thus large companies tend to buy up their smaller suppliers and attempt to control the unions that represent their workers. In some cases systems expand by interlocking in intricate patterns for strictly technical reasons. Efficiencies in the electric power industry depend on serving a very wide area with different levels of demand throughout the day, a fact which explains the growth of gigantic generating plants and electric grids covering continents.

Unlimited expansion thus seems also to be the preferred strategy of system builders.

Large scale technological systems acquire momentum as they grow. By this is meant that once the basic decisions have been made and implemented, the system tends to continue in the same direction indefinitely. The culture of the organization is shaped by its early technological choices and excludes the exploration of alternatives. Often the cost of changing direction is very high. The momentum of the system thus pulls it forward along what appears to be a predetermined pathway. So the electric power industry continues to be based on huge centralized generators although solar and other small scale generation is proving to be efficient and environmentally desirable. Sometimes a large scale system may be drawn toward disaster by its own unstoppable momentum as is the case today with the US auto industry. Its commitment to large vehicles seems to have led it into a dead end where Toyota will pick up the pieces.

The concept of momentum is related to another concept in economics: path dependence. Path dependence means that once a choice among alternatives is made there is no way to go back to the rejected alternatives. The chosen path has altered the environment in such a way as to cancel all second chances. The past continues into the present and cannot be ignored. The adoption of private automobile transportation in the United States is an example. It led to the construction of remote suburbs and the dismantling of public transportation. Today the automobile is essential to daily life in most American cities. The old high density cities well served by buses and trolleys no longer exist to make the return to public transportation practical.

What are some of the implications of this approach to technical systems? Large scale systems with centralized management and a strong tendency to expand along the lines laid out at their origin dominate all modern societies. As they develop they generate more and more technical constraints that lock in their pattern of growth. Although technology as such is not determining, the large scale technical systems it supports have deterministic features. These monstrous systems overwhelm the puny protests of human beings and even political authorities have trouble steering them.

It is difficult to imagine a modern world without large scale technical systems. On the other hand, it is possible to imagine a variety of different ways of building them with very different human and environmental consequences. This is why it is so important that modernizing societies start out right, considering the long term consequences of irreversible decisions that are likely to determine their future.

But this is not at all the spirit of capitalist growth. Capitalism divests itself of social controls to the fullest extent possible. It strives only to achieve the simple goal of short term profitability and if that has unfortunate consequences for third parties or the long term future, so

be it. No one is rewarded with stock options for protecting the environment or the health of future generations. These are not corporate goals but social goals. Government regulation is therefore necessary to protect and further such non-commercial values. But how much regulation and for what purposes? That is a very difficult question.

In the West, regulation usually appeared *ex post facto*, after the initial growth of the large scale technical systems that dominate our societies. Government sometimes planned huge engineering feats, such as hydro-electric dams and aqueducts, but most development was in private hands. In many cases no one in government could anticipate the effects of private decisions that created new and unprecedented industries. Developing societies such as China are in a position to direct development much more actively. They have excellent information at their finger tips about the consequences of technical choices. They control their economies much more thoroughly than did capitalist governments in the early part of the last century. They can, in short, learn from mistakes made elsewhere.

The theory of large scale technical systems explains why this is so important. A technical choice that seems relatively minor and innocent at first may initiate a process with immense consequences over generations. The automobile industry of France started out over a century ago producing small numbers of luxury vehicles and race cars. Today approximately 20% of the economy is tied up in the automotive economy. That dependence on automobiles in turn chains the French economy to Middle Eastern oil producers and therefore also to the increasingly irrational U.S. government which promises regular deliveries from client states such as Saudi Arabia. This is a trajectory of development that meets its limit only in the ultimate constraints of gas prices and ancient stone cities that cannot be rebuilt around wider roads.

Developing societies can look at such examples and consider their own future in the light of our present. Is the pattern observed in this or that industry in advanced societies desirable? Are there alternatives?

Naturally, the accumulated knowledge of advanced societies offers a short cut to rapid development. It is easy to learn about automobile production or the airline industry from Western books and experts. This is a reason to follow the pattern set in the West. But given the nature of large scale technical systems and the momentum they rapidly acquire, there are also reasons for caution. Critical voices in the West and Japan can be extremely useful in evaluating possible trajectories of development before commitments have been made that are difficult to reverse. This is why it is desirable that the huge literature on social and environmental problems of advanced societies be rapidly made available in China and studied by all those with responsibilities for development.

The issue is not whether one is for or against development but concerns which development is best in the long run. These issues are constantly debated in the advanced countries where the momentum of large scale technical systems makes it difficult to promote much needed change. The developing world has an opportunity to start out on the basis of the lessons of this historical experience less constrained by past mistakes.

On Guns and other Devices

Guns exemplify two opposite philosophies of technology.

On the one hand, most people believe that technologies are neutral and merely serve our goals. The American National Rifle Association (NRA) argues that “Guns don’t kill people,

people kill people.” Guns are innocent means, equally useful to defend and to take life. The only important question is who is using them for what purpose. Don’t blame guns for the crimes committed with them, we are told. (And above all, the NRA affirms, No gun control! don’t take away our assault rifles!)

On the other hand, there is the notion that technologies have implications for our values and our way of life. A society in which guns circulate freely is a different place from one in which they are strictly controlled. It is reasonable to ask which kind of society is better and which worse and to judge the technology accordingly. But this is a complicated matter.

In the old West on the American frontier, guns were called “equalizers.” They equalized adversaries of differing strength and intelligence. A weak stupid person could beat a strong intelligent one so long as he knew how to pull the trigger. This conception of guns as equalizers has surprising democratic implications.

Consider the case of 17th century Japan. European traders and missionaries began to visit Japan in the 16th century, bringing with them guns and Christianity. The Japanese were already excellent craftsmen and metal workers, no doubt better than their visitors, and soon they were manufacturing more and better guns than the Europeans. There was a civil war at the time but the introduction of guns helped unify the country. The new government, the Tokugawa Shogunate, closed Japan to foreign contacts and gradually eliminated foreign influences. Guns were collected and gun makers brought under government control. Christians were forcibly converted and the religion, like the guns that had accompanied it, disappeared from view. For 250 years this condition prevailed until American warships forced Japan to open up in the mid 19th century.

Why were guns outlawed in Japan? One answer seems to be the fear that they would fall into subversive hands. Killing with the sword was an art in feudal Japan learned by members of the upper class from childhood. Superior fighting ability was the foundation of aristocratic rule. If an ordinary untrained individual could easily kill a samurai, the state would collapse. The “equalizer” was politically explosive in an aristocratic society.

From this example one clearly sees the value bias built into technology. Swords and guns have opposed political implications and are not simply means to universal goals. They shape a society of a certain type and establish the identity of their users as either subjects or citizens. Indeed, soon after Japan was opened to the world, a citizen army equipped with rifles put down a rebellion of reactionary samurais and saved the new government of the Meiji restoration.

The equalizing effect of firearms continues to this day. A good quality rifle at the time of the American Civil War (in the 1860s) cost about \$40. The rifle was an expensive weapon at that time, paid for with the wages of many months of unskilled labor. Equipping whole armies with guns strained the resources of states. Today in the combat zones of Africa one can buy a far more powerful AK 47 for \$30, a trivial sum for many individuals and for the groups that organize the fighting.

Colonialism was possible because only Europeans had large numbers of firearms and many who knew how to use them before the rest of the planet. A few men armed with early automatic rifles could hold at bay hundreds of fierce Zulu warriors. The English satirical poet Hilaire Belloc wrote of African colonization in the early years of the 20th century, “Thank God that we have got/The Maxim Gun/And they have not.” In a later time, the ready availability of such weapons made colonialism unsustainable. In the period after World War II one European power after another gave up the fight and decolonized its empire. Today the inability of Western armies to dominate the Middle East reflects this changed situation.

Once countries are free of aristocrats and colonizers, guns change their significance. They

become factors of disorder for modern states and their use is strictly suppressed, with the exception of hunting. This is what worries the NRA. They claim that widespread gun ownership guarantees freedom, but this argument confuses a bygone historical factor making for the growth of equality with the cultural, legal, and political institutions that sustain it in the present day.

So far I have discussed the consequences of technology, but we can also identify values in the design of devices. The human needs served by technical devices are themselves shaped by social conditions that are reflected in design. Consider the banal example of the refrigerator. This useful device makes it safe to store food for prolonged periods. The basic technology appears to be indifferent to social conditions but this is an illusion. Everything from the standard size of refrigerators to the design of the motors is socially relative.

The size of American refrigerators reflects the average size of the nuclear family and the use of automobiles for shopping. The types of refrigerators found in European cities vary much more widely in size, with very small units far more common than in America because so many people live alone and shop on foot. Refrigerator design is a clue to family and urban life.

The question of the refrigerant gas is equally revealing. This component of the refrigerator was shown to damage the ozone layer. Without ozone in the sky to absorb ultraviolet light, human beings would be unable to go out in the sun. Scientists alarmed the public and politicians eventually negotiated an effective international treaty that obliged manufacturers to find another refrigerant. Thus what at first sight appears to be a purely technical choice of refrigerant gas actually reveals a social choice in favor of conservation.

The argument could be multiplied over and over to show that technologies are not really neutral outside the very narrow context of uses they themselves define. Of course it is true that guns do not prefer to kill either cops or robbers. But this is a very restricted view of guns. In the larger context of society technologies such as guns embody and further social choices. Their design reflects values widely held in the society they serve.

This argument has important political implications. Contrary to a popular view, we cannot leave the choice of our technological system up to a few experts, presumed to make decisions on purely technical grounds. Technical decisions are never pure. At some level, they always embody values and express a vision of life.

This does not mean that technical decisions are arbitrary. They rest on generations of hard work by intelligent people who have created a range of workable options. Sensible technical decisions will always fall within that range or expand it. The alternative is disastrous failure, breakdowns, destruction of machines and people such as was seen during the Great Proletarian Cultural Revolution. But respect for technical personnel should not mean uncritical acceptance of their views. Within the limits set by technical knowledge, political authority must prevail over technical authority in the definition of the technical future.

From the Information Age to the Communication Age

In the 1960s, sociologists in the United States introduced the new theory of the “Information Age.” They argued that industry was declining in the most advanced countries as a new economic and social paradigm emerged based on the production of information and the provision of services. The employment figures seemed to bear out this argument, especially if one counted all service workers as “information workers.”

Of course, there were some who protested that most service workers had no more to do

with information than industrial workers. I recall one Marxist sociologist of labor indignantly explaining at the time that it was not technical work but janitorial services that had grown more than any other occupation since World War II. Other critics of the new theory noted that the decline of industry in the US was compensated by its rise in countries with lower labor costs such as Mexico and now of course China. The Industrial Age continues on a global scale.

Nevertheless, whatever the flaws in the theory of the Information Age, it was influential with governments attempting to anticipate and plan for the future. But the outcome of policies based on the theory has sometimes proved surprising. This was certainly the case in France and South Korea, two countries that aspired to enter the Information Age quickly through encouraging the accelerated computerization of society.

The French case was once much discussed before the Internet eclipsed it. It is worth recalling the basic facts. In the early 1980s France introduced a nation-wide domestic computer network called Teletel. The French government was convinced that computer networking would turn out to be the Information Age equivalent of industrialism's coal and steel. It was therefore essential to set up a network early, before other countries (read: the United States, IBM) dominated the field.

All this occurred years before the Internet was opened to general use and accustomed us to thinking of computers as network nodes. At the time most computer networking was internal to large computer corporations and a few subscriber services with modest membership. These services were not interlinked and so were not very useful except for specialized purposes. The idea of something like Teletel, or what the Internet was soon to become, seemed a daring projection from a speculative sociological theory. Many predicted failure. What in fact resulted was a kind of success, but it called into question the theory on which the experiment in networking was based.

The Teletel network was implemented by the French telephone company. The key to the success of its network was the free distribution of terminals, called Minitels, to every phone subscriber sufficiently interested to pick one up at his local phone store. Beginning in 1981, the distribution of terminals was enormously successful. Eventually six million were placed in homes, a significant proportion of households in a country of about 50 million.

The existence of a large user base encouraged the creation of services. The directory grew by leaps and bounds from year to year. Soon there were thousands of services offering everything from medical advice to state exam test results, business news to train schedules, real estate listings to games, help with homework to dates.

The government officials who had designed the network and obtained vast sums in state support to launch it imagined that they were contributing to the modernization of French society by increasing the efficiency of everyday life. They intended their network to enable ordinary people to enter the Information Age better equipped to handle the challenges of a post-industrial society. For the officials this meant better access to information. What they got instead was human communication and much of it was about...sex. Here is the story.

Teletel opened with various information services such as a national telephone directory and news provided by newspaper editors. Within a year, one of these news services was hacked. The hack enabled the hackers to send system messages to everyone on the service at the time, essentially what we now think of as instant messaging. The owners of the service were furious at first but the hack attracted a lot of attention around the country and soon thousands of users were signing on to see the messages. Since the newspaper which owned the site was paid by the telephone company for each minute of connection, the editors decided to support rather than

resist the hackers' innovation. Instant messaging software was placed on the site.

What happened next was completely unexpected. Users transformed the newspaper's site into a place to seek dates. Since the messages could be sent anonymously, users dared to explain their desires in the most explicit language. So-called "pink messaging" was born and spread like wildfire throughout the network as service after service introduced similar programs. The telephone company was scandalized but the phenomenon insured Teletel's financial success and could not be stopped. In fact, in 1987, the only year for which I could obtain data, messaging accounted for about 40% of the revenues of the system. Teletel did not preside over the birth of an Information Age in France but rather unleashed a strange Communication Age for which sociology at that time had no good theory.

Instant messaging is only useful for everyday social interaction but it transformed a tool originally designed for the exchange of information into a communication medium. With email, web forums, and blogs the Internet has gone much further in exploring the communicative potential of computer networking. Today classes and business meetings are conducted online, social groups and academic organizations plan events, and political discussions influence elections. The very nature of computer networking has been transformed by users.

The South Korean case is similar in some ways, different in others. Like France, but at a later date. South Korea attempted to modernize quickly by introducing computer networking on a large scale. In the 1990s the government encouraged the widespread adoption of the Internet and supported the introduction of broadband service. South Korea now has the highest penetration of high-speed Internet in the world, reaching 75% percent of households. But as in France, the explosion of interest in computer networking did not have the intended result.

Today young people in South Korea gather in so-called PC-Bangs, local internet cafes, where they sign on to multi-player computer games, do email and instant messaging, maintain personal blogs, and surf online matchmaking sites. The PC-Bangs serve to escape the pressures of home and meet with friends. They are cheap places to "hang out" and teenagers spend most of their free time in these cafes.

Computer gaming has become so popular since the introduction of the Internet that national championship matches attract huge audiences. Over half the population plays online games and the game economy in Korea is worth an astonishing \$4.3 billion a year. The best players become professionals and are worshipped by fans like movie stars. The darker side of the phenomenon is denounced as "addiction," an excessive concentration on gaming to the exclusion of other pursuits. In fact, several players have actually died after lengthy sessions at the computer without proper food or drink. But this is a rare exception to a generally positive picture of safe and entertaining leisure activity.

At first sight it appears that this case is due to an obsession with games that would presumably be unique to South Korean youth. However, research on young Koreans' fascination with computer games reveals a different story. Computer gaming in Korea is the occasion for the formation of youth communities. It is the glue that holds together the social groups in which most young people's social life goes on. The games themselves have both competitive and cooperative elements. They offer opportunities to achieve and also to form community bonds with others in cooperative online ventures. Thus gaming is not just about scoring points. The context of play is a human environment participants join out of social needs.

This case confirms what we have learned from Teletel and the Internet. The computer becomes a medium of communication as soon as it leaves the engineers' desk to enter the daily life of ordinary people. The larger implications of this phenomenon for the study of technology

have to do with the importance of users in influencing the development of technologies once they are unleashed on the public.

What the Atomic Bomb Revealed

In a recent article in *Foreign Policy*, former US Secretary of Defence Robert McNamara wrote: ‘I would characterize current U.S. nuclear weapons policy as immoral, illegal, militarily unnecessary, and dreadfully dangerous. The risk of an accidental or inadvertent nuclear launch is unacceptably high. Far from reducing these risks, the Bush administration has signaled that it is committed to keeping the U.S. nuclear arsenal as a mainstay of its military power—a commitment that is simultaneously eroding the international norms that have limited the spread of nuclear weapons and fissile materials for 50 years’ (http://www.foreignpolicy.com/story/cms.php?story_id=2829&page=0).

Reading these lines reminds me of incidents in my own personal history. My father was a theoretical physicist. During World War II, one of his friends was sent to invite him to Los Alamos to help develop the atom bomb. He declined. He never really explained why he refused to go, but I think it was because he believed the human race was doomed if a bomb could be built. During the war he worked on radar instead of the bomb.

On the morning of the day the bomb was dropped on Hiroshima, he and my mother turned on the radio and heard the bad news. My father said “So this is the end of history.” Certainly, on the evidence of thousands of years of history, human beings are not the sort of animals you would expect to make wise use of such immense powers for destruction and self-destruction. Later as I was growing up and as we saw the effectiveness of deterrence, he became more optimistic. Still, once in a while his gloomy foreboding returned. I recall telling him when I was about 12 years old that we were being taught at school how to survive nuclear attack: duck under your desk, cover your head, and close your eyes. He looked contemptuous and told me I’d be lucky to die in the first seconds of the attack.

As I study technology, these memories remind me that technology is not just a wonder, it is also a terror. We need to think seriously about the risks as well as the benefits, as McNamara reminds us.

Both risks and benefits have increased enormously since World War II. That was when the most powerful institutions in our societies, governments and corporations, got involved with scientific and technological development. Before that time, few domains of science were of practical value. The most important inventions of the previous century came not from the minds of scientists but from the hands of clever inventors. But the first time all the power of a modern state was placed in the service of scientific discovery the result was a huge leap in the scale of human control of natural forces.

After World War II, many of the scientists who had worked on the atom bomb project advocated nuclear disarmament. Unlike military leaders who were contemptuous of the Russians and believe they would never make a bomb, the scientists had studied alongside Russian students in Germany before Hitler came to power and knew their abilities. They foresaw an arms race and their dire predictions have been verified to a frightening degree. After a momentary calm at the end of the Cold War, the risk of nuclear conflict has reappeared with threats of a preventive attack on Iran.

The bombing of Hiroshima should be placed in the larger context of history. It was only

the most dramatic of a series of disillusioning events that shattered our confidence in progress in the 20th century. The First World War discredited both governments and the official socialist opposition, which in most countries supported the slaughter in the trenches. In subsequent years, concentration camps and mechanized warfare did nothing to encourage a more hopeful view. Technology, which the 19th century believed would save humanity, became the great threat to survival in the 20th.

Subtler threats emerged after World War II from the same potent combination of powerful government and corporate sponsors and scientific-technical research. Once again, we are witnessing a rising tide of concern among scientists and engineers regarding the dangers of their own achievements. Just as the atomic scientists called for restraint after creating the bomb, so today scientists who have helped create new technologies in the domains of industrial production, computing and biology are calling for restraint in the application of their inventions.

For example, Bill Joy, cofounder and Chief Scientist of Sun Microsystems, and coauthor of The Java Language Specification, shocked the technical community with a portentous article in *Wired* in 2000. There he wrote, “The 21st-century technologies - genetics, nanotechnology, and robotics (GNR) - are so powerful that they can spawn whole new classes of accidents and abuses. Most dangerously, for the first time, these accidents and abuses are widely within the reach of individuals or small groups. They will not require large facilities or rare raw materials. Knowledge alone will enable the use of them....I think it is no exaggeration to say we are on the cusp of the further perfection of extreme evil, an evil whose possibility spreads well beyond that which weapons of mass destruction bequeathed to the nation-states, on to a surprising and terrible empowerment of extreme individuals” (<http://www.wired.com/wired/archive/8.04/>).

Of course practically no one wants to give up the many benefits of progress, particularly in medicine, agriculture, and communication. The critique of modern technology is not about regression to a premodern condition. The question is what to do about the contradictory effects of progress.

These effects cannot be grasped in the old optimistic view of technology as a benign force for good. The very definition of technology seems to be violated by its evolution. We think of our action as “technical” when it changes the world more than it changes us. The hunter kills the rabbit but nothing happens to him in the process. The driver moves a ton of screaming steel down the highway but sits peacefully in the car listening to music on the radio. This disproportion between action and reaction back on the actor is in the very nature of technique and distinguishes it from activities in which there is more reciprocity such as human relations.

But we seem to have reached the limit to the technical way of being in the world. There is no way to escape the reaction when the technologies become so powerful they overwhelm everyone within their range including those who deploy them. Nuclear weapons revealed our vulnerability to our own technologies. Environmental problems such as pollution and global warming continue to teach the same lesson: we exist in the world our technologies transform and cannot escape their effects.

The German social theorist Ulrich Beck calls this new situation the “risk society.” A risk society is one in which technologies have become so powerful as to interfere with their operators and with each other. Restraint is needed, but also a new sophistication in technical disciplines. For example, it used to be possible to keep engineering and medicine separate, each in its own sphere. No longer. Today many engineering decisions have medical consequences and engineers must deal with health and safety as once they dealt with materials strength and raw materials availability. Similarly, medicine employs many engineering marvels and mistakes in design can

have fatal consequences. The interference and overlapping of technologies creates a new situation in which specialization must be compensated by frequent appeals to the knowledge contained in other disciplines. Only then can we hope to avoid such consequences of modern technology as environmental pollution.

But there is a more basic precondition for surviving the unintended consequences of progress and that is the will to live in peace and harmony with others and with nature. So long as that will is lacking and a will to violent domination continues to be the rule in the affairs of nations, human survival is at risk. After World War II, the scientists who made the bomb formulated the situation in terms of the growth of the human species. Once the toys become too powerful, it is a race between the habits of childhood and responsible maturity. We are still in this race and the outcome is uncertain.

Normal Accidents and Macro-Systems

What does the Chernobyl accident have in common with the threat of Global Warming? Clearly, both involve failures of modern technology but in other respects they seem quite different. At Chernobyl a poorly designed reactor was sent into meltdown due to human error. If the designers or operators could have foreseen the outcome they would certainly have done things differently and better. Global Warming is another matter entirely. It involves not the design of a single technology but rather the design of *most technology*. Whether operators err or not is irrelevant. In either case they contribute to the “accident” or what more accurately would be described as an unintended side-effect.

Yet I want to show that these two cases have something important in common.

The Chernobyl case is an example of what Charles Perrow has called a “normal accident.” Normal accidents result from two aspects of modern technological design. First, many technologies depend on an enormous number of interactions between their parts, so many that their very complexity makes them unpredictable. And second, the tight coupling of parts means that when one is affected the consequences propagate quickly throughout the system.

This is certainly true of a nuclear power plant which is why so much care must go into design, operation, and training of personnel. Thousands of interconnected parts react to the movement of a single switch or a small change in temperature within the reactor core. This is not the kind of technical device human beings have been accustomed to creating and using since they evolved tens of thousands of years ago.

Compared to traditional technical devices, complex modern technologies belong to a new and unnatural world. Consider the tools of an old fashioned farm. These tools are no doubt products of genius but of a very different kind of genius than our modern technology. Each tool is relatively simple and understandable. The farmer expects to be able to repair them all many times in the course of their useful life. And the breakdown of one tool usually has no effect on the others which can still be used while the broken tool is under repair. In sum, the farmer’s tools cannot get out of control and do something untoward that destroys the whole farm or kills the farmer. Of course accidents happen on farms all the time, but they are not “normal accidents.” Rather, they are due to failures of single components or alertness and are usually easily understood.

In so far as modern life is built around complex modern technologies, we have to get used to normal accidents and attempt to foresee and prevent as many of them as possible. This

task requires a new and far more cautious mentality that is not easily learned even by people with sophisticated training. Indeed, well trained individuals may have excessive confidence in their own ability to control complex systems, an error of perspective that led to the failures of the American space shuttles. It is difficult to overcome the habits of millennia during which behavior we would now consider sloppy and dangerous was just fine.

Turning now to Global warming, we find similarities and differences. While normal accidents are unpredictable, we were warned about Global Warming in 1898, over a century ago, by the Swedish scientist Svante Arrhenius. And yet practically nothing has been done to fend off the impending catastrophe. Why not?

The problem results in part from the disciplinary boundaries that separate the sciences and engineering specialties. During the last century of rapid technical progress, there was no reason for engineers developing automobiles and power plants to think about the environmental consequences of their work. The very specialization that made them capable of executing the tasks assigned them blinded them to whole regions of the real world in which their products would have to function. These disciplinary boundaries and specializations are inherited from an earlier era when science had relatively few technological applications. The difference between chemistry, physics, and medicine corresponded to properties of matter human beings could not yet bring into relation intentionally in subtle ways, with complex long term effects.

We now live in a technical environment in which all these connections are made. The isolation of the sciences, medicine, and engineering is breaking down. New disciplines such as ecology begin to pull together a far more concrete and realistic image of nature and of our place in it. Arrhenius's prediction is now charted by sophisticated computer models based on knowledge from many disciplines.

But even this scientific advance is insufficient to get much action. The forces leading to Global Warming are social and economic as well as technical. It is one thing for an engineer to change a component, quite another to redesign a socio-economic system. And yet modern society and the modern economy have become intricate machines, not so very different from the complex systems that suffer normal accidents. Automobiles, roads, oil supply and refining, rubber supply and tire production, job classifications and management techniques, factory design and electrification, suburban lifestyles and urban design, the situating and growth of cities, all are intertwined in such complex ways that sorting out the connections is virtually impossible. This is the world of what the French sociologist Alain Gras calls "macro-systems," gigantic socio-technical systems with roots and branches throughout the social world.

It is true that the couplings are looser than in a nuclear reactor but control is also far weaker since so many different individuals and agencies are involved. The fact of complexity makes it hard to change the system even once problems are identified. The environmentalist must convince millions, nay, billions of people to change their way of life in order to introduce a environmentally sound technology! The issues are political and call for education and mobilization of opinion on a large scale.

The result of this comparison is rather discouraging. We are confronted with the probability of normal accidents where we cannot make predictions and with the probability of inaction in the face of disaster where we can make predictions. Complexities of different types are the problem in both cases. The solution, to the extent that there is one, is caution and education. But the historical precedents suggest a further obstacle.

The modern economy was created by capitalist entrepreneurs. Caution was not their strongest virtue. Rather, they were a daring breed who introduced rapid, wholesale changes with

little thought for the long term future. We are the heirs of a world built by recklessness, not caution. As for education, it is increasingly restructured to service the labor market. Technical specializations are privileged over the kind of wide-ranging learning that would prepare young people to make better decisions about the future. Meanwhile, far more influential than education, the mass media project images of the good life that are environmentally unsound and unsustainable. It is no wonder that many observers today despair of the future.

But I think there is considerable room for hope despite all the bad news. Two of the most destabilizing trends in the environment appear to be self-regulating. The demographic transition is engaged on a global scale, slowing population growth which appeared to be completely out of control 20 years ago. Economic forces at work in the domain of energy will likely force drastic changes in modern methods of production and transport over the next decades, greatly increasing the energy efficiency of global technology.

Still, there is no guarantee that the necessary adaptations will be beneficial for the environment. The risk is that those changes will in turn expose us to ever more “normal accidents” as complex technologies such as nuclear power multiply to maintain the level of energy consumption.

Better responses are possible, but for them to win out, governments must help the many victims of progress today in addressing the issues and bringing them to the attention of the public. Only in this way can the political forces be mobilized to introduce a new model of progress based on caution and understanding rather than the recklessness and ignorance of the past.

Early History of Environmentalism

Environmental politics get off to a rough start in the United States in the 1960s. It is difficult now to imagine a time when the issue of the environment was controversial. But denial of the gravity of the problems was the norm rather than the exception until fairly recently. The undesirable side-effects of progress were generally ignored. Most people assumed that the air and rivers had an infinite capacity to absorb waste. Oil was cheap in the U.S. and wasteful use of energy routine in American industry. Awareness of potential problems grew in the 1960s as smog blanketed the air above major cities such as Los Angeles, radioactive fallout from nuclear weapons testing spread across the Midwest, and pesticides contaminated agricultural products.

The publication of Rachael Carson’s best selling book *Silent Spring* in 1962 was a first turning point in the emergence of environmentalism. Carson argued that human beings and nature are interdependent. DDT use was eventually curtailed in part because of the arguments she presented in this famous book. But Carson, who died of cancer two years after its publication, was widely dismissed as a hysterical woman by interests hostile to environmental regulation.

It was not until the early 1970’s that environmentalism became a respectable political issue with widespread support. The first Earth Day on April 22, 1970 was a second turning point. Huge demonstrations in favor of environmental protection were echoed in Washington by positive oratory from President Nixon and other political leaders. Soon major legislation was passed and environmentalism became a fact of political life in the U.S.

All this political activity took place against a background of intense ideological debate. Two principal positions were advanced by leading scientific commentators on the environment.

On the one hand, population growth was blamed for environmental problems. Paul Ehrlich's 1968 best seller, *The Population Bomb*, predicted mass starvation in the coming decades. This Malthusian trend was soon joined by advocates of limited economic growth. The Club of Rome published its famous study, *The Limits to Growth*, in 1972. Industrial civilization, it argued, would soon devour its own natural basis and collapse. These commentators focused on scarcities of food and resources. In its extreme versions, its advocates proposed allowing starvation to winnow world population back to sustainable levels.

Many of these early advocates of population control believed in coercive solutions. They thought that policies such as China's one child program would have to be backed up by legal sanctions. Some imagined that the rich countries would have to force poor countries to adopt such policies by threatening to suspend food aid. They had less confidence in the demographic transition, which reduces birth rates in response to improved health care, better nourishment and education, and urbanization. In fact a combination of factors has led to a dramatic slowdown in world population growth and it seems likely that sustainable levels will be achieved without global famine. As population growth has slowed, food supplies increased, and resource limits failed to show up as expected, this view became less popular but it still has its supporters.

On the other hand, technology was identified as the culprit responsible for environmental problems. The focus was on pollution and the solution proposed was to redesign technology to make it compatible with the environment. This position has an effective advocate in Barry Commoner, a biologist who was also an avowed socialist. His 1971 best seller entitled *The Closing Circle* argued that capitalist economics and ecology were incompatible. One of Commoner's famous "laws" of ecology says, "Everything must go somewhere." The struggle for higher profits was being waged at the expense of the earth as air and water were contaminated to save money on waste disposal. Ultimately, he argued, an environmentally conscious government would have to intervene in technological affairs to orient innovation and development toward sound solutions to environmental problems.

The economic basis of Commoner's position is the familiar disjunction between the pursuit of private profit and the preservation of public goods. Human welfare is the sum of both private and public goods, but capitalism focuses narrowly on the private kind. One way profits can be increased is to convert public goods into private resources, for example, by obtaining land or mineral rights cheaply from government or dumping waste products on public lands or in the air and water. In both cases the public subsidizes a private business and enables it to make money without compensation. The conversion of freely available natural resources into sources of private profit diminishes overall social welfare and creates a "debt to nature" that must be paid. Commoner argues that the supply of public goods available for exploitation in this way is limited and as it is drawn down fundamental conditions of social life are undermined. The ecological balance is of more than economic interest. It sustains life as a whole in all its aspects. Disrupting the ecological system will thus have catastrophic consequences.

Commoner's position has been forgotten in recent years. Free market ideology received a huge boost from the collapse of the Soviet Union and now few will argue for more government control of the economy. Yet, it remains true that the enforcement of legal standards for such things as air quality is the principal achievement of the environmental movement. Neo-liberal measures such as the sale of pollution credits have had far less impact. Government regulation has not impoverished society as business advocates argued, but has been a spur to innovation, just as Commoner expected.

Commoner hoped that the labor movement would become active in defense of the

environment. Workers suffer the effects of pollution on the job long before the exposures of the general public reach critical levels. Commoner thought that workers could become advocates for the environment to protect their own health and that of their families. He believed this would lead to a revival of the socialist movement in America. Some American unions did in fact ally with the environmental movement but many more were frightened into supporting polluting industries and practices under the threat of job losses.

Nevertheless, Commoner's position has important points of convergence with trends that continue to this day. The labor movement appealed to Commoner as a social base for environmentalism because it had a history of active struggle and the intellectual and organizational resources to impose political solutions to the problems. What has happened instead is that groups with far less organizational coherence have brought specific abuses to the attention of the public. Typically these groups consist in people living in the neighborhood of a polluting factory or associations of sportsmen worried about the contamination of lakes and rivers or advocates for black people who must live near toxic waste dumps. They attract help from scientists in articulating their complaints. Lawsuits or government sponsored hearings give them a platform and eventually public opinion favors new regulations. After many small struggles quite far reaching legislation is passed to protect the environment. Thus environmentalism did emerge as a political movement opposing the public interest to business just as Commoner foresaw, if not in the form he expected.

Another important point of convergence has to do with technology. Commoner was an early advocate of technological change to bring industry into compliance with ecological limits. At that time, technological determinism was a widely held view and it seemed obvious to most people that the pursuit of higher productivity and efficiency conflicted with environmental values. We were told we would be forced to choose between prosperity and survival. Commoner argued that this conflict could be avoided by redesigning technology to provide prosperity in forms compatible with the environment. Today, technological determinism is no longer common sense as it was when Commoner was writing *The Closing Circle*. His argument now can draw force from a great deal of industrial experience and theoretical work in technology studies. Environmental politics has emerged as a politics of technology. That is a result of this history from which other nations can learn a great deal.

Trade-offs and Prosperity^{*}

The term "trade-off" is employed in economics to refer to the fact that budgeting inevitably involves sacrificing some of X to get more of Y. With a fixed amount of savings, one can buy a car or take an expensive vacation, but not both. The car can be "traded off" for the vacation or vice versa. Note that the premise of the argument is the fact that the amount of savings is fixed. If one wins the lottery, both the car and the vacation are suddenly affordable. All this is obvious at least in daily life. But the same reasoning that explains simple trade-offs is often employed to talk about the state of the economy as a whole. Then the obvious turns out to be misleading and ideological.

The issue of trade-offs arises whenever environmental questions are discussed. For example, Americans are told by conservative opponents of environmental regulation that we

^{*} This article was left unpublished at the end of the series.

have traded off a considerable portion of our national wealth for costly environmental protections. Clean air requires the installation of expensive pollution control devices on cars. We could have bigger and better cars if we were not so concerned about air quality. Jobs are lost too when new regulations raises costs of production and close off markets. In a developing country like China, the rate of growth is said to be at stake. Growth would be slowed if more attention was paid to the environment. A society struggling to grow its way out of poverty cannot afford to be too picky about the environment. Or so it is said.

In reality, much regulation encourages innovation, increases the supply of public goods, and stimulates the development of new businesses. For example, many of the effects of environmental protection consist in public goods such as better air quality that benefit everyone in the society. Growth should include these goods too. But the medical costs that decline and the health benefits that rise in a cleaner environment are difficult to calculate and hard to trace back to specific environmental regulations. It is easy to spot a loss of jobs in a regulated business that loses sales and difficult to attribute new jobs in remote sectors of the economy to the innovations or services that respond to the same regulations, yet the connection may be detected in subtle economic analyses. But subtle economic analyses hold no interest for businesses anxious to avoid regulation and their academic, political and journalistic representatives. These latter put out the story that regulation and development are opposed.

This is what lies behind the concern that environmental and other regulations must be traded off against prosperity. But there is a deeper problem. The trade-off ideology is connected to the structure of the prevailing model of wealth in Western societies. This model has been exported to developing societies with unfortunate results. The Western world has developed under capitalist conditions in which a small minority of the population has had the political and cultural power to define a model of wealth based on luxurious private consumption for the few. To own a car and a house is the ultimate confirmation of middle class status in American society.

The costs of this way of life are high but since World War II most of the poor have achieved to a tolerable level of welfare. Governments have succeed in convincing most people of the wisdom of investing in public goods such as cleaner air. And well organized and relatively honest legal and administrative systems protect most poor people from the worst abuses most of the time despite the fact that they have few means to protect themselves. In this sense the system can be said to “work” even though it is unjust and remains far more polluting than it has to be.

Take this same model of wealth and transfer it to a developing economy and chaos results. The chaos is evident in practically every big city in the Southern hemisphere: traffic jams and air pollution are not simply problems of transportation and public health but signify a deeper systemic failure. The problems of rural people in these developing societies testify to the failure. All too often poverty increases for whole sectors of the population as other sectors are enriched. The unbalanced outcome is due to the privileging of the production of such private consumables as automobiles. Organizations like the World Bank are increasingly aware of the fact that they have often promoted the opposite of what they intended by supporting this type of development. A world wide revision in development policy is needed to restore the balance.

It may be asked why Western countries do not accept their responsibility for the situation that has resulted from their exploitative past and more recent bad advice. This is a fruitless complaint, however justified. The fact is that Western countries are unlikely to devote more than a tiny fraction of their wealth to helping poor neighbors. The neighbors must therefore help themselves, and this they can best do by elaborating independent approaches to development that are equitable and respectful of the environment. The production of a huge “middle class”

consuming Western goods and an equally huge poverty class of peasants living with the combined inconveniences of their ancestors and injustices of modernity is a formula for future disaster.

Might a change in course result in slower GDP growth? Perhaps so, if public goods are left out of account as is usually the case in business circles. Even where a slowing occurs, such a trade-off has very little to do with economic principles and a lot to do with the source of investment capital. Lawrence Summers, the prominent American economist, once admitted that globalized capitalism has serious flaws but he went on to say that it is the only thing that seems to work at this point in history. It is true that a tremendous economic dynamic has developed around freer trade and investment. It would be a shame to miss out.

But investors from the developed countries seek opportunities they understand and expect to be profitable. They orient development toward the familiar products that have succeeded at home. Their knowledge of technology, finance and marketing is invaluable when it comes to these products. The demand is there in the developing world, stimulated in every corner of the globe by intense propaganda for the American way of life. Jobs follow the investments and give purchasing power to buy the products. The economic circle of investment and consumption closes like a noose around the neck of developing societies.

National independence has been achieved in the developing world only with great difficulty since World War II and now a similar economic independence is required. Economic independence does not mean autarchy but it surely implies some significant orientation of foreign investment toward sensible goals. There is nothing unprecedented about this.

Western nations protect certain especially privileged industries or sectors of the population such as agriculture despite all their rhetoric about free trade. It is absurd for poor countries to be “more catholic than the Pope,” as we say of someone who aspires to a level of orthodoxy unknown even to the most prominent representative of the church.

In Western countries it is commonplace to demand concessions to the public from private investors. Investors in a large real estate project may be asked to set aside some land for parks or a school. After all, the population their project will attract requires public services. It is reasonable that they share the costs with which they burden the existing community. Where is such a policy followed in the developing world? In Western countries companies are subject to fairly strict regulations concerning the polluting effects of their production and products. Why is this not the case throughout the developing world? In many Western countries governments and companies recognize the social costs of progress to workers displaced by new technologies. Adequate compensation and retraining help soften the blow. Why is this not a normal practice in the developing world too?

One could go on multiplying examples of ways in which Western countries manage development to limit its deleterious effects while maximizing the advantages of private investment. It is time for developing countries to study these strategies and to adopt them. Prosperity will not be achieved without emulating these social techniques that complement and humanize the raw technological advance advertised as the road to riches by those who are already rich.

The Politics of Technological Development*

* This article was judged to be unpublishable and was not translated.

There is a political concept Westerners regard with a kind of holy awe, especially in the United States. This is the concept of “separation of powers.” It originates in the writings of the 18th century French philosopher Montesquieu who believed that only by granting a certain independence to the legislative and judicial power could the executive power—royal in his day—be controlled and abuses prevented. This concept is embodied in the U.S. constitution and recommended by Americans to everyone else in the world, for once not entirely without reason.

Although few constitutions actually institutionalize the separation of power, in many developed countries something similar has been gradually established. An additional separate power that could not have occurred to Montesquieu is a relatively independent civil service, working for the executive but responsible for implementing laws passed by many different governments over many years and loyal primarily to the constitution. As capitalist business prospered and gained an undue influence over government, the civil service became especially important in representing the common interest as defined by law. Another important “separate power” that has emerged in recent years is independent communication media. They provide a further check on the abuse of government and business power by making the truth known to the public.

All these “checks and balances” as American scholars call them are essential to modern regimes. Where they fail and executive and business power operate unrestrained by law and protected by secrecy, political crisis and disaster often occur sooner or later. When the nation is very powerful the crisis and disaster may involve many other nations in terrible wars. A weaker country may only pay a price internally.

The Soviet Union and the People’s Republic of China are unusual in that they rejected the wisdom of Montesquieu and yet managed to avoid the rapid political or military collapse that has so often ended capitalist dictatorships. This is no doubt due in large part to their ability to command the respect of millions of their citizens by introducing many important elements of modern life such as civil equality and technological development in societies still dominated before the revolution by very reactionary and backward regimes.

But it has proven difficult to move beyond the initial organization of society by the communist party toward an organization that is more open and economically efficient. In Russia the transition failed and the capitalism introduced under the successor regime destroyed the economy as the country itself broke apart. China has not had such catastrophic experiences with reform and in fact has made enormous progress in recent years. But some of the less desirable consequences of that progress now suggest the usefulness of a new look at Montesquieu’s inspired idea.

We give too little thought to the reason why capitalism is so successful at what it does. We are told it is because of the reliance on markets, but that is not the whole story. The key to the affair is surprisingly simple. Under capitalism, unlike every other economic system, owners or managers have the authority to pursue a single goal: profit. Assuming markets operate reasonably well, a smart and energetic individual or group of individuals has an excellent chance of succeeding at such a simple game. Capitalist enterprise measures its achievements by its own criterion, that is, profits, and this too is one of the secrets of its success.

Contrast this with economic activity in premodern societies or under communism. From time immemorial farming has been a family enterprise. Its goals were always complex and included not only producing food, but also raising children, caring for elders, maintaining religious rituals, participating in village life, and so on.

Communist enterprises inherited some of these functions. Often the factory was also a

medical, child care, sports and leisure and social service agency all rolled up in one. Maintaining employment was also important. The enterprise was not free to pursue profit at the expense of these other goals but functioned as a social institution with a broad range of responsibilities. No doubt this rendered communist enterprise less “efficient” than capitalist enterprise, but it nevertheless managed to industrialize huge backward countries such as Russia and China and cannot be counted a failure. But as capitalism is introduced in communist societies a new problem arises from the very simplicity of its goals. The single-minded pursuit of profit by the most active elements in society results in neglect of other vital goals.

This happened in the West as well at an earlier date. But capitalist enterprise in the major Western countries had to contend with a political system shaped by the idea of the countervailing powers. Its adversaries, especially labor, used the levers of the divided state to advance their cause. If the executive was unsympathetic, they could appeal to the legislature or the courts. If no branch of government would help, the media might trumpet their complaints. Honest civil servants might reveal abuses that would otherwise have remained hidden. One way or another, the labor movement was able to exercise influence and soften the harsh rule of a single-minded capitalist class interested only in profit.

The result has not been bad for capitalism. In fact mature capitalism prospers under constraints so long as they are not impossibly burdensome and the government that enforces them is reasonably honest. Good entrepreneurs manage to make money even with legislation regulating the hours of labor, pollution controls, and strict accounting rules. This fact does not prevent businessmen from whining about what they consider “excessive” regulation, but the whining is part of the system of checks and balances and cannot be taken at face value. But of course capitalism did not start out like this. The constraints were gradually added on to a wild system that caused huge devastation to disadvantaged groups and nature while developing the economy.

There is much to learn from this history. To an outsider it looks as though China is recapitulating the Western experience but without the background of a divided state that made it possible for disadvantaged groups to advance their interests gradually and on the whole peacefully. The wild capitalism developing in China today is not subject to the limitations we have grown accustomed to in the West. It is a new capitalism that works wonders of development but at a cost that is not counted in the national growth statistics. This cost returns in political protest and public health problems when those who suffer the side-effects of development sicken or resist.

This situation can be conceptualized in terms of two types of accounting. On the one hand a market economy grows in which all exchanges are calculated and added up to measure the official wealth of the society. On the other hand there is an unaccounted economy of goods that diminish as the capitalist economy expands. Some of these diminishing goods, such as clean air, have costs that show up in the official economic statistics for health care as positive contributions to national wealth although in reality they represent suffering and misery rather than prosperity. Other activities of entrepreneurs interfere with the less profitable and less politically influential agricultural economy in ways that escape all calculation and generate political conflict. None of these effects of rapid capitalist development are unfamiliar to Westerners who know their own history.

However, there is significant difference due to the state of technological development. The technologies of early unregulated capitalism were far less dangerous than those currently employed by Chinese business. It is true that workers in certain sectors such as hat making were

poisoned by the chemicals they used even in the 19th century. Hence the old expression “Mad as a hatter.” And air pollution in London finally reached such fatal proportions in the 1950s that the burning of coal had to be curtailed. But after World War II Western economies employed far more dangerous substances and accordingly in recent years they have come under stringent regulation.

Just because the Chinese economy relies on these recent Western innovations, it manipulates an incredible array of extremely toxic chemicals and produces quantities of pollutants out of all proportion to what early capitalist economies were capable of inflicting on their populations. The latest technology has been imported without the accompanying regulatory framework. The result is unprecedented social and public health problems.

What can China do about this unfortunate situation? It cannot stop developing. That would certainly lead to disaster as so many expectations have been raised by the progress of recent years. But nor can it continue as before. The resistance is growing and threatens stability. And without stability no economy can develop. The government has made tremendous efforts to address the problems, especially in large cities, but nevertheless unexpected crises continually arise. The ultimate solution has not yet been found.

The Western example suggests an approach: begin separating the powers, allowing recourse to a variety of institutions that are sufficiently independent they can be used by disadvantaged groups to gradually impose respect for underrepresented social concerns. The introduction of appropriate checks and balances in the specific domain of technology and development can strengthen the authority of the central government and force capitalism to adjust to the many needs of society and the environment that are not served by unregulated markets. A freer flow of information about technology would be especially helpful in combating abuses that develop unchecked in secrecy.

The Chinese situation is incredibly complex. Perhaps this analogy to Western history is misleading. But China’s growing pains are not likely to go away any time soon. The fact is that modern technology is so dangerous and disruptive it requires a very high level of responsibility and control to yield benefits to society as a whole. Capitalism, with its all too simple goal, must be controlled to achieve this as several centuries of Western history demonstrate. One way or another China too will have to come to terms with the limits of capitalism as a principle of social organization. Of this there can be no doubt. How China will accomplish this will be of interest and concern to the entire world.

The Rational Critique of Rationality

Modern societies are rational in a very special sense I will try to explain here. They are not of course rational in the same way in which mathematics or physics is rational. They are still made up of the confused and emotional creatures we are. But something about the structure of these societies is different from premodern societies in a way that resembles rationality as we find it in disciplines such as mathematics or physics. The question is, what is this something? I believe this question is of special importance in societies engaged in rapid modernization, that is, in the attempt to rationalize their economic and social life.

One answer has it that we are more rational than our ancestors because they believed in myths and we believe in science. There is some truth in this but not much. When you consider the bizarre beliefs that are still popular even in the most advanced countries it is clear that little

has changed. For example, a majority of Americans believe in angels but this doesn't prevent them from functioning in an efficient modern way we think of as rational. What is more, people were capable of making discoveries and improving technology long before modern science was developed. Historians have shown that most of what we think of as modern technology did not require science for its invention.

Another and more interesting theory about modernity points out that modern social systems and organizations conform to principles that in some ways resemble our ideas about rationality. Three such principles are constantly at work in modern societies:

1. exchange of equivalents,
2. classification and application of rules,
3. improving efficiency and calculation of results.

Each of these principles looks like something scientific. Calculation is an exchange of equivalents: the two sides of the equals sign are, precisely, equivalent. All scientific work proceeds by classifying objects and treating them uniformly under rules of some sort. And science measures its objects ever more carefully. Social life in our time has come to mirror these scientific procedures.

The first of these principles characterizes the market. Money is exchanged for an equivalent value in goods or labor. The second and third principles are of course present in all societies, but only in modern ones are they implemented by organizations. Traditional societies classify people and apply rules to them but the classifications and rules are handed down in a cultural tradition. In modern societies organizations such as corporations and government agencies construct the classifications and apply the rules. This makes for great flexibility: classifications and rules can be changed overnight rather than evolving slowly as culture changes. They can be designed consciously for good reasons instead of merely inherited from the past. Similarly, some individuals in every society attempt to make their activities and techniques more efficient and measure how successful they are at it. But only in ours is this the primary work of organizations and only in ours do we find constant progress in both efficiency and measurement.

Once social life is totally structured by market systems and modern organizations, it begins to make sense to think of it as rational. This seems like a good thing. Rationality in science has a unique property: it organizes agreement through argument rather than violence or bribery. Scientists agree because the force of the stronger arguments compels agreement, not because some have more guns or money than others. For a long time Western social thinkers believed that a rationalized society could be a pacified society that would resemble science not only in form but also in the dynamics of consensus building. But it has not proven so simple to eliminate the element of conflict in social life.

Social criticism of modernity begins at the end of the 18th century when the principles of social rationality begin to be applied to human beings. People appear for the first time as resources to be used efficiently by organizations and markets take precedence over more personal forms of appropriation and exchange. When human beings are viewed economically and technically their other capabilities and needs are ignored. At this point the functionalization of humanity calls forth a romantic critique of the rational attitude toward the world. Romanticism is exemplified in the proud claim of the French 19th century novelist Balzac's character Vautrin, "I belong to the opposition called life." The image of life versus mechanism reappears constantly in the critique of social rationality, not just in relation to technology but also markets and bureaucracies.

But romanticism has never succeeded in convincing any large number of people to give

up the benefits of modernity. Another and more important tradition of critique of social rationality stems from Marx. Marx was the first to understand the unfair effects of equal exchange. While many of his socialist contemporaries were convinced that, as Proudhon put it, “property is theft,” Marx dismissed such moralizing complaints and analyzed the actual workings of the market. His initial assumptions were based on the principle of equal exchange drawn from contemporary economic theory. According to this theory goods were valued by their labor content and traded for the most part in equivalents. The problem Marx confronted was how to explain the inequalities of capitalist society on the basis of this principle without recourse to implausible notions of merit. It is well known that he explained this state of affairs with his famous theory of surplus value.

What interests us today about this theory is the form of Marx’s argument. He recognizes the coherence of a socially rational society while also uncovering its bias. This bias stems from the design of the system, in the case of capitalism, the control the capitalist exercises over the length of the working day. The method Marx applied to markets he also applied less rigorously to technology in his discussion of mechanization. There he agrees that technological progress is due to advances in human knowledge and control of nature. In the terminology I introduced above progress follows from the third principle of social rationality. And yet, Marx argues, the form taken by progress accords with the needs of capitalism. Invention is guided by the specific problems capitalist experience in controlling the labor force and not merely by the interest of the human species as a whole in better technology.

Technology studies today in the advanced countries of the world more and more resembles this Marxian critique of rationality. The scholars who study technology are for the most part unaware of the importance of Marx’s contribution and do not agree with his critique of capitalism. But unwittingly they are reproducing the very structure of Marx’s argument in many contexts of research. Of course the issues we discuss today in technology studies are not confined to the factory as was Marx’s critique. Technology has spilled over into every area of social life. Medicine, education, sports, entertainment are all highly technologized and technology has widespread effects not just on human beings but also on nature. And in all these areas, as in the factories Marx studied, there are controversies and struggles over how to organize a rational way of life.

The period since World War II is characterized by the emergence of a politics of technology which has gradually refuted the old belief that a more rational society would be able to avoid conflict and reach agreement through consensus. We do not live in the expected technocratic order in which scientists explained to the rest of us the one best way of doing things. Instead, we have seen the rapid proliferation of lawsuits, demonstrations, and political controversies over all sorts of technical questions. Money and power, if not violence in most cases, continue to play a role in decisions about technology. Those who had earlier studied Marx were not surprised since these conflicts merely repeated in new arenas the struggles he analyzed in the 19th century.

Today we no longer expect technical progress to resemble the old image of scientists bending over an experimental apparatus and nodding their heads in agreement. Indeed, we no longer believe that even scientists find agreement so simple. Our model of technical advance increasingly resembles ordinary politics. Diverse interests now contend for influence over the design of technologies just as they have always fought for influence over legislation. Each alternative design of medical technologies, transportation systems, the Internet, educational technology, and so on has its advocates whose way of life or wealth depends on control of

technical designs. They argue more or less rationally for their point of view and criticize each other. Technological controversies appear on the front pages of the newspapers daily and we are aware that we have entered a new era in which the rational critique of rationality is becoming the basis of political life.