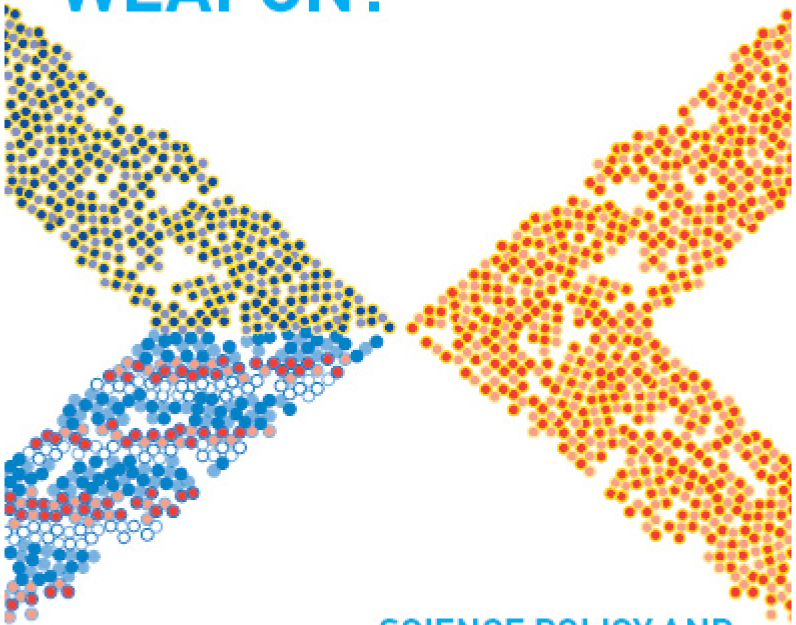
CHINA'S SECRET WEAPON?



SCIENCE POLICY AND GLOBAL POWER
CHRISTOPHER J FORSTER

The Foreign Policy Centre

China's Secret Weapon?
Science Policy and Global Power

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Preface by

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Disclaimer

Ipsa scientia potestas est

Knowledge itself is power

- Sir Francis Bacon

Preface

The Foreign Policy Centre's report on China's science policy is timely, balanced and thought provoking but also sobering from the perspective of China's competitors, especially the UK and the EU.

The Wall Street Journal reported recently how foreign-invested R&D centres in China have almost quadrupled to 750 over the last four years. The Foreign Policy Centre report bears this out with statistics showing that China is now ranked third in the world for total R&D spending. It estimates that by 2010 China will have the same number of science and engineering graduates as the United States. The idea that China is a sweat-shop economy is very dated. Instead it is a growing challenge to the previously comfortable technological lead of the Western countries.

Nevertheless, while China is focussed on closing the 'innovation gap', it still has some way to go. The Foreign Policy Centre's calculations show that China is a technologically hungry nation; good at development and adaptation of technology but not necessarily yet successful at independent innovation. The Chinese leadership is determined to change this. It places growing emphasis on the concept of 'made by China' rather than 'made in China'. As President Hu Jintao is reported to have said 'borrowing and importing can never replace innovation'. The recent 2006 session of China's National Peoples Congress has confirmed the high priority which China plans to give R&D. The Foreign Policy Centre goes further and demonstrates that most R&D spending in China has been the result of state-directed and funded initiatives undertaken for strategic, security or nationalistic reasons – a vivid illustration of the importance placed by China on the link between science and its growing global power.

Other important factors rightly highlighted by this Report include the priority which China now places on extending its capacity in scientific education and training, and the growing emphasis which China is now placing on encouraging private sector investments in R&D. The Report's findings show that domestic Chinese firms are increasingly more efficient, innovative and profitable than foreign high-tech R&D firms investing in mainland China. This is driven by their greater hunger for commercial success. But such success needs the foundation of universities and other educational establishments which encourage creative, innovative and commercially minded scientists. This is an environment which has yet to mature in China.

A substantial underlying issue vital to the role which R&D is to play in China's economic development is the question of Intellectual Property Protection. China has well documented regulations for the protection of IP. The problem is lack of enforcement. As China itself develops more domestic innovations, the hope must be that enforcing the protection of IP will be in the interest not just of foreigners but of an increasing number of local companies. If China aspires to be a leading global power in the field of science and technological innovation, it needs international collaboration with more and more global companies undertaking research activities in China. This can only be achieved if it cleans up its act on protection of IP.

The Report's author, Christopher Forster, and the Foreign Policy Centre are also to be congratulated on their timing in producing this Report just as the United Kingdom is seeking to increase efforts to attract more Chinese investment to the United Kingdom and, particularly to encourage Chinese companies to base their overseas R&D centres in the UK. Britain needs to show imagination and inventiveness, for instance in fostering partnerships between UK and Chinese academic institutions and businesses. This is the reason why the China-Britain Business Council has set up an Innovation and Technology Forum to increase UK commercial R&D partnerships with Chinese counterparts. The Foreign Policy Centre's excellent Report supports our belief that Britain must repeat with China its earlier success in attracting to the UK the bulk of Asian investment by other Asian countries in the EU. That is the best way for both countries to maximise the opportunities for a strong science and technology partnership.

Lord Powell of Bayswater KCMG
President of the China Britain Business Council

CONTENTS

Introduction

China, despite reform and opening over the last twenty-five years, to the outside world remains an obscure entity, controlled by a secretive and camera-shy Politburo. Even those most intimate with China find it difficult to really know what is going on underneath: the motivations, the ambitions, the alliances, the ideologies and the opinions of the leaders go largely unheard. Some see the West as a threat; others see a chance to reorder the global order along more advantageous lines, while the more liberal even hope to change East Asia into something akin to the EU. Despite these disparate perspectives, it would be imprudent to suggest they would disrupt the continuance of China's rapid development.

For the majority of Chinese have a dream to see China restored as a great power. Approaches on how to do so vary, but one that receives wide spread support is the employment of techno-nationalist policies – the use of science and technology to further national objectives. They are popular because they both secure domestic prosperity as well as enhance national power.

What China's full potential is, no one is quite sure. Even while still in the throes of industrialisation, China already wields significant leverage and power around the world. For though much of China remains backward or is still developing, the areas which have reached an advanced stage of development are larger than many Western European nations. Its position on the UN Security Council, its massive economy, its attempts to create its own bloc in Central Asia through the Shanghai Cooperation Organisation, its enigmatic science and technology (S&T) sector, as well as the sheer size of its population all provide China with enough clout to influence global affairs.

For years China has been seen as the world's workshop, but since the beginning of the twenty-first century it has displayed remarkable signs of productivity, ingenuity, innovation and skill. A knowledge-based economy is evolving in China – although not quite one comparable to developed nations just yet. It has also begun to take

an active foreign policy that has revived some hawks in Washington, D.C., to view the rousing giant as a threat.

Relations with the US can be tense. While China resents the role of the US in the Asia-Pacific, its bases in Central Asia, and is apprehensive of its desire to spread democracy so forcefully, the US fears the growing dominance of China in the region, its military build up across the Taiwan Straits, its association with disreputable countries such as Iran, Sudan and Zimbabwe, as well as its role in the proliferation of ballistic-missile technology and 'stealing nuclear secrets'.[1] In an attempt to contain China, explicitly or otherwise, the US tries to limit as far as possible China's access to critical resources and technology. The US Government has introduced new policies preventing Chinese nationals from gaining access to technology in the States, and constraining the trade of high technologies into China, even through third parties.

The belief that the US cannot remain secure unless it is the only superpower[2] clashes significantly with China's own ambitions. Chinese security policy maintains that they should have a military at least capable of dealing with regional difficulties. In the future, as China begins to see itself as a global participant more fully, rather than simply a developing country on the receiving end of aid, its military may have to begin to consider how to secure its interests worldwide. It will not, in a loss of face, outsource its security to the US, as so many other countries have.

The difficult thing for many people to believe, however, is that China poses any kind of a threat at all. China cannot catch up quickly because no matter how fast the country progresses in science and technology, the USA, Japan and Europe are not standing still. China not only has to make up the existing difference, but it has to make up the future difference as well.

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[1] Condoleeza Rice, 'Campaign 2000: Promoting the National Interest', Foreign Affairs, January/February 2000.

[2] A disposition voiced through the Defense Planning Guidance of 1992 that prescribes measures to block the emergence of any potential competitor, undertake unilateral military actions and be prepared to fight Iraq and North Korea simultaneously. Although partially re-written after public criticism it claims to 'set the direction nation's direction for the next century', later to become part of the Project for the New American Century.

However, the United States has, under the Bush Administration, de-prioritised basic science, to help tackle the budget deficit, and made it increasingly difficult to attract foreign students due to visa restrictions – although this might be eased in coming months.[3] On the positive side, American firms are investing more in R&D each year and still represent the primary source of innovation. The US government also wields its own techno-nationalist policies, but these are restricted to the most-cutting edge technologies in only the most sensitive of fields. Globalisation meanwhile is drawing away from the US the assets that have sustained its technological prowess over the decades.

European nations face a much greater challenge. The 2000 Lisbon Agenda to make the EU the most competitive and innovative hub in the world seems unattainable as the EU25 struggle to do either. Europe was the only area where the private sector failed to invest more in R&D than the previous year. Only a few of its universities are in the top 20, while the rest are American. Member states still face obstacles to the transformation to knowledge economies because issues concerning identity and ideology focus attention away from reform.[4]

From a global perspective, though, the US seems so advanced, both militarily and in scientific endeavour, that unless they commit serious strategic policy mistakes there is little chance that any country, let alone China, will ever supersede it. Such thinking misses the point and creates further misunderstandings about China's intentions. It is not necessarily within the aims of the Chinese leadership to confront the US. They are more concerned to seek stability and progress for their country, both for its own sake and to bolster the Party during today's periods of turmoil. Without it, the whole system could collapse under the strain of reform. Through a vigorous S&T policy, they can directly alleviate pressure by introducing societal remedies, such as healthcare and communications. Concomitant with a more

[3] Edward Alden, 'US to ease obstacles for foreign visitors', *Financial Times*, 18 January 2006.
[4] Recent protective measures by the governments of France, Spain and Poland to defend national leaders of industry are symptoms of resurgent nationalism that in fact go against national interests.

advanced S&T sector is an enhanced power projection that can secure global objectives, too. Accumulating power is central to this domestic agenda as well as foreign policy. By doing so, they can better solidify their emergent position and begin to promote their own initiatives and ambitions around the globe. Similarly, they can begin to break the bonds of dependence on the US.

This pamphlet cannot predict where China will be in relation to the rest of the world in twenty to fifty years time. Nor can it foresee a particular global structure. What it does recognise, as by many, is that China's development is causing the greatest change to the fundamental order and function of the world since the rise of the United States. Less noticed are the various implications that China's S&T policies have on itself and the scientific and technological network that binds most nations together. Similarly, the possible impact on American and European power on the global stage is addressed.

Laid out here, therefore, is an overview of China's scientific progress, its integration and impact on the S&T world. Seen in a geopolitical context, and compared to the developments in the US and Europe, the result is a picture of China at a policy crossroads: one that could affect how China is accepted into the international system in the coming decades. Juxtaposed against China is our own progress, which reveals the choice of reactions that exist to the emergence of what many think is the next superpower.

The Reality of China's S&T System

> Government policy is like the moon. It is different in the middle of the month than it is on the first day of the month. Government policy is also like the sun. When it shines on you, you flourish.
>
> - Chinese proverb

Asia-Pacific Precedent

The belief in a reality that China can gain greater independence is not so fantastical. The Far East has already produced many examples of developing nations reaching the technological frontiers. Japan after the Second World War, Korea from the 1950s and other countries such as Singapore and Taiwan demonstrate that with pragmatic and appropriate policies developing countries can do a great deal to catch up in technology-based industries.

Strategies have varied; nonetheless, they have shared common ground. Typically, this has involved a combination of export promotion and efforts to develop national capabilities, such as infrastructure and human resources. Also characteristic are strategies concentrating on exports, building an information infrastructure or even violating IPRs.

Japan's scientific advancement can help create additional perspective when assessing China. Japan's ability in the 1980s and 1990s to drive down costs had a similar impact as China's cheaper scientists do today.[5] Yet Japan, although a world leader in some areas of technology, did not come to dominate high-tech business. The growth and change of the technology markets were too rapid for Japanese large-scale process manufacturing to react to. It was also believed that the Japanese held too much in obeying rules and solving problems rather than coming up with big ideas.[6] The same issues may entangle China on its rise, with a thousand year old culture based on staying within the system coupled with what some

[5] Gary Edward Rieschel, 'Hearing on China's High Technology Development', Mobius Venture Capital, US-China Economic and Security Review Commission, April 2005.
[6] H.W. French, 'A scholar's prescription for getting to next level', *International Herald Tribune*, 15-16 October 2005.

see as the more recent arrival of 'rampant and mindless materialism, careerism and cronyism'.[7]

It is not possible, however, to consign China's fate to that of Japan's. China's size and potential place the country in a different league. The determined ambitions to secure the nation against US encroachments upon its sovereignty will bolster its desire to play by its own rules, and not those dictated from Washington that so influenced Tokyo. In this respect, China's impact as an S&T power is still a large unknown.

For Western policy-makers and investors, the reality of China's *capabilities* is evidently important, but can only be understood in the context of the *condition* of China's science and technology sector. Today China has not yet developed a mature National Innovation System (NIS) that can effectively combine the nation's scientific base with the private sector and instil a climate of creativity within an effective educational system. The essential elements of such a system are nonetheless today being constructed or fine tuned.

The Structure of the System

Two main bodies direct and run China's science and technology system. The Chinese Academy of Science is the foremost scientific institution, equivalent to the National Science Foundation in the US and the Royal Society in the UK. On one level it exists in an advisory role on science policy, and on another it heads numerous research institutes that essentially function as the research arm of the government. The Ministry of Science and Technology (MOST) is the central department that directly coordinates all S&T activities. It launches programs and ensures the strengthening of R&D and technology development. It also stands as the main source of funding for scientific endeavours across the country. A third body, the National Natural Science Foundation of China (NSFC) also provides funds, largely for peer-reviewed basic and applied research in the natural sciences.

The most important initiative that they launched, and that set the agenda for Chinese S&T, was the National High Technology

[7] Gary Edward Rieschel, 'Hearing on China's High Technology Development', Mobius Venture Capital, US-China Economic and Security Review Commission, April 2005.

Program started by MOST and commonly referred to as 'Program 863', so called because it began in March 1986. The investment that this brought into high-tech R&D created a strong infrastructure of research institutes, labs, centres and universities. Much more recent was the '973 Program' or National Basic Research Priorities Program, started in March 1997. The 'Key Technologies R&D Program' and 'Torch Program', which develop high-tech industry in development zones, market high-tech products, promote international cooperation and improve the national workforce, complete the quartet of major MOST initiatives.

In terms of total funding for the S&T system, China ranked as third in the world in 2004.[8] Gross Expenditure on Research and Development (GERD) of GDP reached 1.01 per cent in 2000, with a goal to reach 1.5 per cent by 2005. This is a large jump from the mid-1990s but is still short of the norm among developed countries – between two and three per cent. Suffice it to say, China has the largest GERD of GDP of any non-OECD nation.

The Condition of the System

Using R&D funding as a benchmark, however, is limited since it is notoriously difficult to compare the state of a country's science and technology to another's. The amount of investment each country pours into R&D depends significantly on its sector mix. Even then, the effectiveness of such cash flow is reliant upon a country's National Innovation System. The argument here is for comparisons between outputs, not inputs. Countries, such as the US with an excellent NIS and a culture of free thinking and creativity, can utilise the inflow of investment to maximise innovation production. Joining capital and intellect is critical for the thousands of small- and medium-sized businesses to innovate. The US does this extremely well, with academics often playing the role of businessman, although the EU has yet to develop this tradition. So no matter how much capital China invests, without the capacity to use it effectively it will never perform as well as the US.

[8] 'Guide to R&D Funding Data – International Comparisons', R&D Budget and Policy Program, Science and Policy, American Association for the Advancement of Science (AAAS), 2005.

Characteristics of a modern, Chinese NIS are emerging, however, as reforms under successive Chinese leaderships prove remarkably pragmatic and flexible: one of the major reasons for the rapid development it has experienced. For China's NIS to work effectively, five fundamental activities are essential: R&D, implementation (manufacturing), end-use (customers), linkage (between actors in the S&T sector) and education.[9]

R&D in China has made great strides since the segmented industry became more interlinked and attune to market forces. This has given firms, institutes and universities the freedom to pursue more profitable research. This strategy has been crucial in the face of globalisation and economic reform. The old days of Soviet-style rigidity are coming to a close and an entrepreneurial culture is now being cultivated. By restructuring and re-incentivising, native R&D has become increasingly aware of market considerations, while enhanced performance motivators have planted the seeds of innovation. As such, government-led initiative for the development of S&T has greatly diminished.

In fact, the government has been pulling out of providing the bulk of finance to R&D. For the three scientific communities working in China – firms and enterprises; state research institutes; and universities – funding from the government has shifted in recent years. Government science measures had previously rested on massive funding operations. Yet by 2000 only a third of national funding came from the government, with 58 per cent coming from firms (more than in the EU) and the rest foreign agencies and private foundations.[10] By 2004, 60 per cent of R&D funding was coming from enterprises.[11] This has partly been accomplished by reducing financial aid while nurturing enterprises through tax relief or development zones. Science parks have encouraged 'corporations

[9] Liu Xielin, Steven White, 'China's National Innovation System in Transition: An Activity-Based Analysis', National Science Foundation, Tokyo Regional Office, 16 January 2001.
[10] Wubiao Zhou, 'Inter-organizational R&D Collaboration: Chinese Firms in Reform Era', Department of Sociology, Cornell University, October 2003.
[11] Dr. Denis Fred Simon, 'Hearing on China's High Technology Development', US China Economic and Security Review Commission, April 2005.

to cooperate and interact' while offering 'special perks'.[12] The Zhongguancun Science Park near Beijing is regarded as China's Silicon Valley and has over 150 companies operating there with a joint turnover of over US$12 million.

These links for creating an S&T network have been a priority since the beginning. 'Government monopolies over the transfer of specific resources between organisations have been dismantled in almost all areas.'[13] Engineering Centres, Technology Markets and Productivity Promotion Centres replaced them in order to channel activities between those that research and those that manufacture.[14] Similarly, 'innovation policies directed toward creating a network-based system with active interaction between innovation players' also 'appear to be working'.[15]

Greater flexibility has also begun to appear in production. The once singular functions of an organisation have become more varied, expanding implementation capacity; manufacturing activities have been taken up by institutions not necessarily created to do so. The final product of research users has also been increasingly influenced by customers' needs and desires. Traditional 'technology-push' policies have been abandoned to let industry follow the market.[16] Education's most dramatic achievement has been the jump in national capacity for producing graduates – now the world's leader.

Problems remain, however. The transition to reliance on market mechanisms is still incomplete. State influence remains felt across industries. Central control can be seen in State Council Document #18 from 2000 that directs both the semiconductor and software

[12] 'Report on China's Science and Technology System', EST Section of the US Embassy in Beijing, October 2002.
[13] Liu Xielin, Steven White, 'China's National Innovation System in Transition: An Activity-Based Analysis', National Science Foundation, Tokyo Regional Office, 16 January 2001.
[14] Ibid.
[15] Kazuyuki Motohashi, 'China's Innovation System Reform and Growing Science Industry Linkage', Asian Innovation Policy and Management, 17 September 2005, first draft.
[16] Liu Xielin, Steven White, 'China's National Innovation System in Transition: An Activity-Based Analysis', National Science Foundation, Tokyo Regional Office, 16 January 2001.

industries.[17] In late 2003 MOST published the China Offshore Software Engineering Project (COSEP) that has encouraged 'the further expansion of outsourcing activities, especially those targeted at the US and Europe'.[18] The Five Year Plans are focussing the country on the 'pillar industries', critical technologies and to 'reform China's state-owned enterprise system'.[19] They have also maintained their active role in 'formulating industrial policy and providing strong direction to domestic organisations to implement it'.[20]

Ironically, incentives to promote innovation have sometimes proven perverse or inadequate, with freedom to move jobs creating a 'brain drain' in some areas, for example. Further inadequacies have emerged in the legal and banking environment, which have yet to provide a stable environment to foster optimal growth in the private sector. The OECD in its own reports has seen this mixture of achievement, with significant advancements put into perspective by data on lagging tertiary education statistics, patent submissions, the dominance of foreign firms, IPR infringements and the low level of native innovation.[21] World Bank analyses have revealed deficiencies in tariff barriers, tertiary enrolment, the control of corruption and the rule of law, all critical to the development of a knowledge economy.[22]

The uncertainty existent in this evolution is evident in recent statistics, which have revealed that domestic R&D firms appear to be more efficient, innovative and profitable than foreign high-tech R&D firms on the Mainland.[23] Paradoxically, despite this, parts of the S&T

[17] Gary Edward Rieschel, 'Hearing on China's High Technology Development', Mobius Venture Capital, US-China Economic and Security Review Commission, April 2005.
[18] Ibid.
[19] Kathleen Walsh, 'China's High Technology Development', US-China Economic and Security Review Commission, 21 April 2005.
[20] Liu Xielin, Steven White, 'China's National Innovation System in Transition: An Activity-Based Analysis', National Science Foundation, Tokyo Regional Office, 16 January 2001.
[21] 'An Emerging Knowledge-Based Economy in China? Indicators from OECD Databases', STI Working Paper 2004/4, Directorate for Science, Technology and Industry, OECD, 22 March 2004.
[22] Carl J. Dahlman, Jean-Eric Aubert, 'China and the Knowledge Economy: Seizing the 21st Century', WBI Development Studies, The World Bank, September 2001.
[23] Kathleen Walsh, 'China's High Technology Development', US-China Economic and Security Review Commission, 21 April 2005.

system remain inefficient and ascribe funds to state-owned enterprises that are less likely to repay them.[24] Such contradictions are prevalent in analyses of China's S&T: one glance provides startling evidence of advancement, while another perpetuates a backwater paradigm. This is the result of S&T policy that is directing a nation in transition.

This does not, however, preclude the Chinese from having some of the most advanced technology in the world in their back garden. Witness the building of FAST, the largest telescope in the world that fills an entire valley with a reception area of one square kilometre. The Godson II is China's own central processing unit (CPU) that is equivalent to the Pentium III. In April 2004 China saw the first buffalo in the world cloned amid predictions that it will greatly promote cattle breeding. Innovation I represents China's very own mini-satellite of less than 100kg successfully in operation since October 2003 and enhancing their low orbit communications system. In the same month China sent Yang Liwei on a Shenzhou (Long March) V spacecraft into space, making his the third country ever to do so after the US and USSR. In 2005 a second manned mission was sent into space. The Beijing Communications University developed the world's first IPV6 router for the next generation Internet in August 2004, allowing for a substantial increase in IP addresses for the predicted 300 million Internet users in China alone by 2007. The Dawning 4000A supercomputer, with a speed of 10 trillion calculations per second, made China the third country to manufacture commercial computers of such high speeds.

Taken in perspective, such examples are more often than not the result of state-directed and -funded initiatives that are given a high priority for strategic, security or nationalist reasons. These 'high-profile, mission-orientated projects' even still function as a means to steer 'innovation efforts'.[25] For such landmark achievements to be made without the guiding hand of government, the NIS needs to continue to evolve.

[24] Liu Xielin, Steven White, 'China's National Innovation System in Transition: An Activity-Based Analysis', National Science Foundation, Tokyo Regional Office, 16 January 2001.
[25] Ibid.

Evolution of Policy

China is today trying to create a balanced agenda, between high level technology and more basic research. Yet analysis of the S&T system in China reveals that the majority of R&D activities are focussed on applied research. This relegates pure science, which holds less immediate value in terms of social application or commercial rewards, to a position of neglect. While this may seem more suitable for a developing nation, China has reached a crossroads. Compared to other countries that are developing, China can appear a modern country. Yet for there to be a cutting-edge and fully-rounded science and technology community in China, this more theoretical aspect to science needs much greater emphasis in science policy thinking.

Such emphasis is increasingly present as the system becomes more sophisticated. As Premier Wen Jiabao, in his latest 'Report on the Work of the Government' for 2004, put it:

> We will improve the systems and policies that encourage innovation. We will continue to introduce advanced technologies, assimilate them and make innovations in them, while concentrating on enhancing our own development capacity. We will energetically develop new and high technology industries and integrate information technology into the national economy and society […] We will deepen the reform of the science and technology system, and accelerate the establishment of a management system, an innovation mechanism and a modern system of research institutes that are compatible with our socialist market economy.

Evidence suggests that during the decades of reform China has increasingly refined its approach to S&T policy. In some respects this has been due to a less tangible obstacle facing China – one of attitude – that has now begun to change. Secrecy and isolation had until recently been constant bed fellows in regard to the discussion of policy. Now across government, in business and among academics, discourse has become, relatively, much more 'open and sophisticated'.[26] Foreigners are increasingly sought out for their opinions and to lead investigations into progress, such as with China's 15 Year Comprehensive Long-Term Science and

[26] Dr. Denis Fred Simon, 'Hearing on China's High Technology Development', US China Economic and Security Review Commission, April 2005.

Technology Plan.[27] The motivation to improve their technology base and enhance innovativeness remains focussed. The flexibility in the Chinese leadership and their ability to embrace criticism, while not unique, is important for any sort of positive progress during times of great uncertainty. The culture of tolerance that exists in China toward risk and failure are 'qualities that benefit the technology sector'.[28]

This has allowed policy to sustain a shift, moving away from directly funding enterprises to creating incentives for S&T growth. Investments in kind are now provided to nurse young ventures. Such provisions include: free office and factory space in regional science and technology parks; priority access to university professors and the ability to recruit the most erudite students into a project; preferential access to the state controlled telecom marketplace providers; and interest-free loans with no term and unsecured.[29] Combined with low cost employees, Chinese companies can be extremely competitive. Firms such as Huawei, Legend, Haier and Founder have appeared on the edge of technology alongside foreign-invested firms in part because government emphasis has shifted from the provision of funding to something more policy-orientated.

Conversely, policies designed to provide positive incentives have occasionally been detrimental. By 'making research institutes more dependent on non-government funding they have lost the incentive to invest resources in mid- to long-term research projects whose outcomes are less certain'.[30] State-owned institutes have also been sheltered from bankruptcy, depriving them of the reason to 'introduce process and product innovations'.[31]

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[27] Ibid.
[28] Gary Edward Rieschel, 'Hearing on China's High Technology Development', Mobius Venture Capital, US-China Economic and Security Review Commission, April 2005.
[29] G. Carl Everett, 'Hearing on China's High Technology Development', Accel Partners, US-China Economic and Security Review Commission, April 2005.
[30] Liu Xielin, Steven White, 'China's National Innovation System in Transition: An Activity-Based Analysis', National Science Foundation, Tokyo Regional Office, 16 January 2001.
[31] Ibid.

Overall, however, policies have benefited the innovation industry. This is central to PRC plans since with core technology increasingly banned from transfer to China, the Chinese have no other recourse but to innovate for themselves. Herein lies another motivation to push for a modern and independent NIS. State Councillor Chen Zhili realised that the country will need to 'invest more capital to make breakthroughs in key technologies,' since 'many lessons have taught us that some countries don't lift barriers when we need technologies to improve people's lives and build up national defence'. Wen Jiabao supports this government priority:

> Independent innovations are crucial to the rapid rise of a country. We must introduce and learn from the world's achievements in advanced science and technology, but what is more is to base ourselves on independent innovations because it is impossible to buy core technology. Independent innovation is the national strategy.[32]

Mirroring Western commercial practices, the government has consciously 'embarked on acquisitions of foreign businesses as part of its national strategy for condensed technology growth', for example, 'in the automotive, electronic and chemical sectors'.[33] Chinese domestic firms are actively seeking to take over foreign companies, encouraged by the government's 'go out' policy. Part of the government's recommendations includes merger and acquisitions on a global scale in order to 'help the country's businesses acquire highly advanced technologies and international distribution networks and brands'.[34] This led to the (failed) bid by CNOOC to buy the US oil company Unocal, TCL's successful acquisition of the television and DVD operations of Thomson of France, Lenovo's purchase of IBM's personal computer business and the last-minute offer for MG Rover in 2005 by the Shanghai Automobile Corporation.

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[32] G. Carl Everett, 'Hearing on China's High Technology Development', Accel Partners, US-China Economic and Security Review Commission, April 2005.
[33] 'China's progress in technological competitiveness: the need for a new assessment', Dr. Michael Pillsbury, US-China Economic and Security Review Commission, April 2005.
[34] Ibid.

Cooperation with governments and organisations abroad has balanced this aggressive strategy. China is currently involved in the Galileo Project with the EU in developing a system of orbiting satellites. They also participated in the recently completed Human Genome Project. All in all, China has scientific links with 152 countries or regions and has official science and technology agreements with 96 countries.[35] Whereas before these links were used to send scientists abroad to improve their skills, now they involve technology development, product design and founding joint institutes or laboratories. Since 1981 China-EU relations, to the chagrin of US counterparts, have been incredibly fruitful, with over 300 joint projects in the last quarter century.[36] Even the EU's Fifth Framework Programme, a high-level scientific plan, was opened in 1998 to Chinese scientists, pushing collaboration in basic research and high-tech programs.

Commercial Perspective

It is better to be the head of a chicken than the tail of an ox.
- Old Chinese proverb

With all the efforts put in by government, the private sector remains the best means for developing technology and pioneering science. Since the 1990s, the commercial character of China's scientific community has become more open and developed. Firms have been encouraged to develop their own in-house capabilities and have taken over many R&D activities that had once been conducted by government-run institutes. Nearly two-hundred and fifty state-owned R&D institutes were eliminated during the decade through mergers with private enterprises or disbandment.[37] By 2000 60 per cent of national R&D was done by private enterprises, with government related institutes producing 29 per cent and universities 9 per cent.[38] Their quality has been enhanced by the CAS 'Knowledge and Innovation Program' (KIP), which has 'intensified competition and higher levels of achievement in research' in state

[35] Ibid.
[36] Ibid.
[37] 'Report on China's Science and Technology System', EST Section of the US Embassy in Beijing, October 2002.
[38] Wubiao Zhou, 'Inter-organizational R&D Collaboration: Chinese Firms in Reform Era', Department of Sociology, Cornell University, October 2003.

institutions.[39] Research institutes have become subject to regular formal project evaluations,[40] while job security for all researchers on contracts has become performance-based. Those who were deemed less qualified but had valuable experience were moved to universities or enterprises. KIP also introduced a 'competitive system for appointment while creating a new management system'.[41] Cuts in staff numbers and forced retirement have created opportunities for younger and better-educated scientists.

Private capital investment, however, has been slow to replace the diminishing financial assistance of the state even with increases in FDI. Unclear regulations; an inadequate legal structure; an insufficient financial infrastructure to guarantee security and investment; and, lack of public awareness and understanding, have all hindered the inflow of capital. A lack of accurate market information, absence of viable exit strategies and limitations on stock markets have also dissuaded foreigners from investing in Chinese firms or setting up their own enterprises in China. Further problems include the protection of domestic companies, a deficient distribution infrastructure and price controls that leave very narrow profit margins.[42] Even so, the Samsung Economic Research Institute (SERI) argues that chief investments in China have nonetheless been moving increasingly into advanced sectors, such as home appliances, IT and petrochemicals, instead of the usual in trade and the catering industry.[43]

Aside from tax breaks and science parks, the PRC leadership have enjoyed until recently regulating foreign attempts to establish companies on the Mainland by insisting they collaborate with Chinese firms and share technology. Pre-WTO accession, this technology transfer provided an invaluable shortcut for Chinese

[39] 'Report on China's Science and Technology System', EST Section of the US Embassy in Beijing, October 2002.
[40] Ibid.
[41] Ibid.
[42] Greg Lucier, 'China as an emerging regional and technology power: Implications for US economic and security interests', Invitrogen Corporation before the US-China Economic and Security Review Commission, February 2004.
[43] Dr. Michael Pillsbury, 'China's progress in technological competitiveness: the need for a new assessment', US-China Economic and Security Review Commission, April 2005.

scientists. By encouraging foreign firms to establish R&D centres in China, the PRC consciously adopted a policy of using them as a 'catalyst for sparking innovative behaviour throughout the economy'.[44]

A significant step therefore was the recent removal of requirements to form joint ventures with Chinese companies by foreign firms and allowing them to create wholly owned foreign enterprises. This leaves them 'less inclined to transfer technology to Chinese firms' as well as no longer contractually required to part with their knowledge.[45] This is to the benefit of Chinese firms who have relied a great deal on the technology of others. No longer being spoon fed will encourage them to innovate on their own. It will not disadvantage them too greatly either since the 'indigenisation' – absorbing and mastering of – imported knowledge by Chinese companies had not been high anyway. In the last ten years, large- and medium-sized firms 'spent less than ten per cent of total costs of imported equipment' on indigenising technology.[46]

China's largest hurdle to building its own knowledge-based industry is its lack of IPR protection. Accession to the WTO has forced legislation to be passed in favour of protection. This has brought record amounts of investment into the country, but the failure to implement court decisions has made some foreigners remain tentative about their commitments. Despite victory in court, scientists and research centres lose in the real world with little action following any judgements made.[47] Joining the Patent Cooperation Treaty has moved China in the right direction, and the intellectual property office is perceived to perform better than other developing nations such as Brazil or India. However, the legal infrastructure remains inadequate in dealing with investigations relating to IPR infringements, let alone enforcement.

[44] Dr. Denis Fred Simon, 'Hearing on China's High Technology Development', US China Economic and Security Review Commission, April 2005.
[45] G.J. Gilboy, 'The myth behind China's miracle', *Foreign Affairs*, July/August 2004.
[46] Ibid.
[47] 'Chamber's China Report Highlights Need for More Progress: WTO Compliance Report Says IPR Protections Inadequate', US Chamber of Commerce, 22 September 2004, http://www.uschamber.com/press/releases/2004/september/04-127.htm.

In other Pacific Rim countries punishments for violations were enforced once local businesses had begun to demand it. Only as native innovations begin to require protection are we likely to see government officials and stake holders put pressure on those breaking foreign and domestic IPRs. Ironically, without the pressure to innovate that comes with firm IPR protection, there will be no need to defend native technology.

Efforts to give *de jure* decisions *de facto* impact are thus vital for China to begin to draw in experts and technology on the frontiers of science, as well as push native scientists to develop original research and not simply produce second hand 'knock-offs' of US products. These measures would truly aid China in reaching its goal as being one of the world's leading developers in R&D and with China at a crossroads it might actually be the tipping point for IPR enforcement.

Latent difficulties, however, will prevent domestic enterprises from maturing along the lines of other multinational corporations (MNCs). Chinese business culture restrains managers and hampers the development of native firms. The political system has fostered an environment in which short term profits are more important, local politics is highly influential and excessive diversification is used to stay afloat.[48] Vertical relationships, which bring privileged access to the authorities, are prioritised above horizontal networking, which are needed to create alliances and innovation; in fact, peers are sometimes purposefully eschewed to maintain a monopoly on official contacts. In 2000, 93 per cent of R&D outlay was spent in-house, while only two per cent was spent in collaboration with universities and less than a per cent was devoted to work with other firms, despite the efforts of science parks.[49]

Relationships with Chinese Communist Party (CCP) officials are at the moment vital for any Chinese firm to succeed. These officials nearly always focus on the local economy to benefit regional goals and therefore have a great deal of influence on the fate of any company based in their province or city. While corruption and personal interest are the motivations for the decisions of some, their

[48] G.J. Gilboy, 'The myth behind China's miracle', *Foreign Affairs*, July/August 2004.
[49] Ibid.

choices often serve to promote social and political harmony. It makes sense that an official would rather a company remain local and provide employment in his jurisdiction than expand (even within the country) and risk losing it.[50] In times of rapid reform and potential social unrest, this is actually encouraged by the central government. Unfortunately, it also works against the development of domestic firms. Despite even the best of intentions, the involvement of CCP officials can bring uncertainty to a business. This often forces leaders of the business community to favour short term profits over long term investment. 'Excessive diversification' is used to 'mitigate potential damage of fratricidal prize competition created by excess production capacity and overlapping investments'.[51]

The atmosphere stunting the growth of many Chinese firms is unlikely to dissipate until the higher authorities think it in their interest. Until that happens, the Chinese domestic scene will remain fragmented and provincial as national industries focus on local economies and waste increases because of overlapping investment.

For this reason Gilboy, in an article in *Foreign Affairs*, believes there is nothing to worry about. He diminishes the hype of what he calls 'overestimates of China's achievements and potential', and that there is any reason to fear China as a 'mercantilist economic superpower'.[52] Yet, even with China's S&T sector still developing, the Chinese market is already a global force, one that the Chinese leadership are becoming increasingly deft at manipulating. Although China's economy has relied more on foreign firms exporting high-tech products than the previous 'Asian tigers' during their development, it will still be home for a significant proportion of the world's S&T capabilities, a growing part of which is native. What Gilboy has recognised quite clearly, though, is that China does face some challenging reforms ahead and that the current state of 'nodes without roads', with points of quality research disconnected from each other, needs to change.

[50] Ibid.
[51] Ibid.
[52] Ibid.

Intellectual Investment

> We will strive to improve the quality of higher education. We will fully implement the Party's education policy by strengthening moral education and promoting competence-orientated education.
>
> - Wen Jiabao, March 2005

The foundation of a nation's S&T rests upon the intellectual laurels of its citizens. Improvements have been 'appreciable' in Chinese university education.[53] This has been partly attributed to the reinvigorated infrastructure, with new equipment and better laboratories provided by major investments. Faculties are also improving as authorities crack down on nepotism. The number of students reaching higher education has also jumped. With only three to four per cent of high school graduates entering university just a few years ago, this number has increased to 17 per cent. In 2004 China produced 350,000 IT graduates, while India and the US only managed 300,000 and 50,000 respectively.[54] Observers from foreign-invested firms have also noted the improvement in quality of these graduates, although not evenly across the board.

However, Xu Tian, a Chinese scientist working on the transposition of genes at both Yale and Fudan Universities, believes this is simply not enough.[55] 'They are putting more into education than perhaps any country, but what we haven't taught people yet is to value ideas, and to value the life of the scholar… What China has not realised, if it truly wants to get to the next level, is that numbers are not enough… You must reward innovation, and reward scholarly work.'[56] The culture of staying within the system will be a major internal obstacle that the country will have to face together and also as individuals.

Yet the value of the workforce has increased substantially while still remaining low cost – between a fifth to a tenth cheaper compared to

[53] Dr. Denis Fred Simon, 'Hearing on China's High Technology Development', US China Economic and Security Review Commission, April 2005.
[54] Ibid.
[55] H.W. French, 'A scholar's prescription for getting to the next level', *International Herald Tribune*, 15-16 October 2005.
[56] Ibid.

US talent.[57] The refinement of workers over the last ten years has thus left China with a high-quality pool of skilled scientists and engineers. Not all of them actually reach employment with estimations putting unemployed graduates at nearly a million in 2005.[58] MOST still manages to boast, however, that China now has the largest number of scientists and engineers in the world behind the US. This position drops, though, when assessed on a per capita basis, putting it behind Russia, France, Germany and Japan.

The educational establishment still needs reform. China has, despite its emerging centres of excellence, never won a Nobel Prize in science on home ground.[59] A lack of autonomy for universities from the government, over-emphasis of secondary education on exams rather than cognitive development and slow adoption by universities of new technologies stultify student development. Prohibitive costs to attend university and a lack of backing by the government for private universities, which stigmatises them to a degree, discourages prospective students.[60]

Education reform to date, however, has started to produce results. Chinese scientists are participating and playing more important roles on the international science stage. In advanced subjects such as nanotechnology or biotechnology the Chinese are pushing the field. At Tsinghua University techniques for the production of carbon nanotubes outpace US efforts sixty-fold[61] and the country as a whole is ranked third in nanotechnology patents and publications.[62] Chinese scientists are increasingly cited in Western journals. The US Institute for Scientific Information says that in the ten year period

[57] Greg Lucier, 'China as an emerging regional and technology power: Implications for US economic and security interests', Invitrogen Corporation before the US-China Economic and Security Review Commission, February 2004.
[58] Dr. Denis Fred Simon, 'Hearing on China's High Technology Development', US China Economic and Security Review Commission, April 2005.
[59] http://nobelprize.org/.
[60] Private universities are also unable to award more than an Associate's degree. 'Report on China's Science and Technology System', EST Section of the US Embassy in Beijing, October 2002.
[61] 'China, Emboldened by Breakthroughs, Sets Out to Become Nanotech Power', *Small Times*, 17 December 2001, http://www.smalltimes.com/print_doc.cfm?doc_id=2736.
[62] 'Status of Nanotech Industry in China', *Asia Pacific Nanotech Weekly*, Vol. 2, article #24, 23 June 2004, http://www.nanoworld.jp/apnw/articles/2-24.php.

from 1993, Chinese scientists published 253,566 research papers (9^{th} in the world), were cited 735,288 times (18^{th}) and produced 944 of the world's top one per cent of research papers (17^{th}).[63] Over the last six years, China's patent applications have risen by 212 per cent.[64] International firms are now beginning to fight for these blossoming scientists in what *The Economist* refers to as a 'global war for talent'.[65]

In the Field

Unfortunately, once out of the educational system, China's scientists are hindered by the lack of basic research experience and limited contact with cutting-edge developments and technologies. They also suffer from a deficit of managerial experience. The devastating consequences of the Cultural Revolution left an entire generation without formal education. This has left a gap as older managers retire and younger scientists take on their first responsibilities with no management history. An absence of formal training and instruction in managing has left many companies in the hands of the inexperienced.

Yet these problems are being addressed by attracting foreign technologies and the qualified Chinese scientists that have gained experience abroad. Whereas headhunters had previously scouted foreign individuals to take up leadership positions, they now approach Chinese expatriates to lure them back to their native land. This also combines conveniently with the overall task of combating the 'brain drain'.

Chinese 'brain drain' has three forms. The most significant is the sapping of talent abroad. The other two are internal. One is commercial, with many top scientists working for multi-national corporations or accepting technical positions in non-research organisations, instead of Chinese R&D firms. The other is geographical, with Shanghai and Beijing drawing in the majority of

[63] Dr. Michael Pillsbury, 'China's progress in technological competitiveness: the need for a new assessment', US-China Economic and Security Review Commission, April 2005.
[64] 'Exceptional growth from north east Asia in record year for international patent filings', World Intellectual Property Organization, 3 February 2006.
[65] 'Scattering the Seeds of Invention: The Globalization of Research and Development', *The Economist*, September 2004.

the capable workforce. These two regions also receive the most resources, largely due to the location of the top universities there. This, of course, has led to deficiencies in scientific development in the provinces, as well as under-funding for other universities. The government is already trying to reverse China's decline into a two-tier system – which would only serve to skew social inequalities further – by promoting institutions in the Western provinces.[66]

The outlook, however, is good. Other countries, like Taiwan and South Korea have managed to stem the outward flow of talent. China is now trying to do the same and some changes have been effectual. The 'Hundred Talents Program', 'Distinguished Young Scientists Program' and 'Cheung Kong Program' have enticed expatriates with higher salaries, generous housing packages, research teams and research funds of between US$120-240,000. Motivations to return have varied, but the most important seem to be that the difference in living standards between China and countries like the US are diminishing, and the fact that language barriers block advancement abroad.[67]

Many of the junior and mid-level Chinese scientists that started off in foreign R&D centres are leaving with new-found experience and confidence to join a growing entrepreneurial class. A similar occurrence happened to Taiwan in the 1970s and 1980s. Start-up firms are on the increase in China.

Facing Reality

India's chief scientist, R.A. Mashelkar, believes that fears over China's scientific development are exaggerated, 'particularly in the US, people like to keep themselves on edge with talk of a "threat" but in reality there is none'.[68] In the UK, Lord Sainsbury, as Science Minister, took a similar line suggesting that those who think China will come to dominate the high-technology world should recall the fears over Japan's high-tech rise in the 1980s that came to nought.[69]

[66] 'Report on China's Science and Technology System', EST Section of the US Embassy in Beijing, October 2002.
[67] Ibid.
[68] Clive Cookson, 'Science and Technology Research', FT.com, 9 June 2005.
[69] Ibid.

Other opinions differ. Dr Simon thinks 'the Chinese S&T system is poised for an important take-off – the question is no longer if this will happen, rather when'.[70] He continues to say that the country is set to become a 'major international player in S&T if not, in the long run, a scientific superpower'.[71] Before this can happen there are yet many obstacles that must be tackled, including structural and resource problems.

As with any country developing its National Innovation System for the first time, there will always be need for change. Yet 2005 saw China reach a critical juncture in its scientific and technological journey. The problems are there, but not insurmountable.

In reality, the devil lies in the detail. A value system that promotes ideas and rewards creativity is needed for innovation. The Chinese scientific community complains of skewed government funding and bureaucratic influence from non-academics. The commercial structure of the country has hampered the diffusion of technologies as provinces compete with one another and officials with parochial interests push companies in unprofitable directions. The 'Guangxi' effect, where who you know is more important than the letter of the law, is yet another variable that affects the commercial side of science in China.[72] Lack of protection of IPRs, although largely detrimental to foreign firms, has not forced Chinese enterprises to find a niche of their own, being content to essentially reproduce US research. Some fear that China's R&D is simply an inferior version of US R&D.

It is important to remember, however, that positive reforms have taken place in China and, with the pragmatic stance the Chinese leadership has taken over the past decade, there is little reason to suppose that these changes will not continue. China's expenditure on R&D has risen above one per cent of GDP in recent years, making it one of the largest spenders on science. Outside of the

[70] Dr. Denis Fred Simon, 'Hearing on China's High Technology Development', US China Economic and Security Review Commission, April 2005.
[71] Ibid.
[72] Jason Dedrick, Kenneth L. Kraemer, 'China's emergence as a computer industry power: Implications for the US', Center for Research of Information Technology and Organizations (CRITO), February 2004.

OECD, it is the leader in science and technology funding. The Chinese have been leap-frogging development stages jumping straight from 'trailing-edge' to 'bleeding-edge' technology, such as fibre optics. Programs such as '863' and KIP have pushed China in the right directions. The creation of science parks around China to stimulate research has been successful in bringing companies together and forming zones of creativity. The private sector is producing the world's first Chinese MNCs. Scientists are making their names in fields as complex as nanotechnology.

In short, the National Innovation System in China has seen significant change since the 1970s, and even since 2000. As progress continues and China tinkers with it over the coming decades, it will be in the interest of both foreign policy-makers and businesses to keep an eye on developments. During this time the other eye must be trained upon their own capabilities to ensure they maintain their competitiveness and innovativeness.

Shifting Sands

USA Heads the Pack

In the world of science and technology the United States has been leading for decades. Its enormous expenditure coupled with a very mature National Innovation System has given it a significant advantage – highlighted by its expert ability to project itself across the world. This pole position depends on a number of factors, including relatively high levels of funding for pure science research independently of applied research, and the highest levels in the world of funding for military research and development. The highly intimate relationship between business and academia gets the best ideas to market quickest. The range across which the USA disposes its technological strengths is unmatched in any other country – including genetic engineering, space science (remote sensing), telecommunications and most importantly of all, information processing technology.[73] All of these fields offer the USA superior ability to achieve economic breakthroughs and efficiencies, as well as military dominance in a large number of circumstances.[74]

In 2003, it was the largest global spender on R&D and accounted for 42 per cent of the OECD total, with Europeans at 31 per cent and Japan at 17 per cent.[75] The US, however, was still only second in terms of government spending on R&D as a percentage of GDP, at around 1.2 per cent.[76] Overall, there has been an increase in R&D expenditure of seven per cent,[77] attributed largely to two factors: defence spending and the doubling of the National Institutes of

[73] The entrenched position of the USA in this core technology is underpinned by the dominance of English in computer applications.
[74] Joseph Nye, William Owens, 'America's Information Edge', *Foreign Affairs*, 1996, March/April, pp. 20-36.
[75] 'Briefing Note for the United States', OECD Science, Technology and Industry Scoreboard 2005.
[76] 'Briefing Note for the United States', OECD Science, Technology and Industry Scoreboard 2005.
[77] Compare this to just three per cent in France and one per cent in Germany and the UK. Clive Cookson, 'R&D spending falls further behind target', *Financial Times*, 24 October 2005.

Health (NIH) budget. All other areas, such as energy and space, have flat-lined or declined over the last five years.[78]

When the 2006 budget passed it increased the federal R&D budget by US$2.2 billion or 1.7 per cent.[79] Defence and human space exploration technologies received 97 per cent of this increase. All other programs will fall nearly two per cent after accounting for inflation. The record investments seen in non-defense R&D over the last seven years have largely been due to the campaign to double the NIH budget between 1998 and 2003. In 2006 the NIH budget fell for the first time in 36 years. Agencies aside from the Department of Defense (DOD), the Departments for Homeland Security (DHS) and NIH will see their third year in a row of real budget cuts. Yet it is these agencies, combined with some DOD research, that directs efforts in the physical sciences, non-medical life sciences, environmental sciences, engineering, mathematics, computer sciences and social sciences. In fact, these research areas have all seen their funding stagnate and are likely to decline further after 2006.[80] The American Association for the Advancement of Science (AAAS) regards R&D as a 'significant but declining part of the federal budget'.[81] To counter accusations that US innovation is being stifled, President Bush announced a 'competitiveness initiative' in his State of the Union address.[82] The ten-year plan includes doubling federal spending on basic research as well as making the R&D tax credit permanent. Yet, he also called on Congress to legislate against stem cell research and other areas involving 'human embryos'.[83]

In terms of output, the number of articles in scientific journals stands at nearly a third of world production, but by population is quite average for the OECD and is actually behind countries such as

[78] 'Federal R&D Funding Stalls in Delayed 2006 Budget', AAAS Current Headlines, 4 October 2005, http://www.aaas.org/spp/rd/upd1005.pdf.
[79] 'Congress Caps Another Disappointing Year for R&D funding in 2006', AAAS, 4 January 2006, http://www.aaas.org/spp/rd/upd1205.htm.
[80] Ibid.
[81] '2007 Budget Extends Declining Trends in Federal R&D', R&D Budget and Policy Program, AAAS, http://www.aaas.org/spp/rd/guihist.htm.
[82] 'Bush launches "competitiveness initiative"', EurActiv, Science & Research, 3 February 2006, http://www.euractiv.com/Article?tcmuri=tcm:29-152177-16&type=News&Ref=mail.
[83] Ibid.

Sweden and Switzerland. The US's global patenting is lower than its contribution to global R&D efforts, while science and engineering degrees represent only 16 per cent of all new degrees, compared to 27 per cent in the EU and 26 per cent in Japan. China, meanwhile, already has the second largest number of researchers in the world, just behind the US, and graduates the most each year along with India. In high-technology industries, such as pharmaceuticals, aircraft, ICT equipment and precision instruments, the US has lost market share in the OECD area over the last ten years.[84]

The US is slipping further. Declining US pre-eminence is due to four main shifts, according to a recent study.[85] The first is in relocation. It is nothing new, but a growing number of high-tech companies have been moving their R&D facilities to China, as well as India. They cater for the global market, as well as the growing middle-class domestic market. Over six hundred research facilities from multi-national corporations were in China in 2004. Secondly, skills off-shoring has seen the movement of a great deal of skilled jobs to China from the developed world. Thirdly, according to the Georgia Institute of Technology, China has 'in the last decade reduced its technological capability deficit to the United States'.[86] The percentage of Chinese exports as high-tech products has also risen, making exports the fourth shift. Electronics, machinery and transport equipment jumped from 18 per cent in 1994 to 43 per cent of total exports in 2003. The US, in the mean time, between 1989 and 2001 lost its overall share of the global market, dropping from 24 to 17 per cent. This is almost inevitable as the number of competitors increase, and critics would probably point out that the majority of high-tech exports out of China are made by foreign companies. This, however, does not necessarily restore confidence, since their very absence detracts from developed nations' output.

Education is America's main advantage. Tertiary education there is the best in the world, with Ivy League and Big Ten institutions netting millions and providing lucrative facilities and salaries to the best

[84] 'Briefing Note for the US', OECD Science, Technology and Industry Scoreboard 2005.
[85] 'United States: Study outlines falling lead in science', Oxford Analytica, 10 August 2005.
[86] Ibid.

minds on the planet. Their close location to areas of enterprise also increases the speed with which research makes it to the consumer. However, without students this all amounts to nothing. By 2010 double the number of scientists and engineers are expected to graduate in the EU than in the US. China, which started with zero in 1975, will have equalled the US by the same year. This decline is partly due to decreasing attractiveness. Not only is it more expensive for foreign students to study in the US, but those that do are more likely to choose careers with higher lifetime earnings, such as law or medicine, instead of science and engineering. With institutions at home improving in reputation more students will no longer opt for the extra burden of studying abroad.

Compounding these issues, strategic moves to counter or 'block' China have left the US with a variety of policies that hinder its own development. Visa restrictions since 9/11 are 'preventing and dissuading scientists and engineers from entering the country'.[87] China, meanwhile, now has more English-speaking electrical engineers than the US. America's dependence on foreign students[88], which for the moment still supply the US economy with enough scientists and engineers, means that any disruption, either because of restrictions or negative global perceptions of the US, would severely risk the country's capabilities.

US policy, however, is not addressing these concerns and seems to be increasingly disconnected from what the business community regards as the correct solution.[89] While policymakers regard S&T as a race between nations in a zero-sum game, businesses see themselves as part of a global innovation network. This creates for conflicting priorities. Government officials are more concerned about stemming the flow of technologies to competitors and possible rivals who might use it for military objectives. At the beginning of 2005 ten US states had restricted offshore outsourcing and 82 measures and amendments at the federal level were pending.[90] However, firms

[87] 'Andrew Small, 'Preventing the Next Cold War', The Foreign Policy Centre, November 2005.
[88] 'United States: Innovation, security policies at odds', Oxford Analytica, 10 January 2005: '38 per cent of US scientists and engineers with doctorates now foreign-born'.
[89] 'United States: Innovation, security policies at odds', Oxford Analytica, 10 January 2005. Innovate America, http://www.innovateamerica.org/index.asp.
[90] Ibid.

and businesses prefer a system that leads to the dissemination of knowledge, including to political rivals.

For the US to maintain the advantage therefore requires it to retain its status as the most innovative country in the world. The US Council on Competitiveness recommended increases in federal spending on basic R&D, improvements in maths and science education, increases in 'public and private funds for skills and retraining', more H1-B visas granted and making the R&D tax credit permanent.[91] Unfortunately, the Bush administration is more disposed to restricting the possible military advantage countries like China might take, even if it damages the long term potential of US firms in the important Asian markets.

All these trends, however, must be qualified against the larger National Innovation System. It is true that R&D spending cannot really measure innovation since one is an input, the other, output. Some even believe that 'R&D budget numbers are an exercise in accurate rubbish'.[92] Yet there still remains the fact that money is essential for innovation and should be seen in light of the big picture. While the globalisation of S&T will weaken US leadership over time, it is the overall excellence of the system that will slow the decline. This includes the quality of its tertiary education, which emerging powers such as China cannot yet match; knowledge transfer from research facilities to enterprises; the largest amount of corporate investment compared to any other country; and, government funding, which is still much higher than the most developed nations, let alone China.

EU Struggles to Keep Up

The countries that belong to the European Union are in a worse position. The 2000 Lisbon Agenda of spending three per cent of GDP on R&D by 2010 has become unrealistic as the EU25 struggle just below two per cent. The European Commission even admits that 'Europe is lagging behind the US and Japan in both innovation

[91] Ibid.
[92] Michael Schrage, 'For innovation success, do not follow where the money goes', *Financial Times*, 8 November 2005.

and research'.[93] EU R&D intensity is close to stagnation, while the growth of R&D as a percentage of GDP has been decreasing since 2000, growing a paltry 0.2 per cent between 2002 and 2003.

On closer inspection, Europe is divided in its performance. The leading lights are Finland, Sweden, Germany and Switzerland. Mediocre performers include Denmark, France, Ireland, the UK and the Netherlands.[94] Those attempting to gain ground are most of the new EU10 plus Portugal, apart from Estonia and Slovakia which are actually falling behind. The two prospective members, Bulgaria and Romania, are also failing to perform. At current rates, it would take countries like Hungary, Slovenia and Italy until 2015 to reach the EU average, while Malta, Slovakia and Poland will need at least fifty years. If this trend remains stable, the EU will reach today's US level of innovation performance in 2055.

It is the private sector, however, that largely stimulates R&D investment. In the EU 55.6 per cent of R&D was financed by business in 2002, while in the US it was 63.1 per cent and Japan, 73.9 per cent.[95] Compared to previous years, of the US, EU and Asia, only in Europe did companies fail to invest more in R&D.[96] The European Commission hopes to have this up to two-thirds by 2010, however the latest Eurostat figures have business sector investment down one point to 54 per cent.[97]

Across the board, the European Union's seventh scientific Framework Programme needs to make an impact. The budget proposed in December[98], only committed an eight per cent rise per year, which falls short of the doubling by 2013 wanted by the

[93] 'An action plan to boost research and innovation', Europa press release, MEMO/05/366, 12 October 2005.
[94] The others are Luxembourg, Belgium, Austria, Italy, Spain, Norway and Iceland.
[95] 'R&D spending falls further behind target', *Financial Times*, 24 October 2005.
[96] Ibid.
[97] 'EU's R&D expenditure still at impasse', Science & Research, EurActiv, 13 March 2006, http://www.euractiv.com/Article?tcmuri=tcm:29-153323-16&type=News.
[98] The EU Parliament only finally agreed to the budget in April 2006 after an agreed 2 billion euro increase to the tabled proposal. Member States were then left to make the final decision later in the year. 'Deal reached on EU Budget 2001-2013', Agenda 2004-09, EurActiv, 5 April 2006, http://www.euractiv.com/Article?tcmuri=tcm:29-153940-16&type=News&Ref=mail.

European Commissioner for research, Janez Potocnik.[99] He noted that, 'if current trends continue, Europe will lose the opportunity to become a leading global knowledge-based economy'. Continuing, he warned that if China continues to increase its R&D spending at double-digit percentage rates, it would overtake the EU as soon as 2010.[100] The lack of money could affect the European Research Council (ERC), a body to start in 2007 that will direct important funding for EU level research. The ERC is essential for the Commission's ambitions to keep the brightest scientists in Europe and 'create a critical mass of researchers engaged in "frontier" research in Europe'.[101]

Although the Continent is often lambasted for its uncompetitive legislation and faltering S&T sector, the EU still holds leading centres of science and technology. Nanotechnology in Europe, largely based in Germany, is as big an industry as in the US.[102] The Internet is being used to create science networks and communities across the EU.[103] The gap between business and science is shrinking, although much more has to be done to achieve the intricacy of networks that exist in the US.

The European Commission has therefore tabled a new action plan to respond to the lethargic approach to S&T.[104] It calls for 19 initiatives to stimulate innovation and research and represents the first efforts at 'an integrated approach to EU research and innovation policies'.[105] These apropos efforts include redeploying state aid, improving the efficiency of intellectual property protection, mobilising additional funds for research, creating innovation poles and improving

[99] Jane Burgermeister, 'EU budget deal blow to scientists', *The Scientist*, 22 December 2005, http://www.the-scientist.com/article/display/22868/.
[100] 'R&D spending falls further behind target', *Financial Times*, 24 October 2005.
[101] Jane Burgermeister, 'EU budget deal blow to scientists', *The Scientist*, 22 December 2005, http://www.the-scientist.com/article/display/22868/.
[102] Edelgard Bulmahn, Federal Minister for Education and Science, 'Building the Germany of Tomorrow with Innovation', http://www.german-embassy.org.uk/building_the_germany_of_tomorr.html.
[103] 'Biotechnology-Europe' is a website designed to bring together science and business and can be found at http://www.biotechnology-europe.com/. It is due to launch in April 2006.
[104] 'An action plan to boost research and innovation', Europa press release, MEMO/05/366, 12 October 2005.
[105] Ibid.

university-industry partnerships.[106] Another idea – which the European Council has preliminarily agreed to – includes the creation of a European Institute of Technology that would fill 'the existing gap between higher education, research and innovation'.[107] Such measures are crucial if Europe is to boost its competitive edge. An example of the urgency was demonstrated at the Hampton Court summit in October 2005 where more and better spending of R&D to strengthen the European defence industry was seen as a priority. Javier Solana speaking in his capacity as head of the European Defence Agency, said, 'we clearly need much of [that technology] in our own hands. And for that we need a globally competitive European defence industry'.[108] Only time will tell, however, whether any progress will be made as the EU tackles tougher questions, trying to define itself, reforming the Common Agricultural Policy, stimulating economies and overcoming internal animosities. If nothing is gained, then China is likely to achieve the Lisbon Agenda before the EU.

Looking at the UK in particular, recent brilliance with strong growth, high employment and low inflation for one of the longest periods in its history has dimmed in the shadow of downgraded growth forecasts. The World Economic Forum reported that British competitiveness has seriously diminished, falling far behind other large nations on the Continent to thirteenth place from fourth nine years ago.[109] 'Key long-term weaknesses' exist in the British economy, especially in 'productivity, skills, R&D and infrastructure'.[110] In the latest OECD Science, Technology and Industry Scoreboard, UK S&T appear lacklustre, with 'very little change in its R&D intensity over the years, although the current level is somewhat below the levels in the 1990s'. Investment in research and development has fallen to 1.9 per cent of GDP from 2.1 per cent in the previous decade, while British competitors, such as Japan (3.6

[106] Ibid.
[107] 'Member states opt for a "network EIT"', Science & Research, EurActiv, 24 March 2006, http://www.euractiv.com/Article?tcmuri=tcm:29-153674-16&type=News.
[108] 'EU to boost civil and military security research', EurActiv, Science & Research, 14 February 2006, http://www.euractiv.com/Article?tcmuri=tcm:29-152529-16&type=News&Ref=mail.
[109] 'UK slips in world competitiveness league', *Times Online*, 29 September 2005.
[110] 'OECD joins critics of Brown's optimistic budget arithmetic', *The Guardian*, 13 October 2005.

per cent), the US (2.6), Germany (2.6) and France (2.2) out-perform significantly. Suffice it to say, despite major scientific advances made by the UK in the past and strong pharmaceutical and biotechnology industries, the UK is in a position of retreating lead.

This is not to say that European leaders have not recognised the problem. Luxembourg's Prime Minister was candid when he admitted that, 'we all know what to do, but we do not know how to win elections when we do it'.[111] In the United Kingdom, Tony Blair has been quick to recognise that to sustain Britain's position in the world it must become a competitive knowledge economy, acknowledging that he is 'painfully aware that China has been growing three times as fast as the UK'.[112] If Britain and other Western nations do not reform, the growing pressures of globalisation combined with increased competition from the Far East will only serve to weaken Europe as it fails to adapt. While in one sense this may lead to less jobs, decreasing investment and a diminished capacity to maintain relatively high living standards, in another, less tangible, sense it will mean the erosion of power.

[111] 'Verdict time for national economic reform programmes', EurActiv, Innovation & Jobs, 23 January 2006, http://www.euractiv.com/Article?tcmuri=tcm:29-151824-16&type=News.
[112] Tony Blair, 'Europe is Falling Behind', *Newsweek Special Edition*, December 2005 – February 2006.

Dreams of Power

> We will intensify scientific and technological training for soldiers to turn out a new type of highly competent military personnel. We will greatly strengthen defence-related research and modernise our weaponry and equipment. We will continue to carry out reform and development of our defence-related science and technology industries.[113]
>
> - Wen Jiabao, 5 March 2005

The corollary to a shift in technological capabilities eastward is that the balance of power tilts with it. While the US may have the ambition to maintain its pre-eminence, its leadership is currently failing to do so. The EU, meanwhile, has recognised that it must innovate or lose significant influence on the world stage. China will continue its drive in S&T, not simply to increase growth and spread prosperity. The accumulation of power is an immediate goal to settle both domestic and international issues on terms acceptable to the Chinese government.

This search for power is manifest in the rhetoric and actions emanating from the Chinese government. Premier Wen Jiabao in April 2005 was keen to emphasise that 'science and technology are the decisive factors in the competition of comprehensive national strength'.[114] S&T is seen as a double-edged sword: providing an effective way to improve living standards at home and featuring as a fundamental component of Comprehensive National Power (CNP), a measure of how much leverage one country has against another. Such purchase can be enhanced through close diplomatic ties, trade agreements, public diplomacy, third-party pressure, military prominence, self-sufficiency and so on. Population size, national work ethic, immigration laws, anything that gives a country an advantage over others, contributes to CNP.

Along with S&T, the two fundamental requisites for a nation's power are the military and size of the economy. The military can protect a country, its people and its interests through the threat of force, and

[113] Report on the Work of the Government: Premier Wen Jiabao, '2004 Economic performance official report', Chinability.com, 5 March 2005.
[114] Dr. Michael Pillsbury, 'China's progress in technological competitiveness: the need for a new assessment', US-China Economic and Security Review Commission, April 2005.

ensure stability through peacekeeping. The economy, by turn, can create domestic prosperity, attract investment and trade, and project soft power across borders through the attraction of labour and the promotion of values. Technological development, meanwhile, has strategic qualities because it has 'implications for the relative position of the state in the global military *and* economic balance'.[115] The role S&T plays in strengthening the military and economy is a major reason why Chinese assessments of CNP rank it as second in importance.

The supportive and sometimes subtle qualities of S&T are what give it such prominence. On the one hand, S&T can provide for more high-tech defences and an advanced military. On the other, they can equip a nation with computers, allow access to the Internet, give them mobile telephony and wireless broadband, provide them with the latest manufacturing equipment, improve their education, enhance their literary skills, create improvements in agriculture, transport them efficiently, extend their life spans and make them safer from danger. These gains provide a nation with power through improved competitiveness, extra growth and efficiencies.

S&T policy, therefore, in its simplest form is a benign force providing directly to the domestic agenda of growth. Yet it can also function as a tactical weapon on the global stage if under techno-nationalist influences. This occurs when 'explicit innovation policies' are for 'the most part governed by the nation state' instead of the market or the interest of firms.[116] These techno-nationalist policy measures range from skewed government investment for particular industries, encouraging the purchasing of foreign firms, 'favouring domestic firms and technologies over, or to the exclusion of, foreign brands',[117] forcing the sharing of technology, not enforcing intellectual property rights, encouraging scientists and students to study abroad to gain

[115] Tai Ming Cheung, 'Leaping Tiger, Hybrid Dragon: the search for technological and civil-military integration in the Chinese defence economy', October 2005, p55. Emphasis added.
[116] Sylvia Ostry and Richard R. Nelson, 'Techno-nationalism and techno-globalism: Conflict and cooperation', Brookings Institution, Washington DC, 1995, pvii.
[117] Kathleen Walsh, 'China's High Technology Development', US-China Economic and Security Review Commission, 21 April 2005.

access to technology then return, to even outright spying.[118] China's S&T policy can thus be geared toward strengthening the country's national security and accumulating power. While in some respects these techno-nationalist policies have American and European cousins, the extent to which tools such as protectionism or standardisation are used in the West is relatively minimal by comparison, although notably on the increase in recent months. This is because it is largely recognised that such policies are not always conducive to growth and productivity. In fact, they can be detrimental to nationalist interest. Yet in China, some national science policies have become designed to secure these economic and security interests.

This techno-nationalist flavour to S&T becomes more complicated when infused with a techno-globalist zest. In today's world, globalisation has dragged production lines across borders. Scientists move freely across the globe and converse instantly across networks. MNCs straddle continents. Experiments and theories are published every day. The world of S&T, ideally, is one of communication and collaboration. In some senses, science has become a global enterprise and China has profited greatly from such developments.

Globalisation, however, can be taken advantage of. By bringing foreign firms into China over the last few decades, native industries have been able to creep up the value-chain from manufacture toward design. For China this has intrinsic benefits. The implications of globalisation on product development have shifted technology and knowledge into China at an earlier stage in the life-cycle. To facilitate this, Dr. Denis Fred Simon believes that 'the new core competency for success in this demanding environment of technological globalisation is the ability to identify, harness and

[118] 'Nearly 100 nations, including allies, spying on US', GG2.net, 30 September 2005: 'Chinese intelligence services are mounting wide-ranging efforts to acquire US technology and are among the most active, Michelle Van Cleave, the national counter-intelligence executive, has told a Congressional hearing on foreign spying'. 'Smash and grab, the hi-tech way', *The Guardian*, technology supplement, 19 January 2006: 'British and US security experts believe the hackers are working with the tacit approval – or possibly even direct support – of authorities in the People's Republic of China and are attempting to acquire western technology in a massive hit and run raid on the world's intellectual property to aid their booming economic growth.'

manage the forces for transborder innovation and technological advance' – all skills that China is quickly developing.[119] It has also allowed Chinese scientists to educate themselves in better universities overseas and gain experience with high-technology. Now that domestic Chinese firms have begun to take off, they have used to their own advantage this global phenomenon and become the first Chinese MNCs.

This seemingly contradictory approach of the PRC having both nationalist and globalist policies cannot be attributed to tension between the 'forces of techno-nationalism and techno-globalism'. This only 'creates a false and somewhat inaccurate dichotomy', since they are actually part of the same behaviour, 'intertwined in a single, synergistic relationship with one another'.[120]

> Techno-nationalist imperatives drive Chinese techno-globalist behaviour, fostering expanded economic reforms and greater openness, both of which, in turn, facilitate more foreign involvement in the PRC economy through FDI, technology transfer and the establishment of foreign R&D centres. Techno-globalist actions support Chinese techno-nationalist goals and objectives as broader and deeper engagement with the international science and technology system serves as an enabler for strengthening of domestic technological capabilities.[121]

China is embracing globalisation, unlike some European countries, and exploiting it in order to catch up with the very countries that created it. The abduction of globalisation is characterised as 'neo-techno-nationalism', where 'technological development in support of national economic and security interests is pursued through leveraging the opportunities of globalization for national advantage'.[122] Standardisation of technology can be abused in this way. The population of China is so large that it can quite easily set standards on technologies that will affect the rest of the world

[119] Dr. Denis Fred Simon, 'Hearing on China's High Technology Development', US China Economic and Security Review Commission, April 2005.
[120] Ibid.
[121] Ibid.
[122] Richard P. Suttemeier and Yao Xiankui, 'China's Post-WTO Technology Policy: Standards, Software and the Changing Nature of Techno-Nationalism', NBR Special Report, No.7, May 2004.

because MNCs will want to be compatible with such a lucrative market.

A greater injection of funds for R&D was announced in January 2005 by the Vice-Director of the Ministry of Science and Technology (MOST) Development and Planning Department, Xu Jianguo. The purpose of this initiative, which had originally started in 2002, was to establish 29 international standards in such fields as environmental protection indicators, trace element examination, textile safety, broadband local area networks and RFID. While other countries may try to influence the setting of standards to some degree through lobbying and effective marketing, in China 'companies note a growing influence of standards working groups that either preclude foreign participation or attach certain technology sharing conditions', especially where state funds or concerns are strongest.[123] Where usually 'market competition, industry preference or consumer choice' guide the implementation of standards, increasingly in China direction is discerned more by government priorities.[124]

One example can be seen in the mobile telephony sector. The intense competition between rival phone makers such as Nokia, Ericsson, Siemens and Motorola has led them to invest greater resources into R&D in the hope of setting the standards. Through these efforts, Nokia have been able to secure themselves in the CDMA handset market and will further entrench their position by working with Chinese developers of CDMA technology.[125] For China such control over standards has provided greater investment, more technology transfer and an influence over the direction of global development in the latest technologies.

Motivation for such interference, in the pursuit of techno-nationalist policies, is incredibly complicated. It is not simply about securing growth to provide better growth and prosperity. Neither is it solely about catching up with the West. In a psychological sense, it arises from a general insecurity that China relies too heavily upon the

[123] Kathleen Walsh, 'China's High Technology Development', US-China Economic and Security Review Commission, 21 April 2005.
[124] Ibid.
[125] Dr. Denis Fred Simon, 'Hearing on China's High Technology Development', US China Economic and Security Review Commission, April 2005.

United States – what some see as 'information colonialism'.[126] The creation of native technology is thought to reduce dependence on foreign suppliers and remove opportunity for sabotage, hacking or backdoor programming by foreign agents.[127] This desire for technological autonomy is deeply rooted in some Chinese, who view the dominance of the US as a threat to national sovereignty.[128] Yet the reasons for techno-nationalist policies can also be seen in the relations that exist between China and the US. Their mutual inability to comprehend each other's motives, to present their actions as transparently as possible or avoid a confrontation on various fronts – be they trade, technology or human rights – has created a growing tension in international relations. With such uneasiness difficult to dispel, national security becomes increasingly important and the use of techno-nationalist policies ever more attractive. To prevent an escalation of retrenching policies, to ensure that shifts in global power do not create instability and to assure that China is integrated peacefully and fully into global economic, scientific and technological networks, all sides need to reassess national priorities in the context of China's emergence as a great power.

[126] AnnaLee Saxenian, 'Government and Guanxi: the Chinese software industry in transition', DRC working papers, Global software in Emerging Markets, Centre for New and Emerging Markets, London Business School, No.19, University of California, March 2003.
[127] Kathleen Walsh, 'China's High Technology Development', US-China Economic and Security Review Commission, 21 April 2005.
[128] Barry Naughton and Adam Segal, 'Technology Development in the New Millennium: China in Search of a Workable Model', MIT Japan Program, Center for International Studies, 28 May 2001.

Conclusion

Analysis of China is, however, extremely difficult, especially as it is growing, changing and adapting so quickly. The measure of China's S&T output and input reports growth at a pace that is distancing it from other developing countries and pushing it toward more developed nations. The goal of spending 1.5 per cent of GDP on R&D is attainable, and if they continue it will further increase the speed by which China will reach the R&D spending of developed nations. Kathleen Walsh of the Stimson Center has noted that statistical evidence 'suggests China could be in the early stages of an S&T take-off' that would position the country amongst Western nations in just ten years.[129]

With the 10th FYP at an end, leaders of the PRC have in mind the goals for the eleventh. This includes spending a whole two per cent of GDP on R&D, diffusing native development efforts out West to diminish the disparity between the coast and the inner provinces and, most importantly, to abandon imitation for innovation. This is also known as the move from 'made in China' to 'made by China'.[130]

According to details disclosed by the press, this next FYP will be the most modern to date. In the past, direction and targets were set by officials. Now reports suggest that they may rely more on guidelines, which will greatly benefit China's S&T capacity compared to a more centralised plan. This would then parallel the approach taken by more developed nations.

China's enormous market potential, increasingly educated population, multiplying home-grown talent, and growing venture capital and FDI virtually 'guarantees that China will become a major innovative force in the global economy'.[131] If it continues to develop and modernise its scientific base, combined with current economic

[129] Kathleen Walsh, 'China's High Technology Development', US-China Economic and Security Review Commission, 21 April 2005.
[130] Ibid.
[131] Gary Edward Rieschel, 'Hearing on China's High Technology Development', Mobius Venture Capital, US-China Economic and Security Review Commission, April 2005.

progress, China will have in its grasp the ingredients that the United States had when it began its hegemonic reign as the world's most powerful country.

Yet Nobel Economics Prize winner Douglas North believed that focus on S&T in itself will not produce the rapid pace of development desired. Efficient institutions and the nature of government, he noted, are more critical. Property rights are essential for efficient institutions to flourish – the appropriate system of government to secure these rights is therefore also needed. With these in place growth is much more sustainable.

The inherent weakness of the Chinese S&T matrix, of the entire country, in fact, is therefore the absence of permanent law. The safety of knowing that you can rely on rules and regulations to guard yourself can appear superficial in China since the government can change the rules at any time and without any remedy or recompense for those subject to them.

This volatile situation means long term predictions of China's intentions and motivations are impossible. This ambiguity can be particularly destabilising when juxtaposed with the country's potential capabilities. The country's size allows it to pursue many scientific fields simultaneously and compete effectively across many industries, unlike its Asian neighbours. Consequently, China can become competitive in a number of areas all at once, much as in the US, and disperse 'technological advances westward as the burgeoning coastal areas lead the way in commercial technology innovation'.[132] This could lead investors and policy-makers to underestimate China's capabilities, creating a trade deficit in high-technology goods, compounding the current trade deficit of nearly US$167,000 million.[133] Attempts to rectify it could damage relations with China and affect future business and investment.

[132] Kathleen Walsh, 'Foreign High-Tech R&D in China: Risks, Rewards and Implications for US-China Relations', Henry L. Stimson Center, 2003.
[133] 'Trade in Goods (Imports, Exports and Trade Balance) with China', Foreign Trade Statistics, US Census Bureau, 2005, http://www.census.gov/foreign-trade/balance/c5700.html#2005.

Handling relations with China has always been difficult for policy-makers. It is hard to deal with an extremely attractive market that is perceived by popular opinion to breach human rights and constrain freedoms. This situation will become more complicated as the dynamic of global power changes in the coming decades. The Chinese Modernisation Report 2005, produced by CAS, has predicted that China will be an 'advanced developed country' by 2080.[134] Even if accurate, China's S&T sector has an impact today upon international affairs. Its techno-nationalist policies are altering the mechanics of global science and technology, shifting power away from centres of innovation in Europe and the US. Direct state political control is using globalisation to buttress Chinese economic, political and military spheres.

As China becomes an alternative to Western science, money, jobs, trade, intellect and discovery will be drawn there. This will inevitably reduce the influence of the US and EU. China's appearance on the international stage as a technologically capable power will offer an alternative to the West. Isolated counties, from Zimbabwe to Iran, could find in China a provider, and perhaps even a protector, if interests are aligned.

The real challenge for the West therefore is two-fold: maintaining its own scientific momentum and integrating Chinese S&T into the global network of innovation. Europe and America's competitiveness need to be sustained and continually reinvigorated. Scientific and technological developments in the West have largely been forces for global good with most knowledge freely accessible to all as long as commercial and patent sensitivities are observed. China should be encouraged to allow the same. They must also persuade China to adopt policies that incentivise business to make discoveries and create innovations, rather than using government to dictate development. This would foster growth, prosperity *and* power in China through the development of people's lives rather than the enhancement of the state.

Whether it comes to blows with the US or not, China, because of its dedication to S&T, will become stronger, changing the face of the

[134] Guo Nei, 'China to become "developed country" by 2080', China Daily, February 2005.

global order and returning it to its historical place as a great power. S&T may not be China's *secret* weapon, but it is certainly wielding it with greater awareness and effect than its rivals.

Recommendations

China

China's S&T policy has remained pragmatic and flexible for the environment in which it operates, but needs to shift emphasis in the coming years in order to maintain the edge that has set it apart from other developing countries:

- State institutes and elite universities should channel their efforts into basic and experimental research and concentrate on R&D with high social, but low economic, returns and activities important for national security;
- Reform of the educational structure and fairer allocation of resources will widen and improve the knowledge base: the root of all scientific power;
- The legal and financial infrastructure must be further reformed and enforcement rigorously applied;
- A culture of creativity and innovation needs to be cultivated through push and pull legislation that can create incentives and encourage the marketing of ideas;
- Private firms must be encouraged to network and make links across the S&T sector, while central government must allow native companies to develop and expand with minimal official interference;
- The use of state power and influence must be reduced further to allow the private sector to be directed by market forces, providing the most innovative products in the interest of global markets rather than government priorities.

United States

The world is changing around the US, with globalisation drawing away the assets that have sustained its technical prowess over the decades. To ensure it softens the decline and carries on as a bastion of innovation, it must:

- Resist trying to hamper China's technological development – a virtual impossibility;
- Focus on returning its levels of funding to higher levels;
- Enhance the reputation of the US abroad to attract foreign students;

- Minimise visa restrictions;
- Keep the costs of education within the reach of the brightest;
- Encourage US companies to buy up Chinese enterprises, instead of relying on government protectionism that will eventually stifle American industry.

European Union

The EU is currently at its own crossroads. Hampering advancement are deep crises of confidence and identity that have emerged since the rejection of the European Constitution in May 2005. Only when positive changes begin to take place will the EU gain its second wind and experience its own 'take-off':

- Member states must become more innovative, dedicate more resources to S&T and incentivise companies to perform R&D within the EU;
- Networks between business and academia must be strengthened;
- Measures need to be developed by government to help small- to medium-sized enterprises to innovate;
- National leaders should agree on a broad definition of what the EU stands for so the energy and momentum will be available to push the EU to meet its target set by the Lisbon Agenda in 2000;
- Temptations to invoke their own techno-nationalist policies, either through protectionism or restriction of labour, must be resisted;
- The Commission's plan to enhance 'cooperation', 'capacities', 'people' and 'ideas' should be taken up by all member states and built upon.

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About the China and Globalisation Project

The FPC's China project was launched with a series of seminars held at Downing Street, HM Treasury, Parliament and the Guildhall in May 2004. The Downing St Seminar was attended by the Chinese Premier Wen Jiabao and Prime Minister Tony Blair, and leading business and government figures from the UK. The launch included release of *The Beijing Consensus*, by Joshua Ramo, a publication that has since been translated and circulated to China's leaders. The launch saw the establishment of a formal partnership with the Chinese Academy of Social Sciences (CASS).

The FPC's China project aims to engage a broader group of actors with emerging new thinking on the social and economic consequences for China of globalisation and the impact of the rising Chinese economy on the future of globalisation. The China project will take Chinese perspectives as its departure point, focusing on three principal areas:

- how China's government, interest groups and diverse communities see their values and how they project these values to the world;
- outside attempts to understand and engage with the values of the Chinese government, leading interest groups and diverse communities; and
- the role of these diverse, often competing, Chinese actors in globalisation and global trends.

The 'China and Globalisation' project aims to penetrate beyond broad generalisations about China as some hypothesised monolithic actor yet to have its significant impact on global order. The programme will examine a variety of new issues and cutting edge ideas arising from the huge influence that the wealthier China and its diverse interest groups and communities are already having, both internally and externally on: energy and raw materials; public diplomacy; security and international order; development and governance; technology; and finance and the international economic order.