Irresistible forces vs immovable objects: when China develops Productive Nanosystems

Tihamer Toth-Fejel*

This paper examines a small but crucial part of China’s history, describes some of China’s significant advantages and disadvantages, and examines how they will interact with different aspects of nanotechnology. The predictive heuristics used include understanding history, building on successful predictors, analysing trends, and distinguishing between engineering and science. China’s history has much to teach the world, especially if we look closely at the mistakes that led to its decline six hundred years ago. China is an economic powerhouse that has grown at 10% per annum for decades, and is graduating 350,000 engineers every year—yet it has environmental problems that threaten to poison the country, and social tensions that could tear it apart. Projections of current trends result in either “The Chinese century” or in complete disaster for the most populated nation on Earth. Adding nanotechnology to the mix only exacerbates the problem of predicting what will happen. But the power of nanotechnology makes accurate projections extraordinarily important.

Introduction

It’s difficult to make predictions, especially about the future.

Yogi Berra

There are a number of important ways to predict the future:

1. Prophets: Listen to those people who have predicted correctly in the past—especially when their predictions were contrary to popular opinion, and especially when they provide rational reasons;

2. History: Understand the past, and look for underlying patterns and how they interact with each other;

3. Trend Ranking: Identify the fastest accelerating and longest lasting trends, and their effects on other trends that are growing more slowly or are more recent. For example, business cycles and cultural fads move quickly, but other trends have been maintained for over a thousand years: (1) the accelerated progression of technology; and (2) the

* E-mail: Tihamer.Toth-Fejel@gd-ais.com. Tel: +1 (734) 480-5404


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recognition of human rights for more and more people (e.g. women, other races);

4. **Engineering vs Science**: It is relatively easy to predict new engineering achievements—but impossible to predict the occurrence of any new scientific discovery. For example, the discoveries of penicillin, infrared radiation, Uranus, the thermoelectric effect, and Teflon were completely new discoveries; they were accidently discovered while looking for something else (if we knew what we were going to discover, we would have already discovered it). In contrast, Kennedy’s challenge to land on the Moon was a relatively simple engineering problem that adequate money and manpower could solve on schedule;

5. **Will to Power**: Shape the future to meet our needs and desires—as proposed by progressive thinkers from Fredrick Nietzsche to Alan Kay.

With respect to China, the problem of predicting the future is exceptionally difficult because of the wild contradictions of extremely powerful forces within China.

China’s economic growth is almost unprecedented, and the country is investing serious money in nanotechnology, manufacturing, and their space programme. However, China has some very serious problems. We often hear about the environmental disasters—as one person put it, Americans have outsourced their pollution to China in order get around the Clean Air Act.1 But if history is any guide, once the per capita income of China reaches a certain level (~$4000–$10,000 in 1985 dollars, depending on the type of pollutant)2 it can afford pollution controls. Unfortunately, the current per capita income of China is only $2,556,3 although we hope and expect that nanotechnology will eventually lower the cost of remediation and prevention to that price. However, China has other, more serious problems—problems that can’t be fixed even with precise control over individual atoms: one foreboding statistic is that China is the only country in the world in which the suicide rate for women is higher than it is for men.

**China’s fall from empire**

In order to predict the future, we must understand the past. With China having the longest history of any major nation, this is no easy task. One of the most informative periods of Chinese history is how it moved from the world’s most powerful global state to a weak and vulnerable one.

In 1421, Admiral Zheng He led of huge armada of Chinese ships, some reputed to be four hundred feet long, “to proceed all the way to the end of the earth to collect tribute from the barbarians beyond the seas and unite the whole world in Confucian harmony.”4 This is rather ironic, because Confucius himself wrote in the *Analects* that “While his parents are alive, the son may not take a distant voyage abroad. If he has to take such a voyage, the destination must be known.” This may have been true for Zheng He, since his parents are thought to have been

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slaughtered by the Chinese while putting down the Yannan rebellion, but unlikely for the thousands of other sailors who manned the famed *Treasure Fleet of the Dragon Throne*. The armada not only returned, but brought back tribute. However, it had no lasting effect on policy or government. When the emperor died, his son immediately stopped the voyages of exploration. After the son’s short reign, the grandson sent Zheng He on one more voyage, but after both the grandson and Zheng He died, the fleet was left to rot and further ocean-going ship construction was halted.\(^5\) Subsequent policy curtailed trade and cultural exchange to the point of outlawing ocean-going ships and devastating a strip of land 30 miles wide by 700 miles long along the southern border.\(^6\)

Before 1100, the iron works in northern China produced around 125,000 tons per year, which is significantly more than Britain achieved seven centuries later. In 1736, just as the ironworks at Coalbrookdale, England (one of the birthplaces of the Industrial Revolution) were beginning to boom, the great blast furnaces and coke ovens of Honan and Hopei were abandoned. These Chinese ironworks had been great before William the Conqueror had landed at Hastings, but they would not resume production until the twentieth century.\(^7\)

**China’s fall: the fundamental question**

In addition to their huge navy and heavy industry, the Chinese possessed the inventions of gunpowder, paper, printing, the navigation compass, complex clockworks, and others that Marco Polo didn’t even dare publish for fear of being considered insane. With all these technological advantages, why did China turn inward and deliberately stagnate? Will they do it again? Will the United States? Could the entire world?

**China’s fall: theories**

In fifteenth century China, one problem was political infighting between the palace eunuchs and the Confucian advisors. Because seafaring and trade was overseen by the eunuchs, and were a primary source of their power and income, the Confucians attacked seafaring on philosophical and practical grounds. They went so far as to hide or destroy Zheng He’s official account of the voyages because a powerful eunuch wanted to read them in order to stimulate interest in naval expeditions. Another part of the problem was the disappearing tax base as inflation wrecked the country, as the government monopoly on international trade disappeared, and as the wealthy avoided paying taxes. Finally, as the Mongols increased their attacks, citizens retreated from adventurous thought and followed the Confucian advice of memorizing the classics and avoiding new and foreign ideas.\(^8\)

Environmentalist and author Bill McKibben cites the Chinese abandonment of its voyages of exploration as an example of how a society can relinquish technology and expansion, which he sees as a good thing.\(^9\) However, this is a self-destructive strategy, as the Chinese discovered

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\(^5\) Levathes, *ibid.*  
\(^8\) Levathes, *op. cit.*  
when the Europeans sailed into their harbours in the 1600s, instead of the Chinese sailing into European harbours in the early 1400s.

Biogeographer Jared Diamond argues that environmental destruction has annihilated several civilizations, and for Easter Island, he is almost certainly correct. However, his argument does not seem able to explain the apparently voluntary stagnation of China. In addition, science and science fiction author David Brin points out that, in the long run, Diamond’s prescription of eco-conservative paternalism will destroy civilization just as surely.

Environmentalist John Greer admits that resource depletion played a limited role in the contraction of China’s civilization, but he proposes that when the maintenance costs exceeded the imperial government’s resources, it caused the loss of infrastructure that was the underlying root of China’s problems. He goes on to claim that the reason China did not collapse completely (like the civilizations described by Diamond) is because of (1) the long-term sustainability of traditional Chinese agriculture, (2) a reduction in complexity of sociopolitical organizations, and (3) steep declines in population. Unfortunately, while his economic analysis admits that higher technology effectively increases resources, his model does not explain why a society would give up such technological advantages as ironworking and ocean-going ship building.

In contrast to resource and maintenance issues, futurist Paul Werbos makes the argument that:

“...certain patterns... tend to get repeated over and over again in history. As civilizations age, and idealism wanes, there is often a kind of trend of weaker creativity, then increased self-preoccupation, then increased corruption at the centre of power and increased cover-yourself rigidity in all the various hierarchies in society, increased internal defensive mechanisms to protect from the resulting risks, reduced democracy (democracy defined in broad terms)... on a trajectory to collapse either in civil war and disintegration or by foreign invasion.”

If this is the case, then the fifteenth century Chinese navy was simply dragged down by the crushing force of the downward pattern. However, this “arc of civilizations” theory does not offer a causal reason for the Chinese self-withdrawal, and if anything, China’s recent rise is proof that civilizations can be re-energized (while Egypt perhaps shows that sometimes they are not).

The Chinese decline seems to prove American historian Fredrick Turner’s 1893 theory for the basis of American society. Turner wrote, “It was not legal theory, precedent, or tradition that was the source of America’s egalitarian democracy, individualism, and spirit of innovation. It was the existence of the frontier.” The Turner thesis convincingly claimed that not only American culture, but progressive humanist civilization in general, resulted primarily from the Ages of Exploration—first the exploration of the Mediterranean Sea by the Greeks, and then of the New World by Europe. Turner presented his paper just three years after the American frontier had been declared closed, so he was worried. He asked, “What if the frontier is truly

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11 David Brin, Lifeboat Foundation e-mail, Mon 10/8/2007 2:19 PM. See also his review of Diamond’s *Collapse* at http://www.davidbrin.com/collapse.html
13 Paul J. Werbos, Lifeboat Foundation e-mail, Sunday 10/7/2007 9:09 AM
14 Paul J. Werbos, ibid.
gone? What happens to America and all it has stood for? Can a free, egalitarian, and innovating society survive in the absence of room to grow?” The question was a bit premature in Turner’s time, since more land grants were actually made after he presented his ideas than before, but now his question seems pertinent because there is no more frontier—everything is owned. Robert Zubrin, founder of the Mars Foundation points out that the necessity of a frontier is the primary reason we need to expand into Space, and worries about the loss of vigour of American society that he sees all around.\textsuperscript{15} If the Turner thesis is true, then the reason that the United States hasn’t descended into totalitarianism is that the frontiers of technology have staved off the worst effects of a closed society. The same effect would also hold true for China.

Historian Arnold Toynbee examined the rise and fall of 26 civilizations and proposed a three-step process to explain their destruction. First, there must be a suitable challenge to a people for a civilization to develop. If the challenge is too small, then the civilization does not develop in the first place (as in a tropical paradise). If the challenge is too great, then it destroys the civilization before it develops.

Second, a small minority of the civilization withdraws in some manner from the central majority and undergoes a creative transformation to solve the challenge. The true crisis arises when the “creative minority” introduces the solution to the greater body of the civilization. If it is accepted, then the civilization is maintained and grows; if the solution (and the minority proposing it) is rejected, then the civilization falls.

Third, if the creative minority is not given the opportunity to create, the civilization will fall. This can happen in two ways: The majority group may have enough power to create, but lacks the talent, so the creativity is second rate. Alternatively, a foreign group gains power over the opportunities of creativity and makes it destructive to the civilization.\textsuperscript{16} It is difficult to pinpoint the challenge itself—for example, what challenged the Maya and the Aztecs? Was it the responsibility they felt of sacrificing humans to ensure that the sun would rise the next day? Or something more realistic or prosaic—a particularly warlike neighbouring tribe that needed to be subdued?

Brin points out that Admiral Zheng He’s fleet was the product of one exceptional emperor’s whim. Just like the Great Wall and the Forbidden City, it was an expression of Imperial Will, and not an outgrowth of society’s own imperatives. (Ironically, renunciators like Diamond perceive this “Governmental Will” approach as our salvation.) Brin also points out that the Apollo landings were similar in that no benefits accrued to the general population (other than from the landing itself).\textsuperscript{17} In contrast, social needs drove the subsequent commercialization of space vessels that paid for their construction (e.g. communication, broadcasts, and GPS satellites), hence their continued success.

Brin fears the powerful feudal/hierarchical/despotic governments that can make far-reaching space exploration possible, not only because such governments can drastically change their minds as other priorities surface, but also because they suppress free speech and criticism,

\textsuperscript{17} David Brin, \textit{op. cit.}

and are self-perpetuating.\textsuperscript{18} Liberal societies such as ours should fear totalitarian ones to some extent, especially when the central tenets of tolerance, open-mindedness, and self-criticism make it impossible for liberal nations to defend themselves.\textsuperscript{19}

Chris Phoenix, co-founder of the Center for Responsible Nanotechnology, visited China and later pondered the effects of the many diverse disasters hitting the United States—for example, what would happen if a nuclear “9/11” was followed by bird flu in conjunction with peak oil? Would we be tempted to close our borders, retreat from space exploration, denigrate science, and generally stagnate? (The evidence for all four is around us.) Is it conceivable that this could happen to enough modern nations to damage the world trade on which our high technology depends?\textsuperscript{20}

Yale historian Paul Kennedy claims that China’s problem was its overemphasis on order and community (well illustrated by the fable of the flying machine,\textsuperscript{21} and by the recent movie \textit{Hero}), manifested as an arrogant belief that China was the centre of the world—the Chinese were already perfect, so there was no reason to consider improvements. Kennedy also argues that when a nation’s deficit spending for its military grows too high compared to the industrial productivity of that nation, it goes into decline.

Statistician and author Michael F. Flynn points out that while the Chinese were far advanced in many sciences, they didn’t have Aristotle to tie them all together with an elegant philosophical foundation.\textsuperscript{22} Nor did they have Aquinas to provide a reason for taking the divine Emperor’s scientific toys and bringing them to the peasants to raise their standard of living.

So the Western world has at least two advantages that China did not have—a cultural value on progress, and a philosophical grounding for humanistic values for ensuring that individuals benefit from that progress. Will these advantages be enough to prevent the United States and the Western world from imitating fifteenth century China?

\textbf{China today}

While China certainly has the scientific foundation to succeed in a wide variety of endeavours (e.g. landing human beings on the Moon, developing nanofactories), it is not clear that individual human beings are valued as much they are in Abrahamic cultures—certainly not by the Communist philosophy that drives China’s government. That being said, the personal efforts by Premier Wen Jiabao after the recent Sichuan earthquake have given a sympathetic face to the government, which may be indicative of further rejection of the ideology that has racked China for many decades.\textsuperscript{23} It is possible that the government’s unprecedented openness to criticism and media freedom is a result of lessons learned from the bird flu epidemics. However,

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\item[18] David Brin, \textit{op. cit.}
\item[20] Chris Phoenix, e-mail, 10 July 2007
\item[22] Michael Flynn, De Revolutione Scientiarum in ‘media tempestas’. \textit{Analog}, July/August 2007
\end{enumerate}
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cynics might point to the government’s pandering to world opinion in preparation for the Beijing Olympics. In either case, it could be difficult for China to return to the “old ways” of doing things.

Asia expert Orville Schell summarizes China by pointing out that it “is the most unresolved nation of consequence in the world”, defined by its contradictions and its massiveness—the margin of error in the estimate of its population is greater than the population of France. In order to think about China and its potential futures, one must hold “two utterly contradictory views: on the one hand, a robust and awesomely growing China; on the other hand a brittle China, parts of it truly hellish.”24

The irresistible force: China triumphant

Many analysts have concluded that the 21st century will be “the Chinese century” because China has many advantages as a nation, including:

- An economic growth rate of 9 to 12% a year—for decades
- Relatively peaceful borders with all neighbours
- An astronaut sent into space on a Chinese-built rocket25
- Economic, non-threatening engagement with the entire world
- Growing soft influence worldwide26
- 200 million Chinese recently raised out of poverty
- Private savings rate of 40% (it’s 1% in the USA)
- 300 million people with cell phones, and the best cell phone service in the world
- A superb freeway system (over 22,000 miles) built in only a few years
- New building construction everywhere
- 150 million people online
- 350,000 engineering graduates a year
- One third of the world’s direct investment
- Huge trade surplus
- Government that says that it is open to reforms.27

Futurist Brian Wang noted that while many of China’s official numbers are most likely exaggerated or inaccurate, the economic size and growth numbers are fairly accurate. This is because they can be indirectly confirmed by the weakness of the US dollar, which is off 65% against the euro in seven years, and China has a significant chunk of our world currency reserves.28

The immovable object: imploding China

However, keeping the contradictions in mind, China has some serious disadvantages as a country, including:

27 Michael Bristow, China rules out West’s democracy. BBC News, Beijing, 14 October 2007
28 Brian Wang, Lifeboat Foundation e-mail, Friday 5/25/2007 3:27 pm
• A totalitarian government, with no change in sight. The people lack democratically recognized rights such as freedoms of speech, press, and assembly (Article 35), and freedom of religion (Article 36), even though these rights are guaranteed by the Chinese constitution.

• A lack of experience with democracy. On the other hand, more people voted in the Chinese version of “American Idol” than the entire voting population of the United States, so the Chinese people are learning quickly. But democracy requires that unpopular minorities speak out, sometimes rudely but always critically. An environment in which offending the government can be fatal results in a culture that values polite obtuseness over direct and open confrontation.

• Ruthless suppression of dissidents.

• The Chinese internet is censored.

• Public and official amnesia about history such as the 1989 Tiananmen Square massacre.

• Not much arable land; therefore a growing dependence on imported food.

• The stock markets are grossly manipulated.

• A dependence on economic growth, which the government uses to convince domestic supporters and foreign investors to support it. If that growth stops, then an angry middle class will likely join the disenfranchised to destroy the Communist party.

• The shallowness of the rule of law. More precisely, clan rule trumps the rule of law.

• The Chinese attitude towards the rule of law is captured in the saying, “Heaven is high, and the emperor is far.”

• The government gives unreliable statistics. For example, the government claims 644,000 engineering graduates for 2004, but half of them are technicians, and maybe one in ten could be hired in multinational companies. In fact, many numbers are unreliable.

• There are between 60,000 and 150,000 instances of social unrest (most of them disorganized mutinies) per year, and the number is increasing. What is driving this unrest?

• Widespread corruption of government officials.

• Widening disparities between rural and urban areas.

29 Michael Bristow, op. cit.
33 Schell, op. cit.
36 Schell, op. cit.
38 Gerald W. Bracey, Heard the One About the 600 000 Chinese Engineers? Washington Post, 21 May 2006; Page B03. http://www.washingtonpost.com/wp-dyn/content/article/2006/05/19/AR2006051901760.html
40 Sorman, op. cit.
The privatization of state-owned properties and companies, passing ownership to a small number of elite citizens

Chronic unemployment (many of the “engineers” are pushing brooms)

The unevenly applied one-child policy has enraged rural Chinese people so much that they have attacked and killed Party leaders

Environmental pollution
- Two-thirds of its energy production is from dirty coal, growing at the rate of one to two new coal-fired plants per week
- 30% of China has acid rain; 75% of lakes and rivers are polluted or dry
- China has sixteen of the twenty most polluted cities in the world
- Some industrial parts of China are barren wastelands

A huge and growing gulf between 200 million urban rich and the one thousand million rural poor

An appalling record of industrial disasters

Wide disparities between educational opportunities

A suicide rate higher for women than for men. (This statistic hints at the low status and powerlessness of women in China.)

The overall ratio of males to females born in China in 2005 was 118.6 to 100, and in some areas it was as high as 130 to 100

The population is aging rapidly, with no pension or welfare

A broken healthcare system

Rising inflation—capital inflows are pushing up wages and expanding the monetary base, which inflates asset bubbles in stocks and property.

Simple predictions

How can such contradictions be reconciled?

John Feffer, co-director of Foreign Policy in Focus at the Institute for Policy Studies, writes that

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42 Schell, op. cit.


44 Davalos, op. cit.


“Predicting what will happen with China is a fool’s errand. China is the exception that proves so many rules wrong. It is a Communist system that has managed a transition to ‘capitalism with Chinese characteristics.’ It has fostered market growth without much political reform. And it has pulled huge swaths of its population out of poverty and illiteracy faster than all the well-paid development professionals in the West… “For every fact that is true about China, the opposite is almost always true as well, somewhere in the country.” The dataset is so large that it defies generalizations.”

Caveats aside, one way to increase the reliability of predictions is to listen to people who have made accurate predictions in the past. One of the most impressive predictions made in the last century was Herbert Meyer’s prediction that the Soviet Union would implode. As a senior official in President Reagan’s administration, Meyer also had the clout to help make it happen. Recently, he pointed out one of the biggest differences between Western and Chinese economics: our manufacturing decisions are based on market needs and profit opportunities, but in China the decision is based on the opportunity to create jobs for the newly urbanized millions. The result is that while Americans are addicted to the low prices, China is addicted to creating jobs through manufacturing. This codependency of Chinese economic development and U.S. economic growth will continue until it hits a hard limit—in this case one problem is that China’s manufacturing growth requires the same energy supply that we want: oil.

Meyer also points out that Europe and Japan are dying out simply because they don’t wish to have children. The U.S. would be dying out also, if not for our recent, mostly Latino, immigrant population. China’s growth rate has plummeted, although unlike Russia, because of its younger demographics it hasn’t started shrinking yet. However, the cultural emphasis on boys over girls has a large political side effect, especially when combined with the one-child policy. In the short run, this has resulted in large numbers of female infanticides and gender-selective abortions; in the long run, it is resulting in kidnapping and slave-trading of women.

Some have claimed that this gender imbalance might be caused by differing rates of hepatitis B, but with a re-examination of the evidence, one of the two main proponents of that hypothesis has since changed her mind. The political implications are significant; as Meyer points out:

“The birth rate in Russia is so low that by 2050 their population will be smaller than that of Yemen. Russia has one-sixth of the earth’s land surface and much of its oil. You can’t control that much area with such a small population. Immediately to the south, you have China with 70 million unmarried men—a real potential nightmare scenario for Russia.”

This gender imbalance is also related to the rate of suicide for women in China. In no other nation on Earth do women kill themselves more often than men do, and for Chinese women between 20 and 35, it is the number one cause of death. It is also within the childbearing age range, and traditionally when they are allowed to marry and conceive their one child. What kind

51 Feffer, *op. cit.*
55 Herbert Meyer, *op. cit.*
of oppression or stress is causing this tragedy? Even Islamic society, with its long history of honour killings, multiple wives, and other oppressive measures against women, is not this destructive against women. There seem to be a number of reasons: first, the social security system in China is woefully inadequate, and couples depend (as they have traditionally done) on the eldest son for support, while the daughters become part of the husband’s parent’s support structure. So there is a strong economic incentive to abort or abandon female infants. Second, studies have shown that abortion significantly increases suicide rates.\(^{56, 57}\) The one-child policy increases pressure on both of these factors.

One of the two long-term trends in civilizations has been the extension of human rights to groups previously considered non-human; first foreigners, then other races, and finally women. The pace of nanotechnology will determine whether the next group will be animals with enhanced brains, or artificially intelligent computers, or unborn humans. We do not understand the scientific principles involved well enough to predict if the first two groups can achieve human-level intelligence, much less when. For all three groups, if there is enough of an incentive to keep them defined as non-human, then it will take much longer—consider how long it took to overturn slavery in the United States, even after the founding fathers recognized its immorality and divisiveness. If this long range trend continues, and if the demographics of pro-life and pro-choice groups in the United States continue as heretofore,\(^{58, 59}\) Roe vs Wade may be overturned in another generation. But because of the political situation in China, there is no debate on the subject (even one as rancorous as in the U.S. would be better). Debate or not, the demographic cliff caused by the one-child policy looms precipitously.

Because of the population lag effect (the age distribution in China hasn’t reached an equilibrium yet), China will run into the same problem that American baby-boomers are beginning to face, only China will be much worse because their distribution is much steeper, plus they don’t have significant numbers of immigrants to ameliorate the problem.

Why are the birthrates so low? Meyer points out that the post-modern secular state (whether Japanese, Chinese, or European) requires a traditional religious society birthrate to sustain it.\(^{60}\) Demographic expert Ronald Inglehart agrees, “Secularization has a powerful negative impact on human fertility rates”,\(^{61}\) and so do many others.\(^{62}\) This certainly seems to be the case in the United States, in which the (typically Catholic) Latino TFR (total fertility


\(^{60}\) Meyer, op. cit.


\(^{62}\) Renzo Derosas and Frans van Poppel (eds), Religion and the Decline of Fertility in the Western World. Springer (2006)
rate) is 2.80, while the Caucasian TFR is 1.85.\textsuperscript{63} Also, among U.S. singles, a majority of Christians want to have children, while a majority of atheists are unsure.\textsuperscript{64}

The problem with low birthrate is that as it drops below replacement, the population ages, thus resulting in fewer workers to support more retirees. With a larger tax burden on the smaller group of working age people, young people delay marriage and procreation. The economic investment and cultural reversal needed to arrest this downward spiral is staggering. Adjusted for inflation, the post-World War II tax credit of $600 per child would be $12,000.\textsuperscript{65}

Related more directly to religious issues, it should be noted that while China is the oldest large continuous civilization, its government has set itself against the oldest continuous institution on Earth: the Catholic Church. Historically, any government that has set itself against the papacy has eventually crumbling, starting with the Roman emperors who martyred the first 200 years of popes, and continuing with warlords, monarchs, dynasties, and dictators through the ages, including Napoleon and Hitler. When an advisor warned Stalin against conflict with the Catholic Church, his contemptuous reply was, “How many divisions does the pope have?” Stalin was wrong; not because the Catholic Church has any secret military or supernatural power (à la \textit{Indiana Jones and the Raiders of the Lost Ark}), but because it has, like all the world’s major religions, a more accurate and complete perception of human nature than any totalitarian government. \textit{These accurate perceptions of reality determine long-range survival.}

Reportedly, when Pope Pius XI heard of Stalin’s remark, he replied, “Tell my son Joseph he will meet my divisions in eternity.” Actually, the Soviets didn’t need to wait until eternity—they met those divisions much earlier—in 1979 in the streets of Warsaw when John Paul II visited his homeland. Those divisions flocked to the pope because, as one young physics student put it, “I want to… live without being a liar.” Living in an empire of lies has a corrosive effect on human dignity, and the people living under Soviet communism knew it first hand.\textsuperscript{66} Is China another empire of lies on the scale of the USSR? There is no doubt that China is rife with lies and secrecy, but it is not clear that it is as bad as in the USSR, or even if the tipping point is the same for both countries.

With its atheistic theology, the Chinese Communist Party (CCP) sees all religions as threats, hence their strong attacks against the new spiritual practice of Falun Gong; they tortured tens of thousands of its members and murdered many (422 known as of July 2002).\textsuperscript{67} Muslims are also harassed and sometimes arrested. At least one 38 year old Muslim leader died of a “heart attack” while in police custody.\textsuperscript{68} These attacks on religion do not bode well for the CCP.

Writing in 1987, Paul Kennedy correctly predicted that China would grow into a world economic powerhouse because he saw that the Chinese leadership was recognizing the

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\item[65] Meyer, \textit{op. cit.}
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deficiencies of Marxist economics and making changes. He did not think that the Soviet leadership was flexible enough to make those same changes. And while he saw the huge economic and political problems of the USSR, he confidently wrote, “This does not mean that the USSR is close to collapse” (his emphasis) and warned that “there is nothing in the character or tradition of the Russian state to suggest that it could ever accept imperial decline gracefully.” Truth to tell, there is no historical precedent to the peaceful collapse of the Soviet block—it is one of the greatest miracles of the twentieth century. As Kennedy points out, “None of the overextended, multination empires…the Ottoman, the Spanish, the Napoleonic, the British, ever retreated to their own ethnic base until they had been defeated in a Great Power war.” (his emphasis). Normally, empires collapse unpredictably and at great cost.\(^\text{69}\) Unfortunately, Kennedy’s predictions regarding China stopped at 2000.

Orville Schell thinks that the best everyone can hope for in China is steady piecemeal change. The contradictions will probably not be fatal as long as the Chinese have continued economic growth that can absorb some of the problems. However, what happens when that growth is interrupted, either from inside or outside China?\(^\text{70}\)

There are reasons to be optimistic, partly because it appears that China’s middle class is beginning to form and will continue to grow between 2015 and 2020,\(^\text{71}\) the expected timeframe for the emergence of Productive Nanosystems. In addition, China plans to double its energy infrastructure between now and 2020, so it should be able to buy the newest and most efficient equipment. Therefore, China will shift to cleaner methods of using coal (shutting down older, dirty plants), and utilize larger amounts of hydro, nuclear, wind, and solar power.\(^\text{72}\) This continued flow of money and energy would help keep the country from breaking up and the unrest from being bad enough to disrupt the country.

However, the self-contradictory lies told by totalitarian forms of government always breed resistance, even in environments full of material wealth. As Mahatma Gandhi put it, “…through history the way of truth and love has always won. There have been tyrants and murderers and for a time they seem invincible but in the end, they always fall—think of it, always.” This is because human beings are not robots or animals, and we can’t help needing and desiring truth. The only problem is that it may take a few generations for a tyrannical government to fall.

The flip side of totalitarianism is freedom, and the average Chinese has reservations about it. Interestingly, these reservations make sense because psychological studies have shown that too many choices do not make people happy (a probable reason why the suicide rate in the wealthy West is so high). Is it a Western idea that too few choices and grinding oppression is worse? Probably not, since historically, the virtual enslavement of desperately poor multitudes by a few rich incompetents often leads to violent rebellion—even in China. At any rate, the current rulers of China are quite competent, and they will do their best to stay in power by promoting stability. Unfortunately, mature nanotechnology is guaranteed to make stability impossible.

\(^{69}\) Kennedy, \textit{op. cit.}

\(^{70}\) Davalos, \textit{op. cit.}


\(^{72}\) Brian Wang, China alternative energy, energy efficiency and clean transportation. http://advancednano.blogspot.com/2006/06/china-alternative-energy-energy.html
China and nanotechnology today

Tools and human ingenuity are the main producers of real wealth today. Nations and companies that possess the technology for atomically precise control of bulk products will become extremely wealthy and powerful.

It is not certain how clearly the Chinese leadership recognizes this, but they are funding namijishu—i.e. nanotechnology—to the extent of $1.11 billion (1.11 × 10^9 USD), a level second only to that of the United States (after adjusting exchange rates and reflecting purchasing power parity). China was also second only to the U.S. in terms of published peer-reviewed journal articles on nanotechnology, and ranked third (behind the U.S. and Japan) in nanotech patents.

To make sense of these advances in nanotechnology, one may to examine the miniaturized electronics market. Because of its huge internal market, China does not need to be a technology leader in electronics to be a powerful economy. For example, it makes no sense to invest in very expensive “bleeding edge” chip manufacturing when the Chinese domestic market for “trailing edge” products consumes about two-fifths of the world’s semiconductor production.73

But does this same strategy work for nanotech? Currently, nanotechnology is a fad in China, inspiring companies to boost profits by adding a “nano” label to their products (e.g. nano-gas, nano-toothpaste and nano-beer). Despite this popularity, very few foreign nanotech products have actually penetrated the Chinese market. One major exception is the atomic force microscope (AFM), being sold especially to universities and multinational-funded technology centres.74 These inroads are crucial because AFMs and similar nano-instrumentation tools are the “picks and shovels” of the nanotech gold rush. As Mike Postek, Program Manager of the Nanomanufacturing Program at the National Institute of Standards and Technology, points out, “You can’t make it if you can’t measure it”.75 And if you can’t do it quickly, cheaply, and accurately, then you still can’t build it. That being said, AFMs are only the first generation of nanotech tools—significant work must still be done before anyone develops the next generation of nanomanufacturing systems.

Unfortunately, not only is nanotechnology ill-defined, nobody knows how it will develop. The broad approaches of top-down and bottom-up are well distinguished, but there are overlapping techniques that combine approaches and muddle the vocabulary. This lack of a nomenclature makes predicting the impact of nanotechnology on China much more difficult. Some broad outlines are clear: Mihail Roco, Senior Advisor for Nanotechnology, National Science Foundation, has delineated four major phases:76

1. Passive nanostructures—The current “stone age” of nanotechnology takes advantage of size effects that work when the product consists of a wide distribution of size, location, and orientation of nanostructure. Transparent sunscreen works because the titanium oxide nanoparticles don’t need to be exactly the same size and shape. China has considerable international presence in this area of nanomaterials, nanocomposites, nanocoatings, and nanoparticles.77 There are a number of Chinese manufacturers making

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74 Wolfe, ibid.
76 Mihail Roco, Nanotechnology’s future. Scientific American, July 2006, p. 21
77 Wolfe, op. cit.

When China develops Productive Nanosystems

T. Toth-Fejel

1. When China develops Carbon Nanotubes

Carbon nanotubes, but as in most places around the world, the quality (from an atomic point of view) is abysmal, and will undoubtedly remain so until more precise manufacturing methods are developed.

2. Active Nanodevices—The National Nanotechnology Initiative funds projects that examine how nanostructures (between 1 and 100 nanometres) exhibit novel properties; i.e. change state, transform and store information and energy, and respond to stimuli. The Chinese Academy of Science notes that “nanodevices ... are of special strategic significance, as they are expected to play a critical role in socio-economic progress, national security and S&T [science and technology] development in China.” They also announce their own efforts in developing nano-storage devices, single-electron or molecular devices, and biotransducers. 78

3. Complex Machines—There is some debate over whether the technology that creates 45 nanometre pitch semiconductor chips is nanotechnology, because it uses top-down techniques. However, what is even more important about it than size is that semiconductor chips made the mathematical abstraction of computation (particularly the finite state machine, and the more complex Turing machine) low enough in cost to change the world (via the computer and the internet). The reason this computation is so important is that nanomachines with this complexity will be able to implement error correction codes, which can improve molecular manufacturing by over fifteen orders of magnitude. By comparison, while most good chemical processes have error rates around 1 in 100; protein synthesis has error rates of 1 in a few 1000s, DNA has error rates of 1 in a million, and computers have error rates better than one in 10^23 operations (our error detection and correction codes are better than those developed by evolution, and significantly better than the stochastic methods used by synthetic chemists). As Moore’s Law progresses and spreads out to related fields, the implementation of a physical Turing machine that manipulates atoms instead of bits will change the world again.

4. Productive Nanosystems—Four major approaches have been identified for building nanosystems that can manufacture atomically precise products; two tip-based nanofabrication approaches (diamondoid mechanosynthesis and the two-step process of patterned depassivation followed by atomic layer epitaxy), and two biomimetic approaches (DNA origami and bis peptide synthesis). China achieved the DNA origami technique within a year after Rothemund’s seminal work was published, and with 350 000 new engineers graduating every year, it is highly probable that they are close behind on the other approaches.

In this article, we are concerned primarily with phase 4—Productive Nanosystems—because this phase represents the most powerful technology, and requires the most thought. It is doubtful that the first working prototypes of such systems will be available within five years, but based on current progress and Moore’s Law, it is likely that they will be available in ten to fifteen. The most important property of Productive Nanosystems is that they not only produce useful products, but they also make atomically precise tools for making other (and better) Productive Nanosystems, leading to

79 Qian Lulu et al., Analogic China map constructed by DNA. Chinese Science Bulletin Vol. 51, No 24 (December 2006)

the inexpensive manufacturing of atomically precise bulk material and devices.

Computer scientist Alan Kay has asserted that the most effective method for predicting the future is to invent it. The Foresight/Battelle Technical Roadmap for Productive Nanosystems is probably the most proactive attempt to use this method.\textsuperscript{81}

N.Y. Times Asia journalist Joseph Kahn notes that China’s leadership wants “fast growth, a nonaligned foreign policy and political stability.”\textsuperscript{82} But in many cases, especially in unstable economic conditions driven by technological innovations, all three are not possible to maintain at the same time. If China must choose between them, then which goal will take priority?

Mike Treder, co-founder of the Center for Responsible Nanotechnology, predicts that political stability would be valued above all else. The regime in power will want to stay there—even at the price of sacrificing growth, or making concessions in foreign policy.\textsuperscript{83} The problem is that if they sacrifice technological growth, then they will be left behind by countries that continue pressing forward.

The main concern regarding China is the potential for radical breakdowns such as war, revolution, severe economic collapse, catastrophic pandemic, or ecological disaster (a magnitude 7.9 earthquake isn’t severe enough, despite the fact that it may hint at problems—such as concrete rubble with not a single strand of rebar sticking out). We also need to recognize that with a country as large and powerful as China, even an internal breakdown could seriously disrupt the rest of the world. Our concern is not only that China could cause some sort of radical breakdown in the world system, but also that China could suffer some sort of radical breakdown, which in turn would affect the world system. So Treder suggests that we watch for symptoms of such an impending breakdown, coupled with judicious contingency planning.\textsuperscript{84}

Because of the lack of reliability of the ‘rule of law’, many companies have been reluctant to do proprietary work in China. However, other companies—such as Veeco, General Electric, Intel, Accelergy, and Rohm & Haas—have not been as concerned about intellectual property, and have launched world-class technology centers inside China to tap into China’s rapidly growing pool of world-class scientists. There are risks involved, but if the Chinese trend of scientific innovation and creativity continues, then it will increase demand within China for improved patent laws and enforcement.\textsuperscript{85} Will increased scientific innovation lead to organizational and political innovation?

It seems that to continue its economic progress, China needs creative individuals who are willing to try new methods. But limiting the creative individual to only think about selling goods in new ways is not really possible because the creative individual can’t help but think about how work is organized, how power is exercised, and how corruption wins out over competence and the rule of law.\textsuperscript{86} Is this proposition true?

\textsuperscript{83} Treder, \textit{op. cit.}
\textsuperscript{84} Treder, \textit{op. cit.}
\textsuperscript{85} Wolfe, \textit{op. cit.}
\textsuperscript{86} Rene Wadlow, Review of Challenging China. \url{http://www.transnational-perspectives.org/transnational/articles/article345.pdf}
Historically, the answer is mixed. Nazi Germany’s technological advances stunned the world. But Einstein, Wigner, and Franck fled totalitarian Germany, while Teller, Szilard, and von Neumann fled Nazi-controlled Hungary, and Fermi and Segré fled fascist Italy. Without these scientists, the Manhattan Project would never have existed, much less succeeded.\(^{87}\) Later, Soviet scientists defected to the U.S. by the thousands, despite the fact that the communist government invested heavily in research and development, and emphasized and rewarded people in technical fields.\(^{88}\)

Albert Einstein maintained that imagination is more important than knowledge, and that continual questioning is necessary for scientific and political progress. Hubertus Hoffmann, founder and president of the World Security Network Foundation, continues that thinking by writing that “Freedom is the foundation for knowledge, development, and progress… In the forty–three dictatorships in the world today (not counting China), the [combined] GNP is only six percent [of the world’s wealth].”\(^{89}\) This is because modern economic systems require creativity and open discussion. As technology increases in power and complexity, its development becomes increasingly incompatible with totalitarian, centralized dictatorships.

In the Soviet Union, well-understood engineering fields, such as rocketry, benefited from the totalitarian ability to throw money, effort and human labour at a problem.\(^{90}\) But the USSR did not do well in biology and other innovation-dependent fields, because totalitarianism squelches imagination. Engineering requires teamwork, but it does not require as much open communication and “out of the box” thinking.

The Soviet empire died quietly. It is wildly optimistic to hope for a repeat of that historical event; nobody expects the Chinese Communist Party (CCP) to wither away just because everyone has a nanofactory and access to the Internet. The CCP takes great pains to censor Internet content, and to monitor voice and text communications, strongly hindering the ability of the Chinese people to access data the CCP considers dangerous. There have already been sizable efforts by citizens to circumvent these measures, but the population segment making this effort is quite small. Further, the data restricted in searches and browsing so far is largely political, not technical. One important question is whether and to what extent the CCP would want or be able to restrict a citizen’s access to files enabling the nanofabrication of products and tools.

**Predictions: the impact of Productive Nanosystems on China**

China is huge, consequential for everyone on Earth, with profoundly unresolved problems. It seems impossible to make predictions about it. Determining the effects of nanotechnology on China are likewise nearly impossible. However, there are some guiding questions that, when answered correctly, will help predict general trends:

\(^{87}\) Doug Prouty, Exodus of Scientists—The Race to Build the Atomic Bomb. http://www.cccoe.k12.ca.us/abomb/exodus.htm


\(^{90}\) Note: rocket science is not that difficult—it has become so because NASA became risk-adverse. Keep in mind that the average age of the NASA engineers who first got us to the Moon was 26 years—and that until that time, “might as well fly to the moon” had always been synonymous with the word “impossible”.

1. Is the design of Productive Nanosystems engineering or science?
   a. If it is engineering, then is it straightforward like rocket science, or does it require
      unfettered creative genius?
   b. If it is science, then can the necessary innovative creativity exist within an
      economically laissez-faire but politically totalitarian environment?
2. How will the three most significant application areas of nanotechnology—nanofactories,
   programmable matter, or medical repair/enhancements—impact Chinese society?
3. How chaotic and disruptive are Productive Nanosystems?
4. Since Productive Nanosystems can only arrange atoms, what social evils in China will
   not be fixed by them?

Many more government leaders in China are likely to be engineers or scientists, unlike the
multitude of lawyers that dominate in Western nations.\footnote{China’s Leader Commits to Basic Research, Global Science: Science Interview with President Jiang Zemin. Science 288 (2000) 1950–1953} This difference undoubtedly amplifies
the ability of totalitarian governments to quickly plot a course or change an established
course—there are fewer people who need to be convinced. On the other hand, engineers are
more likely to make colossal blunders concerning human nature. Both these traits are
exemplified in the efficiency of the trains in Nazi Germany, along with the genocide that
logically followed the acceptance of eugenics and the philosophy behind it. What this likely
means is that the engineering leaders of China will understand the potential of Productive
Nanosystems before the legally-minded leaders of the USA, and will act on it quicker.
However, they will not be able to predict and/or control the result. After another 100 million
innocent people die, the world will again realize that empty philosophies are fatally dangerous.

As noted earlier, there is an important distinction between science and engineering.
Totalitarian governments are fairly good at initiating large and predictable engineering projects.
They are usually bad at stimulating creative new science. Is the development of Productive
Nanosystems creative science or simply large amounts of plodding engineering?

The most important limitation of mature Productive Nanosystems is that, even if it
enables precise control over atoms and atomic bonds, the knowledge of where the atoms are
supposed to go sometimes does not exist. That knowledge is gained by scientific discoveries.
However, given the interconnectedness of the world—especially the academic community—
discoveries made in one country are quickly taken advantage of in others. So China’s lack of
scientific innovation may not matter, as long as they can take advantage of innovations faster
than the countries in which the basic principles were originally discovered. At any rate, there
is evidence that China’s technological abilities may soon surpass those of the USA.\footnote{Brian Wang, China is passing the USA in technology development. Next Big Future. http://nextbigfuture.com/2008/01/china-is-passing-usa-in-technology.html}

Given engineering capability and scientific knowledge, there remain significant limitations
on what Productive Nanosystems will be able to do, but these limitations are highly technical
and not clearly understood. In any case, three applications will have the most impact:
nanofactories, programmable matter, and medical repair/enhancement.

First, nanofactories—new types of rapid prototyping 3D printers—will emerge that can:
1. Print with multiple materials, just like they can now print with different colours;
2. Print with atomic precision.

This means that, depending on the “alphabet” of “inkjet feedstock”, they will print anything from supercomputers to respirocytes (nanomechanical systems that replace blood cells). This also means that they will be able to print copies of themselves. This is not self-replication, because the “inkjet cartridges” contain much of the printing capability, both in terms of atomically precise feedstock molecules and in their orientation, transport mechanisms, and interface protocols. Naturally, that means that after printing the first hundred nanofactories, we’d want to reprogram a nanosystem to build or refill “inkjet cartridges” out of cheap resources. There is significant engineering work that needs to be done to accomplish this, and there are some economic details that are uncertain, but once atoms become as easy to manipulate as bits, and almost as inexpensive, the world will change. Human whim will rule the world.

Such an innovation would spell the end to the Chinese manufacturing dominance. But nanofactories are the unavoidable endpoint of Productive Nanosystems. How quickly these nanofactories are developed, and the trajectory of progress on expanding their output envelopes will determine how badly they disrupt not only China’s economy, but the world’s. The Chinese government might hope to be the first nation to build nanofactories and then use them to replace or supplement its current manufacturing base—while keeping details about its nanotech innovations concealed from the rest of the world for as long as possible. However, given the power of nanofactories, using them for military purposes first might be more expedient, because then it might make it possible to keep anyone else from getting the technology. It is likely that the leading political powers within China may try to use nanotechnology to maintain internal power—this is what totalitarian governments always do. It is likely but not as certain that they will apply that new power externally. A paranoid and oppressive ruling class with the power of nanotechnology is frightening, especially if they obtain it before anyone else does.

Second, Productive Nanosystems will produce programmable matter (PM), first envisioned as Utility Fog. PM consists of millions of small, simple machines that can pixilate and flow to form any object desired. With its physical realism and buckets of processing power (literally), PM will not only simulate almost any macrosized tool, but also amplify the addictive potential of computer games and pornography. Such hyperflexible systems will cause huge economic disruptions (with political implications) that cannot be planned or controlled; though China’s political leaders will undoubtedly try. As Treder pointed out, political stability is their highest value.

Third, the human body is made of atoms. Currently, we do not understand enough about the human proteome at a molecular level to understand where those atoms are supposed to go, and it doesn’t help that the human body is an evolved system—which means that reverse engineering it via the scientific method is a difficult task. However, the more we learn about controlling atoms, the better the tools we will have with which to learn about where the atoms in our bodies are supposed to go (e.g. in order to heal people at a molecular level). Soon afterwards, the same medical nanotechnology

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will be used to enhance human bodies. At this point, the question of what it means to be a human being will become vital. Communism has a particular viewpoint on that question, and that viewpoint was ultimately responsible for the deaths of around 100 million innocent people.

Disregarding that potentially dangerous and controversial point, any progress on extending useful human longevity and vitality in old age will benefit China tremendously, because of their quickly-approaching demographic cliff.

With respect to the disruptiveness of Productive Nanosystems, there is a chain of three important concepts that will result in a particularly heavy impact on China: First, mature nanotechnology (particularly Productive Nanosystems) will arrange bulk matter with atomic precision. Second, this capability will greatly increases the technical power of both individuals and nations. Third, quick and uneven increases in these technical powers can and will cause severe disruptions and chaos.

Does Chinese culture value order above justice, truth and progress? Does CCP value order the same way? Philosophically, the fear of change is one reason why China drew back from its borders, and the desire for order is deeply embedded in Confucian thought. Have the recent momentous changes in China also changed the age-old cultural attitudes towards change? China has such a large population that the answer will be different in different areas and subclasses of the nation. So it seems that, especially given the fad surrounding everything nano, as long as the results are perceived as being mostly positive by a large enough middle class, change will be accepted.

Ultimately, the question is how nanotechnology will develop and disturb a country that is under great stress. How China’s advantages and disadvantage will interact with nanotechnology is the key issue. The underlying social unrest—coupled with the rise in communication capability and Productive Nanosystems—could be a disastrous mix.

To some critics, the U.S. National Nanotechnology Initiative funds mostly relabelled pet projects, and it has no cohesive and realistic goal, especially regarding Productive Nanosystems. The Chinese equivalent has suffered similar criticisms regarding its lack of focus. So if achieving “mature nanotechnology” were simply an engineering project, it is likely that both the U.S. and Chinese efforts will waste significant amounts of money before succeeding. However, with a brilliant person—the nanotech equivalent of Werner von Braun—the Chinese have a good chance of achieving some narrow but strategically significant Productive Nanosystems within a decade. If that happens, then we will indeed all live in interesting times.

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