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OUT FLYING THE EAGLE: CHINA'S DRIVE FOR DOMESTIC ECONOMIC INNOVATION AND ITS IMPACT ON U.S.-CHINA RELATIONS

by

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In 2006, the People's Republic of China adopted an innovation policy designed to accelerate domestic economic innovation. With this policy, China aimed to shift its economy from one that manufactures products at the lower end of the value-added chain to one manufacturing products at the top of the value-added chain. China plans to become not only a high-technology manufacturing nation but to become the world-leader in innovation. Certain aspects of this plan for endogenous growth through state-driven economic innovation were economically competitive with the United States. This thesis will assess the impact of the PRC's plans and actions to drive innovation, to include answering the following questions: Have the PRC's actions regarding innovation made an impact on its economic performance? And consequently: How might we expect China's state-driven-innovation to affect U.S.–China relations? This thesis will show that China's "Indigenous Innovation" policy has made some minor contributions to raising the levels of innovation in China but will likely fall short of the 2006–2020 MLP goals. Furthermore, although this policy initially included economically competitive elements, it has been adjusted and in its present form is less likely to have a negative impact on future U.S.-China Relations.

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ABSTRACT

In 2006, the People's Republic of China adopted an innovation policy designed to accelerate domestic economic innovation. With this policy, China aimed to shift its economy from one that manufactures products at the lower end of the value-added chain to one manufacturing products at the top of the value-added chain. China plans to become not only a high-technology manufacturing nation but to become the world-leader in innovation. Certain aspects of this plan for endogenous growth through state-driven economic innovation were economically competitive with the United States. This thesis will assess the impact of the PRC's plans and actions to drive innovation, to include answering the following questions: Have the PRC's actions regarding innovation made an impact on its economic performance? And consequently: How might we expect China's state-driven-innovation to affect U.S.–China relations? This thesis will show that China's "Indigenous Innovation" policy has made some minor contributions to raising the levels of innovation in China but will likely fall short of the 2006–2020 MLP goals. Furthermore, although this policy initially included economically competitive elements, it has been adjusted and in its present form is less likely to have a negative impact on future U.S.-China Relations.

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LIST OF ACRONYMS AND ABBREVIATIONS

EI	Engineering Index, database
FDI	foreign direct investment
GDP	gross domestic product
GERD	gross domestic expenditures on research and development
IPR	intellectual property rights
ISTP	Index to Scientific and Technical Proceedings
MLP	Medium and Long-Term Plan
MNC	multinational corporation
MOST	Ministry of Science and Technology, China
NBS	National Bureau of Statistics, China
NIS	national innovation system
OECD	Organisation for Economic Co-operation and Development
PCT	Patent Cooperation Treaty
PPP	purchasing power parity
PRC	Peoples Republic of China
SCI	Science Citation Index
S&ED	U.S.–China Strategic and Economic Dialogue
S&T	science and technology
R&D	research and development
RMB	Renminbi
USITC	United States International Trade Commission
WIPO	World Intellectual Property Organization
WTO	World Trade Organization

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I. INTRODUCTION

A. WHY CHINA'S ABILITY TO INNOVATE MATTERS TO THEM AND TO THE REST OF THE WORLD

> The history of modernization is in essence a history of scientific and technological progress. Scientific discovery and technological inventions have brought about new civilizations, modern industries, and the rise and fall of nations … I firmly believe that science is the ultimate revolution.
>
> —Wen Jiabao, Premier, People's Republic of China [1]

In 2006, the government of the People's Republic of China (PRC) adopted a policy known as "Indigenous Innovation" (or in Chinese, *zizhu chuangxin*) that was designed to drive domestic economic innovation. The basic tenets of the plan call for:

- Chinese society to develop a culture of innovation; government programs to support basic research
- The creation of an advanced scientific and technical education system; the development of strong intellectual property protection
- The fostering of entrepreneurship

These requirements can be considered the foundations of an innovative society.[2] Certain aspects of this policy worry Western economists especially during current sluggish economic times. This thesis will assess the impact of the PRC's plans and actions to drive innovation, to include answering the following questions: Have the PRC's actions regarding innovation made an impact on its economic performance? And, consequently: How might China's state-led efforts to promote innovation affect U.S.–China relations?

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[1] Norman R. Augustine, C. Barrett, G. Cassell, N. Grasmick, C. Holliday, and S. A. Jackson, "Rising Above the Gathering Storm, Revisited: Rapidly Approaching Category 5" (Washington, DC: National Academy of Sciences, National Academy of Engineering, Institute of Medicine, 2010), 72.

[2] USCC, *Assessing China's Efforts to Become an "Innovation Society" – A Progress Report, Hearing Before The U.S.-China Economic and Security Review Commission*. 112 Cong. 2. (2012) (Statement of Robert D. Atkinson, President, Information Technology and Innovation Foundation). 393.

1. Findings and Argument

With the outcome of "Indigenous Innovation" potentially affecting not only China but also the rest of the world, it is very important to fully understand the details and nature of this policy. Eight years have passed since the implementation of "Indigenous Innovation," in China's Medium and Long-Term Plan (MLP) from 2006–2020, long enough to make some preliminary assessments of its effectiveness and impacts. This thesis suggests that there are three potential effects of "Indigenous Innovation" on China's economic performance. The first possibility, *Indigenous Innovation Flops*, asserts that "Indigenous Innovation" has not been an effective policy thus far, has not brought the desired economic growth, and has needlessly disrupted international trade, investments, and commerce by what has been deemed by some as "techno-national" policies. The second possibility, *Indigenous Innovation becomes China's new economic engine*, finds that "Indigenous Innovation" is on track to succeed, according to output indicators, possibly replacing the old economy dominated by foreign direct investment and low-tech manufacturing. The third possibility, *Indigenous Innovation is Irrelevant for Chinese Growth*, shows that "Indigenous Innovation" policies have had a negligible impact on China's continued economic development and level of innovation. The changes that have allowed for continued growth of China were already happening and would have continued to happen without this policy.

Based on current data and analysis, the most significant finding of this thesis is that so far China's *Indigenous Innovation Flops*. Even though this policy has made some minor contributions to raising the levels of innovation and economic growth in China but will likely fall short of the lofty goals of the 2006–2020 MLP. "Indigenous Innovation" is not yet the new economic engine China hoped it would be, but it is a broad strategic approach that will have long lasting effects in the future. Innovation is driving growth in China, however as shown by the details of patent filing statistics, it is mostly market driven incremental and manufacturing innovation and not the invention or new product innovation that China is seeking. China is likely to reach its innovation benchmarks but not until 10 years after its initial target dates. If China can adjust its policy to focus more on the university-private enterprise R&D nexus and ease societal/cultural pressures to be risk averse and failure avoidant, then it could possibly turn its modernization in the right direction coming closer to achieving its goals for innovation. It is likely only a matter of time before China has its own "Google" or "Apple" like global-tech-giants with regular breakthrough innovations contributing to endogenous growth.

2. Importance

a. China's Rapid Economic Rise and the Need for Sustainable Economic Growth

From the 1980s onward China has grown faster than any other economy in the world. According to official figures, from 1978 to 2005 China's economy, in terms of GDP, grew at an annual average of 10.0%.[3] This growth, for the most part, was built on an increasingly efficient deployment of the country's enormous human and physical capital in the manufacturing sector. By 2006, without the benefits of "Indigenous Innovation," China was already on a trajectory of unprecedented growth. This massive growth, beyond bringing wealth to a few, had the profound effect of lifting hundreds of millions out of poverty. The estimated poverty rate for China in 1980 was 75.7%. Through the rapid growth from 1980 until 2001 poverty was reduced to 12.5%.[4] The percentages stand out even more when one considers the sheer size of the Chinese population now at 1.3 billion people.

Although China's rapid growth has brought much good, the PRC has had to evaluate both where this growth has come from, and how to continue growth into the future. By the turn of the century China had become a manufacturing powerhouse, producing a rapidly growing share of the worlds manufactured goods. By 2011 China surpassed the United States as the world's largest manufacturer of goods.[5] As Chinese government officials evaluated the status of their nation's economic growth they recognized the need for change. They realized that in order to obtain sustained

3 Barry Naughton, *The Chinese Economy: Transitions and Growth* (Cambridge, MA: MIT Press, 2007), 3.

4 Loren Brandt and Thomas G. Rawski, "China's Great Economic Transformation," *China Business Review* 35, no. 6 (November 2008), 32.

5 Peter Marsh, "China Noses Ahead as Top Goods Producer," *Financial Times* 13 (2011), 1.

growth, they needed to improve their Science and Technology (S&T), and innovation capabilities.[6]

Without continued growth China may not be able to employ large portions of its massive population, which could lead to instability and political unrest. Both the Chinese government and economists alike assess that the current pattern or model of growth is unsustainable. Rapid industrialization and urbanization have impacted China with several major issues including: massive consumption of energy and raw materials, degradation of the environment, regional disparity in growth and wealth distribution, mass migration from rural to urban areas. Couple these issues with rising wages, an aging workforce, and higher demands for social services and the outlook, if unchanged, is rather bleak. The staggering size of China's population brings a unique set of issues to the government of China, multiplying the effects of their growth issues.[7]

Much of China's recent growth has been through technological diffusion, foreign direct investment and domestic investments. This growth model has been characterized by Jeffery Sachs as *Catching-up growth*.[8] This catching up growth made China a global leader in low-tech manufacturing. According to Bottelier and Foster of the Norwegian School of Management, the recent growth in China was not fueled by low wages but instead by high productivity growth primarily in the manufacturing sector.[9] Growth on the basis of physical and human capital runs into the law of diminishing marginal returns. Neo-Classical economic theory has established as axiomatic that only growth based on innovation—measured as total factor productivity—can allow a country, once it has "caught up," to sustain high growth rates over a long period of time.

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6 "White Paper on China's peaceful Development," Accessed on January 20 2013, http: //www.gov.cn/english/official/20 ll-09/06/content_ l941354_2.htm.

7 *OECD Reviews of Innovation Policy China*, Organisation for Economic Co-operation and Development, 2008.

8 Jeffrey D. Sachs, "Globalization and Patterns of Economic Development," *Weltwirtschaftliches Archiv*, Bd. 136, H. 4 (2000), 581. Accessed January 13, 2013, http://www.jstor.org/stable/40440807.

9 Pieter Bottelier, Gail Foster, and Conference Board, *Can China's Growth Trajectory Be Sustained?* (New York: The Conference Board, Inc, 2007), 6.

b. Significance of Innovation

Throughout the world governments and scholars emphasize innovation as the key to global prosperity.[10] In his 2011 State of the Union Address, U.S. President, Barack Obama used the word "innovation" nine times and the need to renew American sources of innovation was a central theme of his speech.[11] European Commission President José Manuel Durão Barroso said the following regarding the importance of innovation: "History shows - from the Renaissance to the industrial revolution and to the current ICT evolution that there is no sustainable path to growth and prosperity outside the research-innovation-education triangle."[12] China's leaders since reforms were initiated have also focused on the advancement of S&T and innovation. They firmly believe, like President Obama, in the inherent and essential link between innovation and economic growth as explained by Pack and Westphal.[13] A general explanation of the relation of innovation to economic growth draws from the Endogenous Growth Theory.[14] This theory asserts that growth is a product of human capital, physical capital, and Total Factor Productivity (TFP). TFP is a measure of technology, innovation, and labor productivity. Therefore, as a nation increases innovation its economy grows. Most recently China's new president Xi Jinping was quoted by Xinhua saying that "Implementing a strategy of innovation-driven development will be fundamental in accelerating the transformation of China's growth pattern, solving deep-rooted problems concerning economic development and enhancing economic vitality."[15] *The Economist* claimed in a 2010 article that: "...Emerging countries are no longer content to be sources of cheap hands and low-cost brains. Instead,

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10 "2011 State of Innovation Report Featuring DWPI" (New York: Thompson Reuters, 2011), 3.

11 Barack Obama, "Remarks by the President in State of Union Address," Office of the Press Secretary, The White House, (25 JAN 2011), accessed February 13, 2013, http://www.whitehouse.gov/the-press-office/2011/01/25/remarks-president-state-union-address.

12 José Manuel Durão Barroso, *The Innovation Union One Year on Innovation Convention 2011, SPEECH/11/847,* (Brussels: 5 December 2011), 2.

13 Howard Pack and L. E. Westphal, "Industrial Strategy and Technological Change: Theory Versus Reality," *Journal of Development Economics*, 22, no. 1 (1986): 87–128.

14 Paul Romer, "Endogenous Technological Change," *Journal of Political Economy* 98, no. 5 (1990): 71–102.

15 "Xi Urges Innovation-Driven Growth," *Xinhua*, March 4, 2013, Accessed March 14, 2013, http://news.xinhuanet.com/english/china/2013–03/04/c_132207617.htm.

they too are becoming hotbeds of innovation, producing breakthroughs in everything from telecoms to car making to health care. …Developing countries are competing on creativity as well as cost."[16]

As innovation has taken the spotlight for economic development so has international competition associated by some with innovation. There is a significant amount of concern both among U.S. citizens and government leaders regarding the relationship of the United States with China. If China's economic growth and policies directed toward growth continue along the present course the probability of increased tensions and strained international relations are likely.[17] Chief among the Chinese policies that could potentially stifle the United States economically is China's proclaimed "Indigenous Innovation" campaign. This campaign, embarked on in 2006, consists of both top-down state driven policies mandating innovation and efforts to encourage bottom-up incentive-fostered innovation. Some of these policies potentially hamper free trade and reduce competitiveness of U.S. corporations—issues that top agendas at almost every bilateral meeting between the two nations.[18]

c. China's "Indigenous Innovation" Policy

China has in the last seven years embarked on a major drive to shift its economy from one that manufactures products at the lower end of the value-added chain to one that is inventing, developing and manufacturing cutting edge technology products at the top end of the value-added chain. The policies adopted by the government to increase innovation are split between top-down mandated innovation and bottom-up self-driven innovation. China wants to incrementally move up the chain toward becoming not only a high-technology manufacturing nation but to become the world leader in high technology and innovation. Although the drive for innovation had manifested years earlier it

16 "Innovation: The New Masters of Management," *The Economist*, April 17th, 2010, http://www.economist.com/node/15908408.

17 Jonathan Kirshner, "The Consequences of China's Economic Rise for Sino-U.S. Relations," in *China's Ascent: Power, Security, and the Future of International Politics*, eds. Robert S. Ross, and Feng Zhu (Ithaca: Cornell University Press 2008), 239–240.

18 Micah Springut, Stephen Schlaikjer, and David Chen, *China's Program for Science and Technology Modernization: Implications for American Competitiveness, Prepared for The U.S.-China Economic and Security Review Commission* (Arlington; VA: CENTRA Technology, Inc., 2011), 130.

solidified in 2006 as outlined in the 15-year Medium and Long-Term Plan (MLP) to 2020.

The plan for innovation in the MLP was referred to as the campaign for "Indigenous Innovation" and included a list of 402 technologies (in many of these the United States is currently the market leader) that China was seeking to develop as areas of expertise. The plan called for China to become an "innovation-oriented society" by 2020 and to become a world leader in science and technology (S&T) by 2050. The MLP also set benchmarks for 2020 that included: increasing gross domestic expenditures on research and development (GERD) from 1.34% (2005) to 2.5%, increase economic growth fueled by technological advance to 60%, and limit its dependence on foreign technology to 30%.[19]

Since its announcement of the "Indigenous Innovation" plan, China reiterated its focus on innovation with the announcement of the 12th Five-Year Plan in March of 2011, that called for seven high tech industries to boost their percentage of gross domestic product (GDP) from the current 5% to 15% by 2020.[20] According to the U.S.-China Economic and Security Review Commission 2011 report, China plans to increase its GERD from 1.75% of GDP (in 2010) to 2.2% of GDP by 2015.[21] In comparison, the United States government and private sectors combined to spend 2.8% of GDP on GERD in 2011.[22]

The United States is also seeking to drive economic growth through innovation. It is the view of many that because markets are competitive; this will undoubtedly lead to

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[19] Cong Cao, Richard P. Suttmeier, and Denis Fred Simon, "China's 15-year Science and Technology Plan," *Physics Today* (December 2006), 38.

[20] Thomas Stanley, and Vivian Xu, "China's 12th Five Year Plan: Overview," KPMG China, (March 2011), http://www.kpmg.com/CN/en/IssuesAndInsights/ArticlesPublications/Publicationseries/5-years-plan/Documents/China-12th-Five-Year-Plan-Overview-201104.pdf.

[21] U.S.-China Economic and Security Review Commission, *2011 Report to Congress* (112th Cong. 2, November, 2011), 90.

[22] "R & D Spending Growth Continues while Globalization Accelerates," *R&D Magazine* 53, no. 7 (2011): 35.

friction between the United States and China.[23] Despite the competitive nature of markets that does not necessarily mean that growth or innovation is zero-sum. As history has proven many nations can share the top economic positions; while sometimes competing, each can specialize in different sectors. U.S. government spending on R&D has dropped since 2009 in conjunction with the global economic recession. An increase in private spending on R&D in the United States has kept year to year spending from an aggregate decline. The Obama administration has made declarations regarding innovation that are quite similar to their Chinese counterparts. With the economic setbacks of the recession, the administration has been hampered in its effort to spark U.S. innovation through spending on R&D. At an address before the National Academy of Sciences in 2009, President Obama announced his plan to increase GERD from 2.7% to 3.0% in terms of GDP (see Table 1).

Table 1. Forecast GERD in Billions of Dollars

Global Rank	Country	2010 GDP PPP Bil. $	2010 R&D as % GDP	2010 GERD PPP Bil, $	2011 GDP PPP Bil, $	2011 R&D as % GDP	2011 GERD PPP Bil, $	2012 GDP PPP Bil, $	2012 R&D as % GDP	2012 GERD PPP Bil, $
1	United States	14,660	2.83%	415.1	15,203	2.81%	427.2	15,305	2.85%	436.0
2	China	10,090	1.48%	149.3	11,283	1.55%	174.9	12,434	1.60%	198.9
3	Japan	4,310	3.44%	148.3	4,382	3.47%	152.1	4,530	3.48%	157.6
4	Germany	2,940	2.82%	82.9	3,085	2.85%	87.9	3,158	2.87%	90.6

Source: Data adapted from; Battelle, R&D Magazine, 2011.[24]

[23] United States International Trade Commission, *China: Effects of Intellectual Property Infringement and Indigenous Innovation Policies on the U.S. Economy* USITC, Investigation No. 332–519, Publication 4226 (2011), xiii.

[24] “R & D Spending Growth Continues,” *R&D Magazine* (2011): 36.

Although U.S. government spending on R&D has fallen short of goals due to the economic recession, the administration has continued its charge for growth through innovation seeded by R&D spending. In his 2011 State of the Union address, President Obama proclaimed, "Maintaining our leadership in research and technology is crucial to America's success." He called for actions to double "the budgets of three key science bureaus: the National Science Foundation, the National Institutes for Standards and Technology, and the Department of Energy's Office of Science."[25] If the global percentages of investment toward innovation shifts between the United States and China will this lead to a shift of global economic leadership from the United States to China? This is a similar question that was asked regarding the United States and Japan in the 1980s. Japan's economic rise is a good historical example of how economic success and growth of other nations, although sometimes competitive, does not foretell economic disaster for the United States.

3. Literature Review

Literature on the effectiveness of innovation policies in China and its subsequent effects on U.S.–China relations, provide numerous conclusions and hypotheses. This thesis will evaluate these views based on the evidence provided and determine which is most persuasive. The extant literature relating to "Indigenous Innovation" its effectiveness and resulting impacts on U.S.-China relations breaks down into the following schools of thought:

Effectiveness of "Indigenous Innovation"

- *Superpower on the way*–China's "Indigenous Innovation" policies have it on track to become an "Innovative Society" boosting its economic growth. (e.g., R&D Magazine 2013, Thompson Reuters, Steve Lohr)
- *Not anytime soon*–China will not become an innovative society according to its goals laid out in the campaign for "Indigenous Innovation" retarding China's future economic growth. (e.g., Joseph Sternberg, Anil K. Gupta, Wang Haiyan, Ross Terrill, Geoff Dyer, Richard Waters, Yuqing Xing)

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[25] "U.S. Scientific Research and Development 101: Understanding Why These Investments Are Key to Our Future Economic Competitiveness," *Science Progress* (online magazine), (February 16, 2011), 1, accessed 01 September 2012, http://scienceprogress.org/2011/02/u-s-scientific-research-and-development-101/.

Impact of “Indigenous Innovation” on U.S.–China relations

- *The U.S. is in peril of falling behind*–The United States is in peril from China’s mercantilist policies. (e.g., Robert D. Atkinson, Clyde Prestowitz, Thomas M. Hout, Pankaj Ghemawat, Adam Segal, USCC)

- *The United States maintains dominance*–The United States is still the best, and will continue to be the best. There is no need for the west to worry about “Indigenous Innovation.” (e.g., Edward Steinfeld, C. Fred Bergsten, Bates Gill, Nicholas R. Lardy, Derek Mitchell, OECD reports on China innovation, Tai Ming Cheung, Anil K. Gupta, Wang Haiyan)

- *China is catching up but the U.S. is still in the lead*–The U.S. share of global innovation has dwindled but the game has changed and the U.S. can continue to lead if it proceeds with caution. (e.g., Dan Bresnitz, Michal Murphree, National Academy of Sciences, Dennis Fred Simon, Cong Cao, Henry S. Rowen, Barry Naughton)

a. Superpower on the Way

According to the believers in “Indigenous Innovation” China’s campaign for innovation is leading it to become a world superpower within the next 20 years. Battelle R&D experts claim that China will surpass the U.S. economy by 2015 and become the world’s top funder of R&D before 2020. They use the following statistics to show the trend based on China’s focused effort to modernize through innovation. In 2012, China increased spending on R&D by 11.3% and in 2013 it is expected to increase R&D spending by an additional 11.6%. In 2011, China’s spending on R&D was 43% of the amount spent by the United States. In 2013, China is expected to spend 52% of what the United States spends on R&D.[26] Bob Stembridge and Eve Y. Zhou, with Thompson Reuters, cite patent filing statistics and other data to show that “Indigenous Innovation” is working and that China is on its way to becoming the world economic hegemon. They claim that “Never before in history has such a concentrated culture of innovation grown so quickly and with such unity of purpose.”[27]

26 *2013 Global R&D Funding Forecast* (Rockaway, NJ: Advantage Business Media, R&D Magazine, Battelle, December 2012), 29.

27 Bob Stembridge and Eve Y. Zhou, *Patented in China, the Present and Future State of Innovation in China,* New York: Thompson Reuters (2010), 24.

Believers in “Indigenous Innovation” also cite statistics of China’s growing numbers of engineering graduates, published research papers, and “high-tech” exports (see Table 2). These numbers at first glance seem staggering however this is often a case of quantity over quality and most of the “high-tech” exports either originate outside of China or are manufactured under patents held by foreign corporations.

Table 2. Status of China’s R&D Spending and Publication of Research Papers

2013 GDP, billion $, PPP	13,344
2013 GERD, billion $, PPP	220.20
R&D/GDP	1.65%
Population, million	1,343
GERD/Person	$164
Published Research Papers	
1999–2003, Physics	31,100
2004–2008, Physics	66,200
1999–2003, Chemistry	44,600
2004–2008, Chemistry	99,200
Basic Research Share	5%
Applied Research Share	13%
Development Research Share	82%

Source: Battelle/R&D Magazine, 2013.[28]

b. Not Anytime Soon

Many experts are skeptical that China will meet its goals for innovation. These skeptics argue that while throwing billions of $ at education and R&D will definitely have some effect, innovation is not something that you can mandate, develop, or buy at a whim. According to Sternberg one need only “Scratch the surface of China’s impressive metrics, such as patent filing data, and there is often less genuine innovation there than meets the eye.”[29] Sternberg also concludes that multinational corporation (MNC) interest in R&D in China has been driven more by market forces than by any government

28 *2013 Global R&D Funding Forecast* (Rockaway, NJ: Advantage Business Media, R&D Magazine, Battelle, December 2012), 29.

29 Joseph Sternberg, “China’s Innovation Future? Market Forces are Driving an Uptick in R&D Activity, Independent of Beijing’s High-profile Plans,” *Wall Street Journal (Online)*, (13 OCT 2011), accessed 15 FEB 2013, http://search.proquest.com/docview/897466162?accountid=12702.

policies. He estimates that it will take several more five-year plans before China is able to actualize its desire to become a R&D powerhouse.

In 1995, China's high-tech exports accounted for only 2.1% of the global market. During this same time China's total high-tech exports were equivalent to only 8% of what the United States was exporting in 1995. However, in 2006 China supposedly surpassed all other nations to become the world's leading exporter of high-tech goods.[30] According to Yuqing Xing these often quoted statistics are overinflated and distort the reality of China's ability to produce high-tech products.[31]

Most of the skeptics think that China is making progress toward becoming an "innovation-oriented society" by 2020, but that it will take much more time to meet its goals. Other reasons cited for China's obstacles in innovation include: cultural and societal pressures punitive to the failures inherent in the invention process; as well as the inability of the Chinese higher education system to produce S&T graduates ready to succeed in the MNC environment.

c. The U.S. is in Peril of Falling Behind

There is a steady stream of more conservative pundits that see China's potential for innovation as a significant threat to the U.S. economy. One example, Clyde Prestowitz, asserts that laissez-faire economics and free-market policies have led to U.S. economic decline. He subtly blames China for also contributing through its policies such as "Indigenous Innovation."[32] Along a similar vein, Robert Atkinson asserts in that China has adopted an innovation mercantilist approach to gain not just competitive advantage but absolute advantage over the United States and the rest of the world.[33] Atkinson has acted as a lead advisor to several U.S. government administrations regarding innovation

30 Thomas Meri, "China Passes the EU in High-tech Exports," *Science and Technology, Eurostat Statistics in Focus* (2009): 2.

31 Yuqing Xing, "The People's Republic of China's High-Tech Exports: Myth and Reality," *ADBI Working Paper Series*, Tokyo: Asian Development Bank Institute, paper #357,(2011), 1–2, accessed 10 JAN 2013, http://www.adbi.org/working-paper/2012/04/25/5055.prc.high.tech.exports.myth.reality/.

32 Clyde Prestowitz, *The Betrayal of American Prosperity: Free Market Delusions, America's Decline, and How We Must Compete in the Post-Dollar Era* (New York: Free Press S.& S. 2010), 15–16.

33 Ibid., 200.

policy and has provided testimony at numerous hearings related to China's "Indigenous Innovation" policies and its ramifications on U.S. China-relations.[34]

The literature produced by this group has a highly politicized tone and tends to over exaggerate the significance of statistics such as the "China accumulated $3.2 trillion worth of foreign exchange reserves and [the] $276.5 billion trade surplus with the United States."[35] Although these are impressive numbers they have practically nothing to with the "Indigenous Innovation" policy as is claimed by Prestowitz and Atkinson.

Many of the pessimistic claims sound similar to those made in the 1980s as the trade deficit grew between the United States and Japan. In 1983, the following statement was made in "A Nation at Risk," a federally commissioned report regarding slipping national education standards: "our once unchallenged preeminence in commerce, industry, science, and technological innovation is being overtaken by competitors throughout the world." As was seen in the case of Japan much of the rhetoric is out of proportion related to the size of the issues.

d. The United States Maintains Dominance

Many scholars categorize China's "Indigenous Innovation" policy as non-threatening either because they think that China is incapable of innovation anytime soon or because they see innovation in China as a contribution to global good. Some claim that China has made it possible for more developed countries to get farther ahead in innovation and global commerce. Many in this school of thought feel that China has great potential for innovation. Edward Steinfeld specifically asserts that China is innovating with the help of and through MNCs, and therefore everyone is winning. [36]

The pundits that fall in this camp claim that simple statistical evaluation of numbers of college graduates and export metrics are not enough to determine if China is

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[34] *Assessing China's Efforts to Become an "Innovation Society" – A Progress Report, Hearing Before The U.S.-China Economic and Security Review Commission*, 112 Cong. 2 (May 10, 2012), 8.

[35] Robert D. Atkinson, *Enough is Enough: Confronting Chinese Innovation Mercantilism* (Washington, DC: The Information Technology & Innovation Foundation, February 2012), 5.

[36] Edward S. Steinfeld, *Playing our Game: Why China's Economic Rise Doesn't Threaten the West* (New York: Oxford University Press, 2010), 172–174.

becoming a technology superpower on par with the United States.[37] Further statistics cited by some in this camp illustrate that if China was to seriously pursue catching up to the global military leaders it would need to dedicate significantly more resources than it presently does. One example is just how far behind China is in S&T expenditures. In the late 90s, China only spent 5% of what the U.S. did on military S&T.[38]

e. China is Catching Up but the U.S. is Still in the Lead

This view of China's efforts at innovation seems to be the most rounded of all the literature. This group of scholars account for progress that China has made without demonizing China for its efforts and without dismissing the potential threat of "Indigenous Innovation" policies. They admit that the U.S. share of global innovation has dwindled but the game has changed and we can continue to lead if we proceed with caution. This group is split into two sub-groups categorized by those that find China has major obstacles preventing them from becoming an innovative nation, and those that see that China is already an innovative nation or soon will be.

Those that find China has major obstacles standing in the way of innovation cite several key reasons. One of the reasons noted was that the Chinese have self-identified an absence of a "culture of creativity."[39] This phrase is describing traditional social pressures that have made professionals risk averse and failure avoidant. This in turn has limited the innovative spirit. They claim that although R&D expenditures have gone up, China is nowhere close to U.S. spending on R&D. The labor pool is inadequate to answer the needs for R&D and S&T on the scale desired by the government (see Table 3). The high numbers of graduates do not mean that they are ready for employment at the level

37 C. Fred. Bergsten, Bates Gill, Nicholas R. Lardy, and Derek Mitchell, *China–the Balance Sheet : What the World Needs to Know Now about the Emerging Superpower* (New York: Public Affairs, 2007), 99–107.

38 Tai Ming Cheung, "The Chinese Defense Economy's Long March from Imitation to Innovation," *Journal of Strategic Studies* 34, no. 3 (June 2011): 325–354.

39 Denis Fred Simon, and Cong Cao, "China's Emerging Science and Technology Talent Pool: A Quantitative and Qualitative Assessment," in Henry S. Rowen et al., eds., *Greater China's Quest for Innovation* (Stanford, CA: Shorenstein Center, 2008), 181–196.

needed for high technology R&D. Cultural, political and social factors will continue to inhibit China in its quest for "Indigenous Innovation."[40]

Table 3. China's Human Resources in S&T (thousands of persons per year)

	1999	2000	2001	2002	2003	2004	2005	2006
Scientific personnel	2,905	3,224	3,140	3,222	3,284	3,481	3,815	4,132
Scientists and Engineers in scientific activities	1,595	2,046	2,072	2,172	2,255	2,252	2,561	2,798
R&D personnel	822	922	957	1,035	1,091	1,153	1,365	1,502
Scientists and Engineers in R&D activities	531	695	743	811	862	926	1,119	1,224

Source: Simon, and Cao, "China's Emerging Science and Technology Talent Pool"[41]

Those scholars that see China on the cusp of becoming an innovation nation have a different interpretation of many of the same statistics relating to growing numbers of engineering graduates and percentage increases of spending on R&D. "China is estimated to have produced 600,000 college and technical school graduates in science and engineering in 2004, whereas the United States produced an estimated 70,000 graduates the same year."[42] Although there is a shortage in the S&T labor pool there are many professionals currently in education and training. The positive effects of increases in R&D spending are just around the corner. The high numbers of patents are indicators of innovation in China. The literature in this category is potentially too optimistic on the side of China succeeding in innovation and does not take into account the implications of

40 Henry S. Rowen et al., eds., *Greater China's Quest for Innovation* (Stanford, CA: Shorenstein Center, 2008), 194.

41 Ibid., 184.

42 Alan WM Wolff, "China's Drive Toward Innovation," *Issues Online in Science and Technology,* National Academy of Science (2007), accessed 19 September 2012, www.issues.org/23.3/wolff.html.

the statistics in relation to the population of China. Another problem with this group is the failure to indicate the global impact of China's "Indigenous Innovation" policy.

f. Conclusion of Literature Review

The literature available on the subject of China's "Indigenous Innovation" policy and its impact on other nations is broad in its scope and specific in multiple areas. The body of literature provides a balanced view of multiple opinions and theories. Not only are there multiple peer-reviewed articles and books available but there are numerous news reports and government documents regarding "Indigenous Innovation." As certain pundits draw judgments regarding whether China is over-innovating or under-innovating there remains a gap in the literature discussing what the appropriate level of innovation is for developing nations. This thesis will not address this but will address gaps in the literature assessing the effectiveness of China's "Indigenous Innovation" policy and its effects on U.S.-China relations.

B. HOW DOES INNOVATION AFFECT ECONOMIC GROWTH?

1. Growth through Innovation

Political economist Friedrich List, in his book on *The National System of Political Economy,* was one of the first in his field to place significant emphasis on the role of science, technology, and skills in economic growth. He criticized the classical economists such as Adam Smith for focusing so heavily on capital accumulation and labor and not paying enough attention to technology and skill. List advocated policies to aid in the acquisition, learning, and application of new technology.[43] These principles are at the foundation of China's new policy for innovation. Since WWII economists have generally accepted as common knowledge that innovation is a necessary component of economic growth.[44] A general explanation of the relation of innovation to economic growth draws

[43] Friedrich List, *The National System of Political Economy* (English edn, London: Longman, 1904) 1941.

[44] Lowell W. Steele, *Managing Technology, The Strategic View* (New York: McGraw Hill, 1989), 265.

from the Endogenous Growth Theory.[45] This theory asserts that growth is a product of human capital, physical capital, and Total Factor Productivity (TFP). TFP is a measure of technology, innovation, and labor productivity. Therefore, as a nation increases innovation its economy grows.

2. What Are the Different Types of Technological Innovation?

There are many different types of innovation related to technology as shown in Table 4, however most types of technological innovation that are commonly referred to in the discussion of innovation and its impact on economic growth can be categorized into the following three basic types of innovation. The first, and most commonly understood type, is innovation through invention or major breakthrough. "Break-through innovation," as described by Dr. Naazneen Barma, is more typical in developed nations with advanced economies. The second type of innovation is that of production chain innovation. Production chain innovation speeds up systems and processes and improves efficiency leading to higher output at lower costs. The third type of innovation is incremental innovation, which improves on existing products in some way.[46] Both production chain innovation and incremental innovation are common in developing economies such as China.[47]

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[45]Paul Romer, "Endogenous Technological Change," *Journal of Political Economy* 98, no. 5 (1990), 71–102.

[46] A more detailed description of innovation theory is given by Zhao, Xinli and Wenfei Gao in their article "The theory of innovation and its application in China." They refer to J. Schumpeter's 1912 innovation theory. Schumpeter's description of innovation is slightly broader than Barma's including the following categories: (1)Product innovation, that is, producing new products; (2)Technique innovation, that is, adopting a new producing technique; (3)Market innovation, that is, opening up a new market; (4)Material innovation, that is, obtaining a new source of material or Semi-finished products supply; (5)Innovation of organization management.; Xinli Zhao and Wenfei Gao, "The theory of innovation and its application in China," *Management Science and Engineering, 2008. ICMSE 2008. 15th Annual Conference Proceedings., International Conference on,"* (2008), 1401,1408. doi: 10.1109/ICMSE.2008.4669090.

47 Naazneen Barma, "The Emerging Economies in the Digital Era: Marketplaces, Market Players, and Market Makers," in *How Revolutionary Was the Digital Revolution? National Responses, Market Transitions, and Global Technology*, eds. John Zysman and Abraham Newman, (Stanford University Press, 2006), 149.

Table 4. Specific Types and Examples of Innovation

Incremental improvement in product, process or system	• Better color or efficiency in lamp phosphors • New lower-cost catalyst • Improved word processing software
New component, process, or technique in a larger system	• Plastic dishwasher tub • Sintered instead of forged jet engine parts • Automated lamp filament inspection
New product for existing market	• Compact disk • Color TV • Lucalox lamp
Radically new process	• Pilkington float plate glass • Low-pressure polyethylene
New product for new market	• Lexan • Silicones • Personal Computer • VCR
New system	• Satellite communication • Doppler radar for wind shear • Fiber optic communication • Computerized passenger reservation
Entirely new capability	• Xerox • Instant photography • Beta blockers for high blood pressure • Interleukin 2 • Satellite earth sensing

Source: Brian Rushton, "Strategic Expansion of the Technology Base," 1986.[48]

C. PROBLEMS AND HYPOTHESES

There are three plausible hypotheses explored here to explain the effectiveness of China's "Indigenous Innovation" policies. The first claims that "Indigenous Innovation" policies will fall short of goals and not add to significant economic growth in China, while the second concludes that China will experience successful economic growth spurred through "Indigenous Innovation," and the third finds that "Indigenous Innovation" is irrelevant to continued economic growth.

48 Brian Rushton, "Strategic Expansion of the Technology Base," *Research Management* November-December (1986), 22–28.

1. Indigenous Innovation Flops

In the first hypothesis, *Indigenous Innovation Flops*, multiple disruptive economic factors contribute to the shortcomings of "Indigenous Innovation." The misallocation of investments and resources to non-performing sectors will stifle economic growth. Additionally growth might be slowed due to the demographic shifts in an aging workforce and rising social safety net costs. The impacts of environmental contamination from years of unchecked industrial pollution will draw money away from overall growth. "Indigenous Innovation" policies themselves may be too rigid in the current political structure to allow free market forces to take advantage and turn investments into growth. In short, Total Factor Productivity will not reach the levels necessary for China to experience the economic growth that it seeks through innovation policy.

2. Indigenous Innovation Becomes China's new Economic Engine

In the second hypothesis, *Indigenous Innovation becomes China's new economic engine*, the policies emplaced in 2006 payoff, allowing for continued growth as China transitions from an industrial to high-tech economy. In this scenario, there are three potential futures depending on how China's policies and growth affect its relations with the United States. These alternatives are broken down in more detail during the literature review but can be summarized as: One, China's "Indigenous Innovation" is a beggar-thy-neighbor and mercantilist policy that threatens the U.S. economy and security; Two, there is no need for the west to worry about "Indigenous Innovation," economic growth is not zero-sum and The United States will continue to be the best; or Three, the U.S. share of global innovation has dwindled and the game has changed but the United States can continue to lead if it proceeds with caution.

3. Indigenous Innovation is Irrelevant for Chinese Growth

In the third hypothesis, *Indigenous Innovation is Irrelevant for Chinese Growth*, China continues strong economic growth that would have happened independent of the 2006 "Indigenous Innovation" policy. This rests on the debate between Neo-Classical and Interventionist theories. The Neo-Classical theory argues that China's increased access to open free markets and increasingly free trade allowed for systemic self-corrections which included market-driven innovation, leading to economic growth. Conversely the Interventionist or dirigiste theory claims that China's top-down direct political intervention in "Indigenous Innovation" was necessary to direct policies that protected and fostered innovation leading to economic growth, through tax breaks, financing incentives, awards, and other means.[49]

Neo-Classical theorists have argued that the growth and in this case innovation, would have happened despite or in spite of government actions. Interventionists contend that many other nations had as favorable or more favorable conditions but stagnated during the same period of China's innovation-driven growth. Chalmers Johnson, in an evaluation of the neighboring successful economies of Japan, South Korea and Taiwan, correctly pointed out that there were many factors other than government manipulation that contributed to these "miracle" economies, however without the government manipulation in several specific and key areas the other variables would not have been enough to bring about the astounding growth of these nations. Other economists argue that these nations simply oriented their policies correctly in order to benefit from market-led growth and were also very fortunate to enjoy open American markets and U.S.-subsidized security in the geopolitical context of the time. Johnson argues that despite other variables contributing to their rapid growth, Japan, South Korea, and Taiwan all made it possible by control and direction from their governments.[50]

4. Summary of Hypotheses

The reality of the common circumstances and actions found in China's innovation/modernization and economic growth model are a mix of both theories. Some have identified these circumstances and called it the Beijing Consensus, inferring that China set in motion a grand plan that brought about its economic growth and that this can somehow possibly be held up as a model for economic growth to be employed by other

[49] Alice Amsden, "Why Isn't the Whole World Experimenting with the East Asian Model to Develop?: Review of The East Asian Miracle," in *World Development*, vol. 22, no. 4 (1994): 628.

[50] Chalmers Johnson, "Political institutions and economic performance," in *The Political Economy of the New Asian Industrialism*, ed. Fredric Deyo (1987), 136–164.

developing nations.[51] This Beijing Consensus would be an alternative to the Washington Consensus which is described as a more conventional free-market approach to economic development.[52] Critics of the Beijing Consensus, including many in China itself, claim that there was no grand scheme or "consensus" and that the unique set of circumstances for China's rapid growth may not be applicable as a model.

Despite the criticisms of central planning, China's leaders have taken a concerted introspective evaluation of their national growth trajectory, asking in particular what approaches might be applicable to future growth. Following its analysis and hedging against divergent theories for economic growth China has adopted a dual track policy approach to continued growth. One track embraces the rigid government planning, top-down direction that mandates growth through policy and the other embraces more liberal free-market approach to growth providing incentives and investment to enable a bottom-up fostered growth. This is the same method applied in China's National Innovation System (NIS) and incorporated into "Indigenous Innovation." This approach brings scoffs from both sides of the Neo-Classical and Interventionist economic growth theories debate, as it does not fully embrace either but attempts to blend the two. This may seem like China is betting on all the horses in a race rather than picking a likely winner but in the case of economic development their broad investment, unlike in a horse race, is likely to bring an overall net gain.

D. SUMMARY OF FINDINGS

China's drive to become an innovative nation by 2020 affects not only its economy but also the rest of the world. As China strives for innovation as a sustainable impetus for growth it is likely to achieve this end. China's dual track policy approach to continue growth may waste money on ineffective actions but hedges against failure of any one track. China has already achieved growth through incremental innovation in

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51 Joshua Cooper Ramo, *The Beijing Consensus: Notes on the New Physics of Chinese Power* (London: Foreign Policy Centre, 2004), available at: http://www.fpc.org.uk.

52 John Williamson, "What Washington means by policy reform," in John Williamson, ed., *Latin American Adjustment: How Much Has Happened?* (Washington, DC: Institute for International Economics, 1990), 8, available at: http://www.iie.com/publications/papers/print.cfm?ResearchId=486&doc=pub.

manufacturing. Incremental innovation, combined with other policies adapted prior to 2006, has continued to drive growth through 2013. China's economic growth from 2006–2013 has had little to do with "Indigenous Innovation" but has occurred irrespective of these policies. Influencing innovation is something that takes governments years to achieve and China's future innovation and growth will likely be influenced by "Indigenous Innovation."

After the first eight years of "Indigenous Innovation" analysis of the output indicators and desired outcomes show that China's *Indigenous Innovation Flops*. Even though "Indigenous Innovation" has contributed to raising the levels of innovation and economic growth in China it is off-track to meet the goals of the 2006–2020 MLP. "Indigenous Innovation" is not yet the new economic engine China hoped it would be, but it is a broad strategic approach that will have long-lasting effects in the future. Innovation is driving growth in China; however, as shown by the details of patent filing statistics, it is mostly market-driven incremental and manufacturing innovation and not the invention or new product innovation that China is seeking. China is likely to reach its innovation benchmarks but not until 10 years after its initial target dates. China must adjust its policy to focus more on the university-private enterprise R&D nexus and ease societal/cultural pressures to be risk averse and failure avoidant, to possibly turn its modernization in the right direction coming closer to achieving its goals for innovation.

1. Organization of Thesis

This thesis addresses first the importance of "Indigenous Innovation" for China and the ideas, explanations and theories already available in literature. The next two sections (B and C) of Chapter I will explore the main assertions on how innovation effects economic growth and China's chances for achieving this growth through "Indigenous Innovation." Chapter II will explain the nature of innovation modernization in China including "Indigenous Innovation" policies. Following these explanations, chapter three presents data to help assess improvements in innovation and economic performance and examines the effect of "Indigenous Innovation" policies on this performance so far. Based on a survey of the literature (Battelle, Stembridge and Zhou, Wolff, and Meri), I rely upon five primary indicators in assessing China's level of innovation Chapter III provides an assessment of the validity of these indicators, which are: expenditures on R&D, patent filing statistics, talent pool of S&T scientists, academic and scholarly articles published, and high-tech exports. Using these indicators this chapter assesses each, prior to and after 2006, to see if they point to one of the three potential effects of "Indigenous Innovation" on China's economic performance; *Indigenous Innovation Flops*, *Indigenous Innovation becomes China's Economic Engine*, and *Indigenous Innovation is Irrelevant for Chinese Growth.* It also includes the assessment that China is growing regardless of "Indigenous Innovation" but that future growth will be impacted by China's current actions under this policy. Last, Chapter IV assesses the impact of "Indigenous Innovation" on Sino-U.S. relations and concludes with an evaluation of China's current state of innovation and the feasibility of achieving the MLP goals.

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II. REVIEW OF CHINA'S INNOVATION POLICIES

"Indigenous Innovation" was not China's first attempt at innovation but was the most recent iteration of China's planning model for continued economic growth. This chapter explains why China cares about innovation, what policies existed prior to 2006, the details of China's "Indigenous Innovation" policies launched in 2006 and the desired impact of these policies on China's economy.

A. WHAT HAS CHINA DONE TO PURSUE INNOVATION?

1. What Does Innovation Mean to China?

Wen Jiabao expressed that "science is the ultimate revolution," using communist ideological rhetoric to put in perspective just how important S&T innovation is to China. Statements such as this tie innovation back to Mao and the drive for continuous revolution. Although rhetoric may be used to inspire the Chinese people it is couched in the reality that without ongoing advancement in S&T China will be faced with a likely economic slowdown and possible recession.

a. Extraordinary Growth

Over the last 20 years, China had the highest average annual economic growth rate at 10.2% equating to approximately 40% of global growth during this period. China is now the world's second-largest economic power, behind the United States, and is estimated to cross over and become the world's largest economy by 2025. China now has the largest number of millionaires (1,020,000) and billionaires (115) of any nation. This staggering and unprecedented economic growth has been fueled by an abundance of low-cost labor driving massive industrial manufacturing. In 2011, China was the world's leading exporter of manufactured goods.[53]

[53] David Shambaugh, *China Goes Global: The Partial Power* (New York: Oxford University Press, 2013), 156–157.

b. Growth without Change Destined to Slow

If China were to remain the world's factory, churning out low-cost goods, it would inevitably experience economic slowdown due to multiple factors. First and foremost, growth on the basis of human and physical capital deployment inevitably hits diminishing returns. In addition, along with the unprecedented growth experienced by China, came the accompanying issues of resource consumption, pollution, and increased need for social welfare. In 2011, China accounted for 71% of global energy consumption growth (see Figure 1).[54] Such massive consumption of fossil fuels has had significant impacts on the environment. In 2005, Yongjin Zhang estimated that annual environmental impact of China's industrialization amounted to between $130 billion and $200 billion.[55] Facing increasing wages and an aging workforce, China is set for some major hurdles related to taking care of its population of 1.3 billion in the next 10 years. According to China's National Bureau of Statistics the working age population shrank for the first time in 2012 by approximately 3.45 million. It is estimated that in 10 years China will lose 21% of its male population between the ages of 15–24 (approximately 38m). Such a large loss in income earners will have a significant impact on the large aging retired population that they are supporting.[56]

54 *BP Statistical Review of World Energy June 2012*, BP, (2012), 2. accessed 16 FEB 2013, http://www.bp.com/statisticalreview.

55 Yongjin Zhang, *China Goes Global* (London: The Foreign Policy Centre, 2005), ix.

56 "China's population: Peak toil," *The Economist* (26 January 2013).

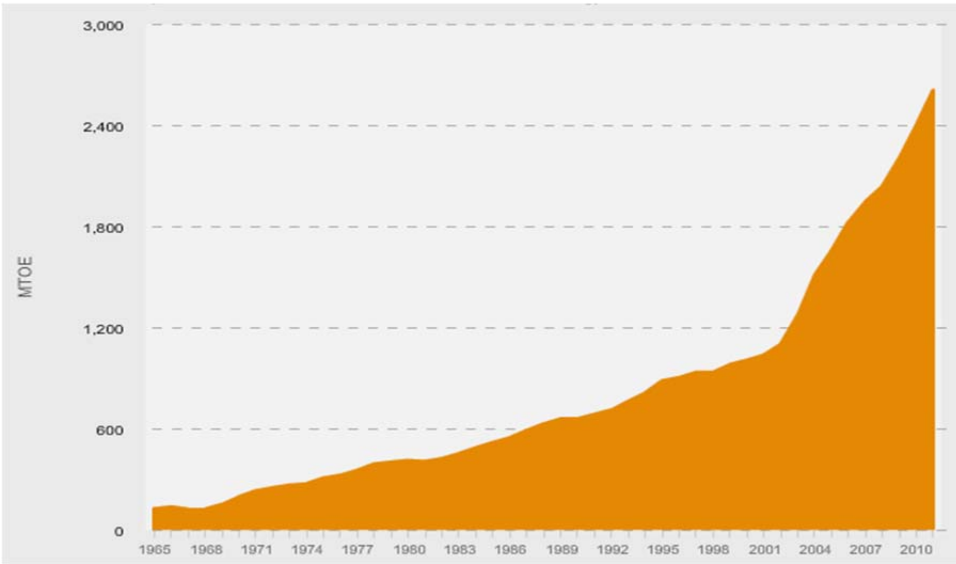

Figure 1. China’s Primary* Energy Consumption from 2001–2011 Measured in MTOE

Source: BP (2012) *Primary energy consists of Coal, Oil, Natural Gas, Hydroelectric, Nuclear, and other Renewables.[57]

c. Growth Challenges Are Met by the Best Laid Plans

Modeled after Soviet style central planning, the PRC began its efforts at modernization shortly after taking power 1949. These plans for technological development were incorporated into five year plans, the first of which appeared in 1956. The S&T modernization model set forth in these plans were characterized as highly bureaucratic and hierarchical. The industrialization and agricultural efforts of the Great Leap Forward, from 1958–1961, led to widespread famine. This model of centralized planning continued until 1965, and from 1966–1976 during the Cultural Revolution modernization suffered major setbacks, leading to the loss of a generation of scientists and engineers. China’s model for research was modeled similarly to that of the USSR with the Chinese Academy of Sciences in charge of basic research and the universities responsible for the development of human capitol. Even though China was able to develop nuclear weapons and ballistic missiles using this top-driven policy style it was overall detrimental to S&T development. This model of modernization was inefficient

57 *BP Statistical Review of World Energy* (London: British Petroleum, 2012), 2.

and lacked the benefit of a link between industry and research. After languishing for years under this model China reemerged under the leadership of Deng Xiaoping in 1978.[58]

Along with Deng Xiaoping's economic reforms came a new system of research and innovation. Science and Technology was identified in Zhou Enlai's Four Modernizations program (implemented by Deng in 1978) as essential to the continued modernization and economic success of China. In March 1978, Vice-Premier Fang Yi emphasized the importance of S&T and the reversal of past policies when he proclaimed that China "is entering a new stage of flourishing growth [in S&T] … The dark clouds [of the Cultural Revolution] have been dispelled … and the way has been cleared. A bright future lies ahead of us."[59] From that point China initiated a series of programs to advance S&T and innovation as well as to encourage opening to foreign direct investment (FDI).

2. Policies Related to Innovation Prior to 2006

Starting in 1978, with the implementation of the Four Modernizations program at the third plenum of the 11th Central Committee, China adopted a series of policies related to modernization leading up to "Indigenous Innovation" in 2006. After 1978, the Chinese government leaders knew that in order to have a more market driven innovation framework, the old S&T institutions would need significant reform. These institutions would need to establish and foster relationships with industry and universities. S&T institutions would need to be more open and collaborative. They would also need significant increases in R&D funding. Over the course of the next 25 years, China mapped out a series of policy actions incorporated into short-term 5 year plans, and medium- to long-term plans. These policies are best categorized into four periods: Reformation of Planning Practice (1978–1984), Performing the S&T activities in the "Market" (1985–1991), Bridging S&T activities closely to "Socialist Market Economy"

[58], Charles W. Wessner and Alan Wm Wolff, eds. *Rising to the Challenge: U.S. Innovation Policy for Global Economy* (Washington, DC: National Academies Press, 2012), 211–212; Sylvia Schwaag Serger and Magnus Breidne, "China's Fifteen-Year Plan for Science and Technology: An Assessment," *Asia Policy*, No. 4 (July 2007), 138.

[59] Fang Yi, "Report to the National Science Conference (March 18, 1978)," in *Chinese Science and Technology* I (1), summer (1979), 9.

(1992–1998), and Large-Scale Transformation of R&D institutions (1999–2005). The details of each policy action and its intended goal or target are illustrated in Table 5 (also see Appendix A. STAGES OF NIS REFORM, for details on the progression of R&D/innovation reform).[60]

Table 5. Chinese Reform Policy for Public S&T Institutions: 1978–2005.

Period	Policy actions target	Policy actions
Reformation of Planning Practice (1978–1984)	Recover and develop the R&D system and integrate it into the planned economic practices.	• Rehabilitation and improvement of R&D institutions after the damage during Culture Revolution (1966–1976). • Integration of R&D activities into the 6th National Five-Year Plan (1980–1985).
Performing the S&T activities in the "Market" (1985–1991)	Establish the horizontal and regular connection between S&T sector and enterprises.	• Replace the former S&T funding method that is mainly through planned appropriation by the program projects competition mechanism. • Diminish the government grants to force the R&D institution to establish cooperation with industry. • Create a "Technology Market" to legitimize paid transactions for technology and set up the agencies to support the transactions. • Promote the autonomy of R&D institutions and mobility of the S&T Personnel. • Attempt merging the R&D institutions into enterprises. • Support the spin-off enterprises.
Bridging S&T activities closely to "Socialist Market Economy" (1992–1998)	Run non-basic research R&D institutions as run enterprises.	• Endow the R&D institutions the comprehensive economic autonomy as the same hold by normal enterprises. • Encourage spin-off activities through promoting science park and incubators. • Continue the merging strategy.
Large Scale Transformation of R&D institutions (1999 till now)	Transform nearly all of the government owned R&D institutions.	• Transform the R&D institutions into enterprises, non-profit organizations, intermediary organizations or merged them into universities.

Source: "Organization, Programme and Structure: an Analysis of the Chinese Innovation Policy Framework," *R&D Management* 34, 4, (2004), 371.[61]

The first post Mao era period of S&T policy reform, Reformation of Planning Practice, was kicked off by Deng's speech at the National Science and Technology Conference of 1978, in which he emphasized the importance of S&T in the economic

[60] Can Huang et al., "Organization, Programme and Structure: an Analysis of the Chinese Innovation Policy Framework," *R&D Management* 34, 4 (2004): 367–371.

[61] Ibid., 371.

advancement of China. Following this renewed emphasis on S&T there was a draft Outline of a National Plan for the Development of S&T (later scaled back) that was supposed to direct implementation from 1978–1985. It was tied to the Ten Year Plan for the Development of the National Economy (1976–1985) both of these plans were scaled back from their original drafts.[62]

The first major policy actions were seen in 1982 with the development of the National Program for Key Sciences & Technology Projects. This program, now a recurring component of the five-year plans, is designed to:

> Find solutions to the scientific and technological bottlenecks in the medium and long-term national economic and social development; promote the modernization of traditional industries and the optimization of industrial structures; support development of high technology and its industrialization; improve the quality of national economic development and people's life; and enhance the nation's S&T capacity.[63]

Although it maintained focus on S&T the National Program for Key S&T Projects did not have the impact of later plans and programs.

China recognized the weak nature of extant-R&D-infrastructure which focused on major SOEs and the defense industry, and in response implemented the Program on the Construction of National Key Laboratories in 1984. This program aiming to build world class research centers tied to universities and some state institutions has facilitated the construction of over 150 laboratories.[64]

All major S&T innovation policies in China since the Cultural Revolution were based on four major decisions issued on S&T policy by the Central Committee of the Chinese Communist Party. These were:

- Decision on the Reform of the Science and Technology System, 1985.
- Decision on Accelerating Scientific and Technological Progress, 1995.

62 Liu Li, "The Evolution of China's Science and Technology Policy, 1975–2007," in *OECD Reviews of Innovation Policy: China* (2008): 381–383.

63 "Science and Technology Programs in China," Consulate-General of the PRC–Chicago, accessed February 23, 2013, http://www.chinaconsulatechicago.org/eng/kj/t31882.htm.

64 Ibid.

- Decision on Strengthening Technological Innovation and Developing High Technology and Realizing Its Industrialization, 1999.
- Decision on Implementing the Medium and Long-term Strategic Plan for the Development of Science and Technology and Improving the Indigenous Innovation Capability, 2006.[65]

a. The 1985 Decision

The 1985 Decision marked the first large scale systemic reform of China's S&T programs. This resolution, published by the Central Committee, set the directions, guiding principles and overall goals of reformation of the S&T institutions and systems in China. It included guidelines for reform in three principle areas: the operating mechanism, institutional structure and human resources / S&T personnel management.[66] The key programs initiated during the period after the 1985 Decision were: the National High Technology research and Development Program or 863 Program (1986); the Spark Program (1986); the Torch Program (1988); National S&T Achievements Dissemination Program (1990); and the National Program for Key Basic Research Projects or the Climbing Program (1991).[67]

(i) 863 Program. Initial reforms in the 1980s included efforts to restructure state research institutions by picking winners and losers in an effort to allocate funds to key sectors. One of the first noted set of policies, implemented in 1986, was the State High-Tech Development Plan, also known as the 863 Program. This plan was the brainchild of four Chinese scientists that previously worked on Mao era strategic weapons. 863 was designed to give China independence from foreign technologies in areas such as satellites and computer processing. The Program also highlighted the importance of closing the gap between China and developed countries in high

65 Liu Li, "The Evolution of China's Science and Technology Policy, 1975–2007," in *OECD Reviews of Innovation Policy: China* (2008): 381–382.

66 Liu Li, "The Evolution of China's Science and Technology Policy, 1975–2007," in *OECD Reviews of Innovation Policy: China*, 2008, 381–382; Xue, Lan, "A historical Perspective on China's Innovation System Reform: A Case Study," *Journal of Engineering Technology Management* 14 (1997): 67–81.

67 "Science and Technology Programs," Consulate of PRC Chicago.

technology. Highlighted by the program are eight specific fields in which China planned to focus their S&T: biotechnology, space technology, information technology, lasers, automation technology, energy technology, advanced materials technology and marine technology.68

(ii) The Spark program. This 1986 program was designed to develop the rural economy through S&T. Spark was designed to improve labor production, through S&T, centered on newly constructed cities and towns. These locations were to become regional pillar industries.[69]

(iii) The Torch Program. The primary objective of the Torch Program, initiated in 1988, was to create the critical nexus between innovation and R&D and industry. It focused on the commercialization of ideas in S&T. Along the lines of the Special Economic Zones the government, under the Torch Program, created 53 Emerging Technology Industry Development Zones. These centers were identified to receive special government funds, preferential tax policies, and priority in the receipt of bank loans.[70]

(iv) The National S&T Achievements Dissemination Program (NSTADP). Starting in 1990, the NSTADP called for further integration of S&T into industry. It was designed to extrapolate further economic gain from S&T activities.[71]

(v) The Climbing Program. Primarily designed to boost basic research, the Climbing Program of 1991, focused on areas deemed critical to S&T development. These areas included: mathematics, physics, chemistry, mechanics, astronomy, geography, biology, energy, materials, information and computer, basic agronomy, basic medical sciences, resource and environment, space science and engineering science.[72]

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[68] Ibid.

[69] "Science and Technology Programs," Consulate of PRC Chicago.

[70] Ibid.

[71] Ibid.

[72] Ibid.

b. The 1995 Decision

The Decision on Accelerating Scientific and Technological Progress stated that S&T is a productive force and a key to economic development as outlined by Deng Xiaoping. The resolution was to enable S&T and education to take its place as the primary driving force of the reform movement. The 1995 Decision was a continuation of principles outlined in the 1985 Decision plus the determination to expand basic scientific research to world-class levels. [73]

c. The 1999 Decision

Focusing on state-owned enterprises (SOEs) that further promoted technological innovation, the 1999 Decision promoted expansion and strengthening of innovation along with industrialization in the public sector. SOEs were expected to use high technology to modernize their processes and develop new products and services.[74]

d. Summary of Pre-2006 Policies

All of these modernization efforts from 1978 to 2006 had significant impacts on China's economy and brought them forward to become the world's second largest economic power behind the United States. This staggering and unprecedented economic growth has been fueled by an abundance of low-cost labor driving massive industrial manufacturing. In 2011, China was the world's leading exporter of manufactured goods.[75] More details in assessment of these policies are provided in the following chapter.

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[73] Cao, Cong. "Strengthening China through science and education: China's development strategy toward the twenty-first century." *Issues and Studies* 38, no. 3(2002): 122–149; Liu Li, "The Evolution of China's Science and Technology Policy, 1975–2007," in *OECD Reviews of Innovation Policy: China* (2008): 387.

[74] Liu Li, "The Evolution of China's Science and Technology Policy, 1975–2007," in *OECD Reviews of Innovation Policy: China* (2008): 387.

[75] David Shambaugh, *China Goes Global: The Partial Power* (New York: Oxford University Press, 2013), 156–157.

e. The 2006 MLP Focused on Indigenous Innovation

Despite significant advances in technology and modernization, China still faces major obstacles to sustainable development. OECD categorizes these obstacles as: *i)* social developments, that have not kept up with economic development, such as public health; *ii)* the disparity in standards of living between urban areas on China's coast and rural areas in the Northeast and West, has increased with economic growth; *iii)* the negative environmental impacts of China's rapid industrialization are taking a serious toll; *iv)* despite significant growth there are not enough job opportunities to support China's massive population; *v)* low value-added products continue to be the primary source of growth; *vi)* China continues to rely on costly advanced technology from developed countries in order to catch-up; *vii)* and finally China has run such large trade surpluses with its trading partners that it faces frequent trade disputes, necessitating a new strategy to create sustainable growth.[76]

3. China's Adaptation of "Indigenous Innovation" Policy

Hu Jintao, as the General Secretary of the Chinese Communist Party Central Committee, introduced the implementation of "Indigenous Innovation" at the 2006 National Conference on Science and Technology in Beijing with the following statement:

> China will embark on a new path of innovation with Chinese characteristics, the core of which is to adhere to innovation, seek leapfrog development in key areas, make breakthroughs in key technologies and common technologies to meet urgent requirements in realizing sustained and coordinated economic and social development and make arrangements for frontier technologies and basic research with a long-term perspective.[77]

China's new "Indigenous Innovation" policy was published as the *Medium to Long-Term Plan for the Development of Science and Technology 2006–2020.* This plan called for broad goals, such as boosting spending in R&D to 2.5% of GDP by 2020, and

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[76] Liu Li, "The Evolution of China's Science and Technology Policy, 1975–2007," in *OECD Reviews of Innovation Policy: China* (2008): 389.

[77] "China Outlines Strategic Tasks for Building Innovation-oriented Country," *People's Daily Online*, 2006, Accessed 20 February 2013, http://english.people.com.cn/200601/09/eng20060109_233919.html.

catching up with developed nations in advanced sciences. Some of the significant programs and goals outlined are 11 "priority fields" of science, eight areas of "frontier technology" and a further eight areas of "cutting-edge science" (see Table 6).[78] The MLP also called for the development of the following four major research areas of basic science: developmental and reproductive biology, nanotechnology, protein science, and quantum research.

Table 6. Focus Areas of "Indigenous Innovation"

11"priority fields"	***Eight areas of "frontier technology"***	***Eight areas of "cutting-edge science"***
• agriculture • energy • environment • information technology and modern services • manufacturing • national defense • population health • public security • transportation • urbanization and urban development • water and mineral resources	• advanced energy • advanced manufacturing • aerospace and aeronautics • biotechnology • information technology • lasers • new materials • ocean technologies	• cognitive science • structure of matter • core mathematical themes • Earth system processes and resources, environmental and disaster affects, chemical processes • life processes • condensed matter • new approaches to scientific experimentation and observation • research technologies.

Source: CENTRA Technology, 2011.[79]

One of the most ambitions areas of modernization outlined in the MLP is the plan for 16 Major Special Projects or Mega Projects. China's goal with the megaprojects is to leapfrog technology and decrease dependence on costly foreign technology.

The 16 megaprojects proposed in the MLP are the following:

- Advanced numerically-controlled machine tools and basic manufacturing technology
- Control and treatment of AIDS, hepatitis, and other major diseases
- Core electronic components, including high-end chip design and software

78 Charles W. Wessner and Alan Wm Wolff, eds. *Rising to the Challenge: U.S. Innovation Policy for Global Economy* (Washington, DC: National Academies Press, 2012), 215.

79 *China's Program for Science and Technology, Modernization: Implications for American Competitiveness*, prepared for USCC, (Arlington: CENTRA Technology, 2011), 42.

- Extra large-scale integrated circuit manufacturing
- Drug innovation and development
- Genetically modified organisms
- High-definition earth observation systems
- Advanced pressurized water nuclear reactors and high-temperature gas cooled reactors
- Large aircraft
- Large-scale oil and gas exploration
- Manned space, including lunar exploration
- Next-generation broadband wireless telecommunications
- Water pollution control and treatment103
- Numbers 14–16 are unannounced projects, thought to be classified.[80]

Over the next 15 years, the plan is designed to setup the framework of a national innovation system. This framework is intended to put enterprises at the center of innovation. It also includes policy support for venture capital, improved protection of intellectual property rights, investments in infrastructure, human resource development and a promotional campaign aimed at promoting the public understanding of innovative culture.[81]

4. What Will the Impact be if China Succeeds with Innovation?

The outcome of China's "Indigenous Innovation" plan will have a broader impact than just the sustained economic and social development of one nation. This plan can be viewed as a great experiment to answer many questions related to debates about S&T and

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80 For a more detailed description of the Mega Projects see Appendix B; James McGregor, "China's Drive for 'Indigenous Innovation:' A Web of Industrial Policies," U.S. Chamber of Commerce, 2010, 16, http://www.uschamber.com/reports/chinas-drive-indigenous-innovation-web-industrial-policies.

81 *Outline of The National Medium- and Long-Term Program for Science and Technology Development(2006–2020)*, downloaded from China Science and Technology Exchange Center, February 2013, http://www.google.com/url?sa=t&rct=j&q=&esrc=s&frm=1&source=web&cd=5&cad=rja&ved=0CFYQFjAE&url=http%3A%2F%2Fwww.cstec.org%2Fuploads%2Ffiles%2FNational%2520Outline%2520for%2520Medium%2520and%2520Long%2520Term%2520S%26T%2520Development.doc&ei=T6krUcusDuKsiAKYpoC4CQ&usg=AFQjCNEDPFlAjNsnkbMGPq6N5-zy8PhuXg&sig2=_1sqI4CBpbozNnPkIm146Q.

its impact on economic and social development as well as debates regarding government intervention and direction in national innovation systems.[82]

If China succeeds in its goals laid out in the MLP it will certainly have risen to lead the world in innovation. Chinese society will have emerged as an innovative society that is centered on S&T.

B. MLP OF 2006 "Indigenous Innovation"

China's new program of "Indigenous Innovation" focuses on achieving three major goals: *i)* Building an innovation-based economy by fostering the ability to innovate, *ii)* Fostering an enterprise-centered S&T innovation system and bolstering the innovative capacity of Chinese corporations, *iii)* Achieving significant achievements in specific areas of technological development and basic research. In order to achieve these goals the State Council announced policies covering four broad categories outlined in OECD's report on innovation policy review of China:[83]

- Enhancing R&D financing not only through enhanced public funding, but also through extended tax incentives for S&T, government support for the development of financial market funding channels, public funding to support the absorption of imported technology, etc.
- Promoting innovation through improved framework conditions: active use of intellectual property rights (IPR) protection, active participation in setting international technology standards, public procurement, and R&D infrastructure construction, including key labs, science parks and incubators, etc.
- Enriching human resource in S&T by nurturing scientific leaders and talent and tapping into the global pool of HRST, including overseas Chinese, reforming higher education, and improving public awareness of innovation.
- Improving the management of public R&D by introducing a new evaluation system and increasing policy co-ordination.

[82] Cong Cao, Richard P. Suttmeier, and Denis Fred Simon, "China's 15-year Science and Technology Plan," *Physics Today* (December 2006), 42.

[83] *OECD Reviews of Innovation Policy China*, Organisation for Economic Co-operation and Development, 2008.

1. Top-down Policies

Although China has made significant strides in creating a more innovative society it suffers from the burden of centrally planned policies that are characterized by a top-down approach. The top-down policies of the MLP, some of which were previously mentioned, include raising the share of GDP dedicated to R&D to 2.5 % by 2020 from 1.5 % today, and investing in eighteen science and engineering "megaprojects."

In an effort to create technological autonomy, or reduce the payment of licensing fees to foreign companies, China has focused on the development of competing technology standards. One policy to this end mandated that companies wanting to be included as recognized vendors in the government's product procurement catalog would have to demonstrate that their products included indigenous innovation and were completely free of foreign intellectual property. Due to the global nature of product production this raised a number of issues; first, it was difficult to find adequate "Indigenously Innovated" product, second, this was highly prejudicial to international companies attempting to compete in China's market; and last, China attempted to force international companies to hand over sensitive intellectual property if they wanted to be included in the catalogs. Ultimately due to intense international pressure China repealed some of the more discriminative policies.[84]

2. Bottom-up Policies

Recognizing the fickle nature of creating an innovative society China has adopted a multi-faceted strategy to this end. While it historically is more comfortable with centrally mandated policies and procedures China has created a bottom-up approach to fostering or cultivating innovation. These policies are based on the experience of Silicon Valley and centered on university-industry collaboration, venture capital, and small-start-ups. Some of the basic provisions of these policies aim to:

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[84] *China's Five-Year Plan, Indigenous Innovation and Technology Transfers and Outsourcing, Hearing Before The U.S.-China Economic and Security Review Commission,*112 Cong. 5 (June 15, 2011), 72–73.

- reduce the enterprise income tax for high-tech firms that invest heavily in R&D
- provide financial support through soft bank loans
- provide protection for intellectual property rights
- focus on merit or peer-reviewed selection of research grant recipients

Although China recognizes the importance of fostering bottom-up innovation it is still weak in this aspect of its NIS.

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III. EFFECTIVENESS OF "INDIGENOUS INNOVATION"

With the outcome of "Indigenous Innovation" potentially affecting not only China but the rest of the world, it is very important to fully understand the details and nature of this policy. Seven years have passed since the implementation of "Indigenous Innovation," in China's Medium and Long-Term Plan (MLP) from 2006–2020, long enough to make some preliminary assessments of its effectiveness and impacts. This chapter evaluates China's innovation efforts both before and after 2006. There are five primary indicators widely used by economists in assessing a nation's level of innovation. This chapter provides an assessment of the validity of these indicators, which are: expenditures on R&D, patent filing statistics, talent pool of S&T scientists, academic and scholarly articles published, and high-tech exports. Using these indicators this chapter assesses each, prior to and after 2006, to see if they point to one of the three potential effects of "Indigenous Innovation" on China's economic performance; *Indigenous Innovation Flops, Indigenous Innovation becomes China's Economic Engine,* and *Indigenous Innovation is Irrelevant for Chinese Growth.*

Although increasing numbers of several of the indicators may correlate to concurrent actions and policies under the auspices of "Indigenous Innovation" this does not indicate that the increases are the result of the actions and policies. This chapter pokes holes in some of the faulty logic that have led some to conclude that innovation has significantly increased in China in recent years.

A. ASSESSING INNOVATION

China rests its future economic growth on its ability to increase levels of innovation and has worked hard to evaluate the effectiveness of its programs for innovation. It has attempted to evaluate innovation by measuring statistics of specific indicators. The reliability of statistics published by China regarding its economy has been frequently questioned. The Chinese government itself has recognized past problems and has revised figures and implemented reforms aimed at increasing accuracy. As China's published statistical data is very pertinent to the evaluation of China's ability to implement “Indigenous Innovation” it is important to acknowledge that numbers cited in this thesis are subject to imperfections ranging from miscalculation in an imperfect system of the National Bureau of Statistics, or possible manipulation to protect political or economic interests. Most of the data in this report used for argument in evaluation of the effectiveness of “Indigenous Innovation” comes from the year 2000 onward and are not subject to as many of the cited errors or problems that plagued Chinese economic statistics in the past. Many recent laws and reforms have improved the accuracy of reported statistics.[85]

Measuring innovation is extremely complicated. It could easily be compared to evaluating good verses bad dreams or counting the numbers of good ideas in a society. Changes in a nation’s level of innovation are very difficult to quantify. International economists and governments have gone to great lengths to measure innovation. Emerging from their efforts are five common measures of a nation’s levels of innovation: funding of R&D, patent filing numbers, numbers of S&T scientists receiving college degrees along with numbers of scientists employed in S&T, numbers of scientific articles published in academic journals, and numbers of high-tech exports (Battelle, Stembridge and Zhou, Wolff, and Meri). These output indicators do not translate directly to outcome indicators such as economic growth. This chapter will show that just because China is spending more on R&D, does not mean that innovation and economic growth will increase correspondingly. This thesis will compare each of these specific areas of measure from a pre-”Indigenous Innovation” baseline to the time elapsed since implementation of this policy. This comparison will weigh the validity of the numbers presented and present conclusions regarding indicators pointing to the outcomes listed in the three potential theories previously mentioned; 1. *Indigenous Innovation Flops,*

[85] It is commonly held that China’s statistical performance improved significantly from 1949–57 but was devastated by the Great Leap Forward, because of the politicization of production numbers and “plans became dreams.” After the Great Leap, however, China’s statistics work steadily improved. People’s communes and their subdivisions were under continual pressure to produce reliable statistics. There was also a steady increase in rural statistics personnel, helped by expanding literacy and training of accountants. Thomas G. Rawski, “On the Reliability of Chinese Economic Data,” Journal of Development Studies 12:4 (1976), 438–441; Iacob N. Koch-Weser, *The Reliability of China’s Economic Data: An Analysis of National Output* (U.S.-China Economic and Security Review Commission Staff Research Project, January 28, 2013) 7; Denis Fred Simon, and Cong Cao, “Examining China’s Science and Technology Statistics: A Systematic Perspective,” *Journal of Science and Technology Policy in China* 3, no. 1 (2011), 3.

2. *Indigenous Innovation becomes China's new economic engine,* and 3. *Indigenous Innovation is Irrelevant for Chinese Growth.*

The MLP containing China's "Indigenous Innovation" plan still has seven more years of implementation until its end in 2020. Therefore, the evaluations made in this thesis, unfortunately, can only be counted as an assessment of a work in progress. A fair assessment of the complete effectiveness of "Indigenous Innovation" will have to be done after 2020 and again after 2050 to assess the benchmarks set forth for these years. This thesis will suggest future indicators or trends that would reveal the realization of one of the three indicated theories.

B. ASSESSMENT OF 2006 BASELINE

Each of the indicators of innovation will be examined to show the trend of these indicators leading to 2006, and the subsequent post 2006 evaluation will show if the same trend continued without change, increased or decreased. In the 10 years before 2006, China experienced significant economic changes to include the transition from a planned market economy to a more market oriented economy. These changes led to a shift in funding for S&T with enterprises contributing more than government from 2001 onward (see Figure 2). This shift is hailed, by professors of the Zhejiang University School of Management in Hangzhou, as a move toward "Indigenous Innovation" and the overall goal of enhancing national innovation capabilities.[86] This may be an overly optimistic view of innovation progress according to other Chinese scientists and scholars.[87]

[86] Qingrui Xu; Suping Zhang; Zhiyan Wu; Shouqin Shen, "The 5 waves of indigenous innovation in China," *Management of Innovation and Technology (ICMIT), 2012 IEEE International Conference on,* (2012), 5–10, doi: 10.1109/ICMIT.2012.6225770.

[87] Xinli Zhao and Wenfei Gao, "The theory of innovation and its application in China," *Management Science and Engineering, 2008. ICMSE 2008. 15th Annual Conference Proceedings., International Conference on,"* (2008), 1401,1408. doi: 10.1109/ICMSE.2008.4669090.

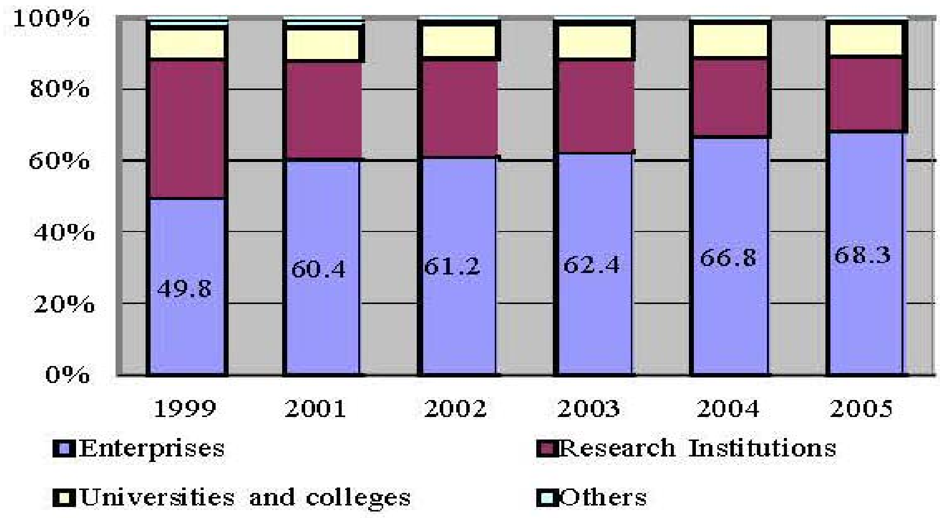

Figure 2. Increasing Share of Enterprise Expenditures on R&D

Source: *China Statistical Yearbook of Science and Technology* (1999–2005).[88]

1. China's Expenditures on Research and Development Prior to 2006

Along with incredible economic growth, China invested exceptional amounts in R&D for S&T. The decade long trend prior to 2006 showed spending increasing at a rapid annual rate of nearly 19% since 1995. In 2005, China's R&D spending was the sixth largest worldwide at $30 billion (2006 exchange rates). This amount was equivalent to 1.34% of China's GDP in 2005 exchange rates (see Table 7).

Table 7. GERD as a Percentage of GDP

	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
China	0.57	0.57	0.64	0.65	0.76	0.90	0.95	1.07	1.13	1.23	1.33
Japan	2.92	2.81	2.87	3.00	3.02	3.04	3.12	3.17	3.20	3.17	3.32
United States	2.51	2.55	2.58	2.62	2.66	2.74	2.76	2.66	2.66	2.59	2.62
Total OECD	2.07	2.10	2.12	2.15	2.19	2.23	2.27	2.24	2.24	2.21	2.25

Source: MOST, S&T statistics website.[89]

88 *China Statistical Yearbook of Science and Technology*, China Ministry of Science and Technology, (1999–2005), 21.

89 MOST, S&T statistics website. Ministry of Science and Technology, Accessed March 15, 2013, http://www.most.gov.cn/eng/statistics/2007/index.htm.

As acknowledged in its goals for "Indigenous Innovation" China still has a long way to catch up with or pass the United States in the amounts it spends on R&D. In 2005, only about one-quarter of R&D spending went towards basic research and applied research while more than 75% was devoted to experimental development. When comparing the statistics from China to those of other countries, it is important to note the massive difference in total population size. With nearly 20% of the world's population residing in China, the per-capita ratio lowers the magnitude of amounts spent on R&D as well as other statistics such as numbers of scientists, compared to other nations (see Figure 3). With significantly more spent on experimental development than on research China was less likely to develop many patents.

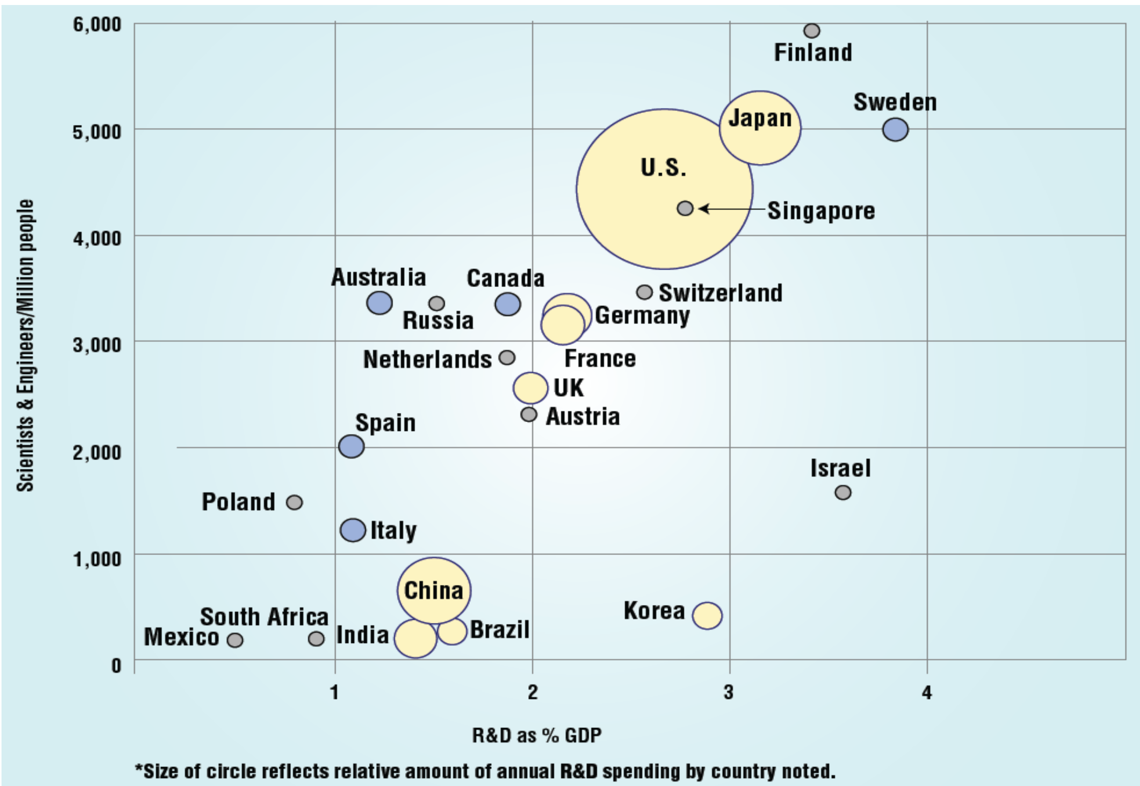

Figure 3. World of R&D 2004

Source: 2005 Global R&D Report, Battelle, *R&D Magazine*.[90]

[90] 2005 Global R&D Report, Battelle, *R&D Magazine*, OECD, World Bank, K4D, UNESCO.

2. Patent Filing Statistics Prior to 2006

Despite record increases in spending on R&D the corresponding outputs remained relatively weak. Although China, during this period, was doubling the number of patents it was filing every two years (see Figure 4); an examination of patent filing numbers leading up to 2006 shows that China was still far behind developed countries in patent filings prior to 2006.

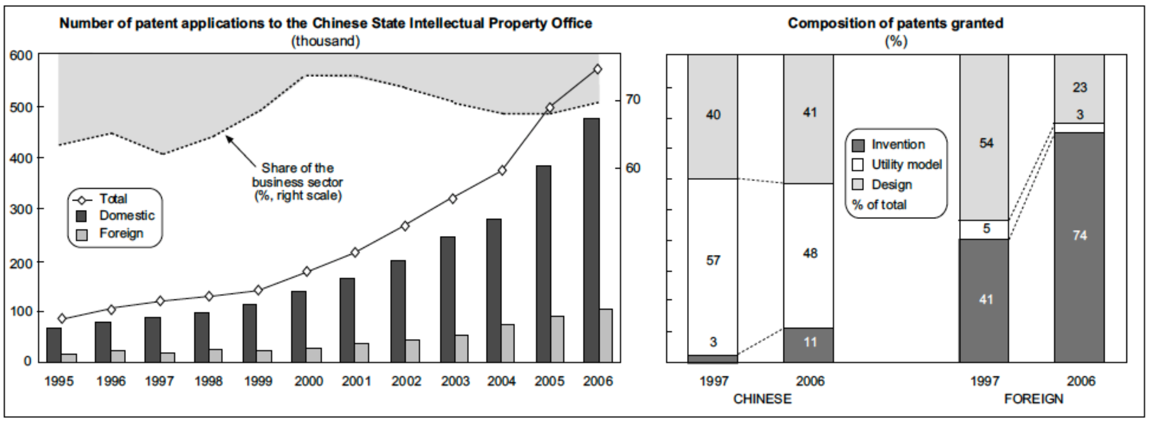

Figure 4. Patent Applications 1995–2006

Source: MOST, S&T statistics website.[91]

An evaluation of China's patent numbers in 2006 show that in relation to the rest of the world, Chinese patent applications only accounted for 3% of applications filed under the Patent Cooperation Treaty (PCT) of the World Intellectual Property Organization (WIPO). Additionally only 11% of patents filed by Chinese firms were considered inventive (invention patents), compared to 74% of patents by foreign firms filing patents in China.

3. Talent Pool of S&T Scientists Before "Indigenous Innovation"

In 1995, China committed to bolster S&T through education and build on old policies that over the previous 20 years aimed at strengthening China's abilities in S&T. Subsequently other initiatives have focused on increasing national strength through

[91] MOST, S&T statistics website, accessed 15 March 2013, http://www.most.gov.cn/eng/statistics/2007/index.htm.

talent. This focus on education and building a larger pool of S&T talent contributed to greatly increasing enrollment in higher education as well as the numbers of scientists and engineers working in R&D (see Figures 5 and 6). China historically suffers from a scholar diaspora problem often referred to as the "brain drain," where Chinese citizens, highly educated overseas, choose to stay overseas and work rather than return to China. This means that some of China's best and brightest are adding to the increase in knowledge and economic output of other nations.

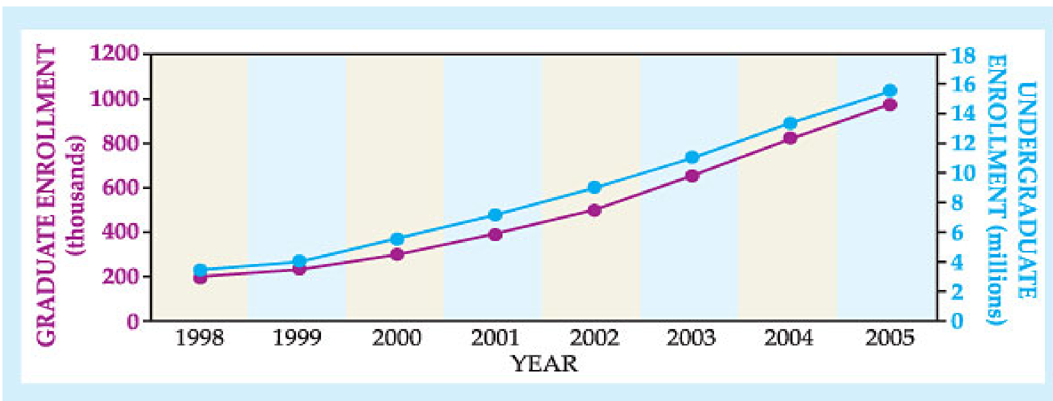

Figure 5. Student Enrollments in Chinese Higher Education Have Risen Since 1998 at Both the Graduate (purple) and Undergraduate (blue) Levels

Source: NBS and MOST, 2006.[92]

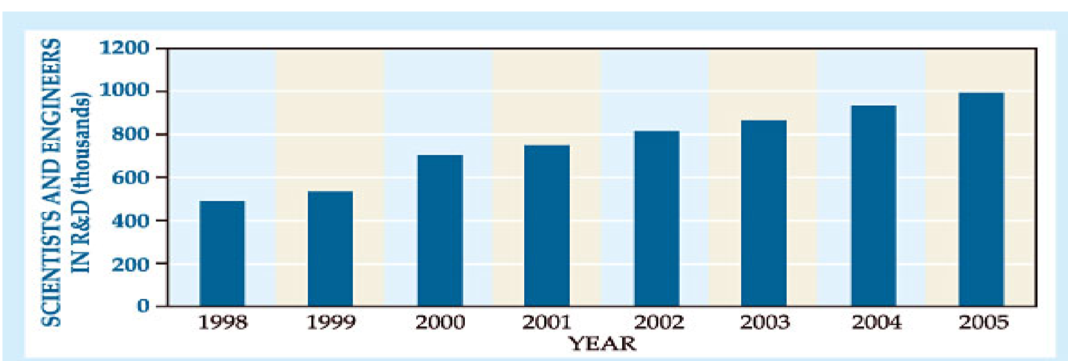

Figure 6. Year on Year Increases in the Number of Scientists and Engineers Engaged in R&D in China

Source: NBS and MOST, 2006.[93]

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92 MOST, S&T statistics website, accessed 15 March 2013, http://www.most.gov.cn/eng/statistics/2006/index.htm.

93 Ibid.

From 1994 to 2006, the number of Chinese university graduates jumped from almost 640,000 students to an astounding 3.77 million. This amounts to an almost six-fold increase in just 12 years. Only the United States leads China in terms of total numbers of science and technology workers.[94] According to Cao, Suttmeier and Simon's assessment in 2006, although the numbers were increasing, the quality of China's S&T talent pool was still lacking many of the overall characteristics that were frequently sought after by leading R&D industries.[95]

4. Academic and Scholarly Articles Published Leading to 2006

In the 10 years prior to 2006, China significantly increased its research output publishing astounding numbers of scholarly papers and journal articles. A chart showing China's marked year-on-year increase in the number of publications in relation to the United States, the United Kingdom and the rest of the world, is shown in Figure 7. According to statistics published by the Ministry of Science and Technology (MOST), China increased the number of articles published annually from 26,395 in 1995 to 153,375 in 2005 (articles counted in SCI, ISTP and EI).[96] China's share in the numbers of scientific publications across the world rose from 2% to 6.5% from 1994–2004. After the United States, China ranked second in the world with respect to publications on nanotechnology. Despite increasing publication numbers, China still lagged far behind developed countries in comparisons of numbers of times articles were cited in other works. This could indicate that although China is publishing high numbers of scientific articles they are not cutting edge or of interest to much of the rest of the international scientific community. When scientific articles published in China are cited with the same frequency of articles published by nations leading in innovation, this output indicator will more directly reflect actual economic growth through innovation.

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[94] Denis Fred Simon and Cong Cao, *China's Emerging Technological Edge* (New York: Cambridge University Press, 2009), 146–147.

[95] Cong Cao, Richard P. Suttmeier, and Denis Fred Simon, "China's 15-year Science and Technology Plan," *Physics Today* (December 2006), 40.

[96] SCI-Science Citation Index, ISTP-Index to Scientific and Technical Proceedings, EI-Engineering Index; MOST, S&T statistics website, accessed 15 March 2013, http://www.most.gov.cn/eng/statistics/2007/index.htm.

This lack of frequency with which Chinese articles were cited may have been a result of overly applied research or lower quality research or neither. It is unclear, based on the sources referenced for this section, what the specific reason was for the lower numbers of citations.[97] Some researchers are quick to claim that the articles were cited less because of poor quality; however those claims are typically not substantiated with specific evidence.[98]

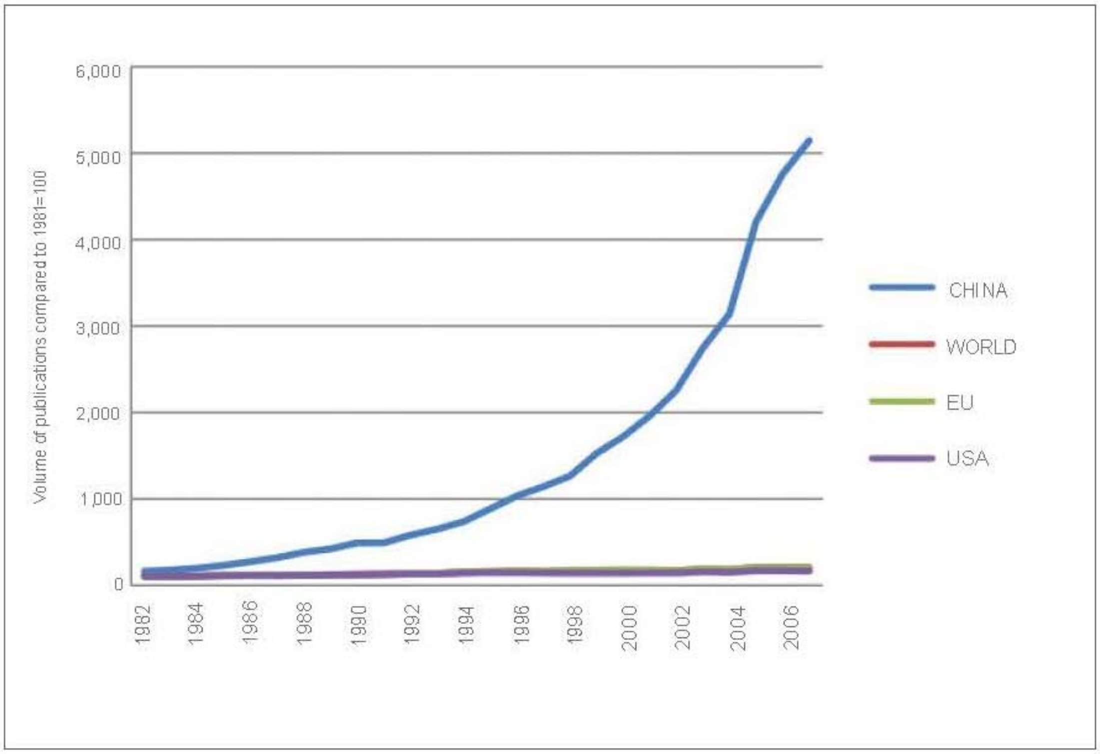

Figure 7. China's Year-on-Year Growth in Numbers of Research Publications

Source: Adams, King, and Ma. *Global Research Report, China,* Thompson Reuters, 2009.[99]

[97] Ronald Kostoff et al., "The Structure and Infrastructure of Chinese Science and Technology" (Washington, DC: Office of Naval Research, 2006), 58.

[98] The research needed to evaluate the quality of Chinese articles compared to those of other nations that are cited more frequently is beyond the scope of this thesis. In order to accomplish a conclusive analysis it would be necessary to examine a number of Chinese articles on a given subject and non-Chinese articles on the same subject, evaluate them for quality and accuracy and then compare the number of times each was cited. To form a valid conclusion it would be requisite to repeat this evaluation for many articles written across multiple disciplines to establish national trends: Kostoff, et al., "The Structure," 58.

[99] Adams, King, and Ma, *Global Research Report, China* (New York: Thompson Reuters, 2009), 5.

5. Numbers of High-tech Exports

The numbers of China's high tech exports rose significantly from $6.3 billion in 1994 to $218.2 billion in 2005. Year-on-year increases of these exports are shown in Table 8. The European Commission published a report in 2006 claiming that China had passed the United States and Japan and become the world leader in high-tech exports. At face value it appears that China must certainly be increasing in innovation through this decade. The trend of China's high-tech exports from 1995 to 2009 shows that from 1995 to 2005, high-tech exports grew at approximately 30% annually, much faster than the growth of overall exports. However, when China's high-tech trade numbers are examined in detail they reveal that a great portion of the high-tech products counted as exports first originated as high-tech components imported to China and then assembled into finalized products.[100]

Table 8. China's High-tech Exports from 1995–2005.

	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
Numbers of High Tech Exports in billions of U.S. $	10.1	12.7	16.3	20.3	24.7	37.4	46.5	67.9	110	165	218

Source: MOST, S&T statistics website.[101]

Yuqing Xing claims that China's supposed lead in technology is not due to technological advancement of indigenous companies; rather, it is the result of outdated statistic methods. According to Xing's calculations 82% of China's high-tech exports were of assembled products composed of imported high-tech parts from other countries. Therefore, the actual value added by China was merely cheap labor to assemble high-tech

[100] Thomas Meri, "China passes the EU in high-tech exports," *Science and Technology, Eurostat Statistics in Focus* (2009): 1.

[101] MOST, S&T statistics website, Ministry of Science and Technology, accessed March 15, 2013, http://www.most.gov.cn/eng/statistics/.

products.[102] Another significant factor related to exports was that 88% of high-tech exports originated from foreign owned or joint venture companies operating in China.

6. Overall Assessment of Status of Innovation in 2006 prior to Implementation of "Indigenous Innovation"

The indicators of innovation prior to 2006 were all showing steady significant gains. Regardless of the gains of the input indicators, the output indicators still appeared weak. Furthermore, the shift from output indicators to actual desired outcomes of "Indigenous Innovation" is even further into the future. If adjusted for purchasing power parity (PPP), China's GERD, at $73.5 billion, trailed only the United States and Japan. China's R&D intensity, measured by a ratio of GERD to GDP, rose substantially; however, when compared to developed nations, it still lagged significantly. A mathematical assessment by Zhao and Gao in 2008 showed that the contribution ratio of scientific and technological progress in China was about 40%, while in developed countries the ratios were more than 80%. They also assessed China's dependence on foreign tech at approximately 60% while developed countries dependence only measured around 20%.[103]

It is no surprise that China had a long way to go to catch up with the developed nations in terms of innovation capacity. This is the main reason China adopted all of the policies and goals of the 2006 MLP. China was steadily increasing numbers of output statistics but needed to at the same time increase the quality of outputs and hence achieve meaningful innovation outcomes that could actually have the intended effect on economic growth.

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102 Yuqing Xing, "The People's Republic of China's High-Tech Exports," 3.

103 Xinli Zhao and Wenfei Gao, "The theory of innovation and its application in China," *Management Science and Engineering, 2008. ICMSE 2008, 15th Annual Conference Proceedings, International Conference on"* (2008), 1406, doi: 10.1109/ICMSE.2008.4669090.

C. ASSESSMENT OF TRENDS FROM 2006 TO 2013

1. Assessment After Eight Years of "Indigenous Innovation"

China's MLP that includes the "Indigenous Innovation" policy is a 15-year plan and some might question the validity of an assessment with seven years remaining in the plan. The important question is whether the output indicators that are evaluated here actually represent change due to implementation of the "Indigenous Innovation" policy. Based on analysis of the data evaluated within this thesis, it appears that the output indicators are valid; however, not all of them translate directly to the outcomes desired by the Chinese government.

2. China's Expenditures on Research and Development After 2006

Booz and Company issues a yearly report on the top innovative companies around the world, *The Global Innovation 1000*. In the eight-year history of this report, it has found that, for companies, spending more money on R&D or innovation does not correlate directly to increased revenue. Instead, its findings show that in efforts to increase revenue through innovation, "what matters is how companies use … money and other resources, as well as the quality of their talent, processes, and decision making."[104] The same logic rationally can be applied to national level R&D spending. Just because China is spending more on R&D, does not mean that innovation and economic growth will increase correspondingly. What matters most for China in creating an innovative society is how effectively China is managing its spending on R&D, how it is growing and leveraging its talent pool, and whether it is shaping its national innovation system (NIS) based on a nexus between industry, universities and research centers.

[104] Booz and Company, "The Global Innovation 1000: Making Ideas Work," *Strategy and Business*, issue 69, (winter 2012), http://www.booz.com/media/uploads/BoozCo_The-2012-Global-Innovation-1000-Study.pdf.

In realization of its goal to become a world leader in innovation from 2006–2013, China only increased its global share of spending on R&D by 2% (see Table 9). In the eight years prior to "Indigenous Innovation," China increased its R&D spending as percentage of GDP by 0.68%. In the years following the announcement of "Indigenous Innovation," China increased its R&D spending, as percentage of GDP, by only 0.26% (see Table 10). This indicates that the rate in which China is increasing its R&D spending has slowed during the same period China's actual GDP growth has also slowed. This trend seems to indicate that "Indigenous Innovation" has not helped to increase R&D spending. In order for China to reach its goal of 2.5% by 2020, it will have to significantly increase the year-on-year spending increases on R&D.

Table 9. Share of Total Global R&D Spending

	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013
Americas	37.8%	37.5%	35.7%	34.4%	33.1%	39.1%	37.8%	34.8%	34.3%	33.8%
U.S.	32.7%	32.0%	32.7%	31.4%	30.1%	34.7%	32.8%	29.6%	29.0%	28.3%
Asia	37.6%	38.7%	36.9%	38.8%	40.8%	33.6%	34.3%	34.9%	36.0%	37.1%
China	11.8%	12.8%	13.5%	15.6%	17.9%	11.2%	12.0%	12.7%	13.7%	14.7%
Japan	13.0%	12.6%	13.0%	12.8%	12.4%	12.6%	11.8%	11.2%	11.1%	10.8%
Europe	24.6%	23.8%	25.2%	24.6%	23.9%	24.1%	24.8%	24.6%	24.0%	23.4%

Source: Battelle, *R&D Magazine*.[105]

Table 10. GERD as a Percentage of GDP 2006–2013

	2006	2007	2008	2009	2010	2011	2012	2013
China	1.39	1.40	1.47	1.70	1.76	1.55	1.60	1.65
Japan	3.41	3.46	3.47	3.36	3.26	3.47	3.48	3.48
United States	2.64	2.70	2.84	2.90	2.83	2.70	2.68	2.66
Total OECD	**2.25**	**2.28**	**2.35**	**2.40**	**2.38**	**…**	**…**	**…**

Source: OECD, 2013, 3.[106]

105 *2013 Global R&D Funding Forecast* (Rockaway, NJ: Advantage Business Media, *R&D Magazine*, Battelle, December 2012).

106 OECD, Main Science and Technology Indicators database, January 2013; 2013 Global R&D Funding Forecast (Rockaway, NJ: Advantage Business Media, R&D Magazine, Battelle, December 2012), 3.

Despite its seeming stagnation in the overall ranking in the percentage-of-global-R&D-spending, China now outspends every other nation with the exception of the United States. According to the 2013 Global Funding Forecast, by R&D Magazine, China will surpass the U.S. in R&D funding in 2020 (see Figure 8).

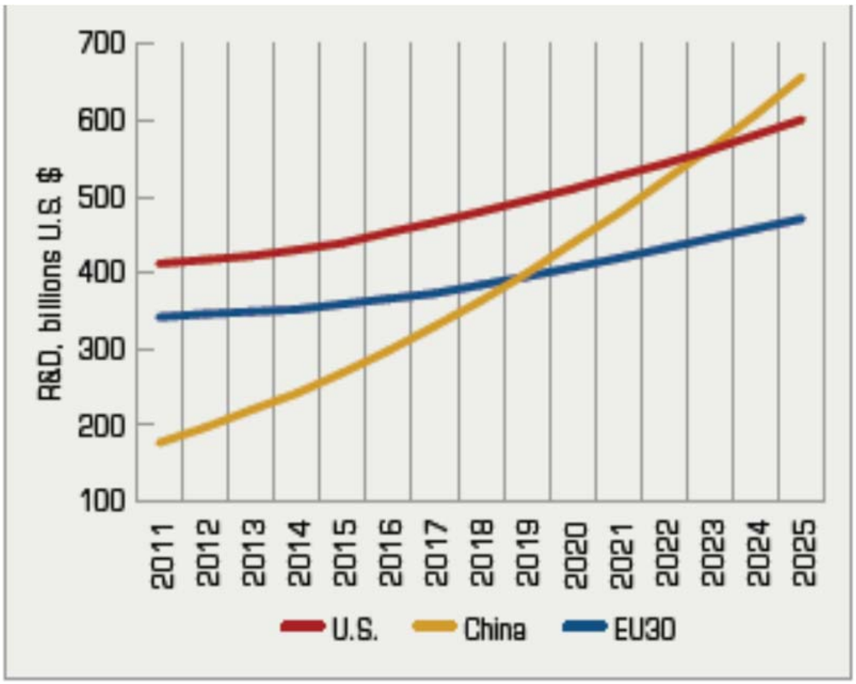

Figure 8. 2022 Crossover of R&D Spending

Source: 2013 Global Funding Forecast, Battelle, *R&D Magazine*, International Monetary Fund, World Bank, CIA World Factbook, OECD.[107]

Continued GDP growth at approximately 8% will continue to fuel R&D spending increases allowing China to make these investments. However, as Figure 9 indicates, although China's overall contribution to R&D makes it a world leader in spending, China is still far from its MLP goal of dedicating 2.5% of GDP to R&D by 2020.

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107 Ibid.

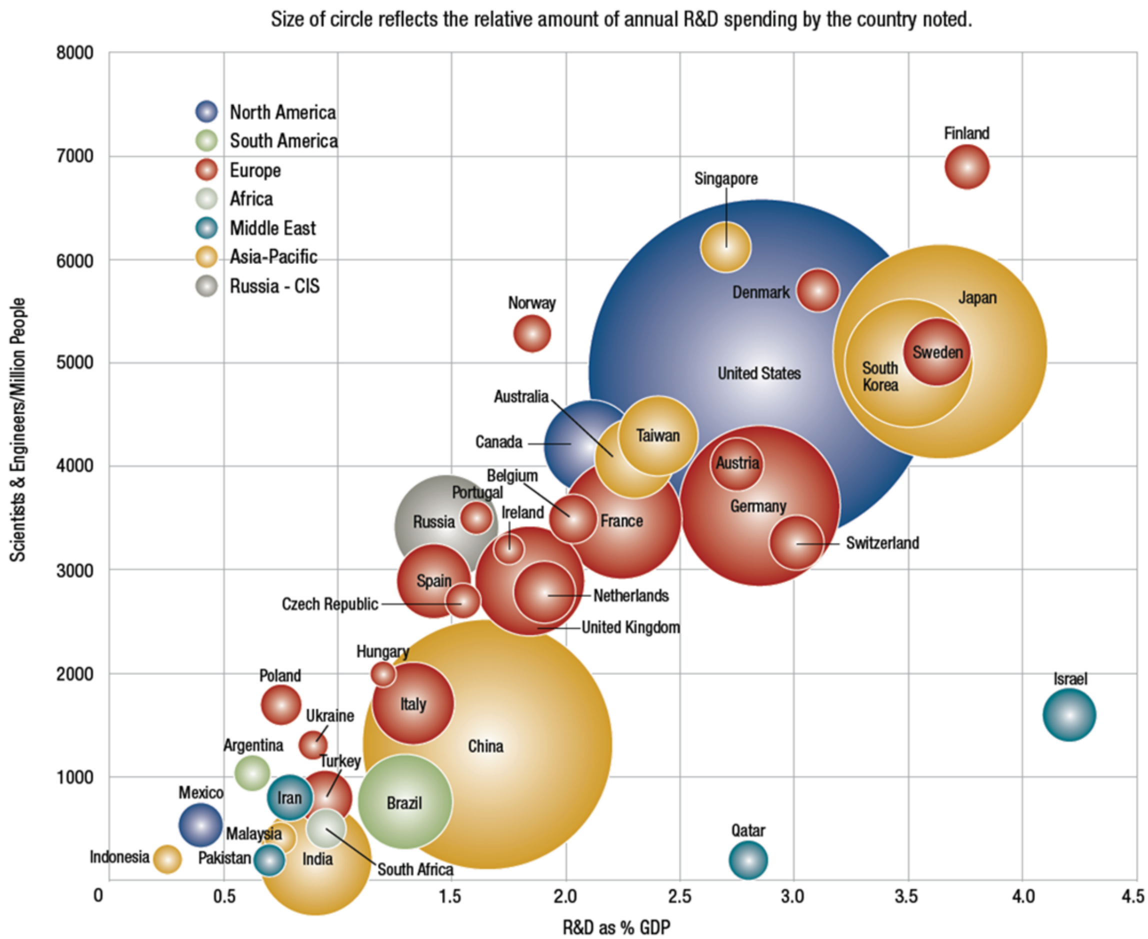

Figure 9. World of R&D 2011

Source: 2013 Global Funding Forecast, Battelle, *R&D Magazine*, International Monetary Fund, World Bank, CIA World Factbook, OECD.[108]

The yearly statistical data in Table 10 also shows that while China is steadily increasing R&D spending, the rate at which it is progressing is likely going to leave it short of its MLP goals. Further evaluation showing the amount of R&D spending contributed by business expenditure indicates that China is becoming more innovative but that the rate has slowed since 2005.

108 Ibid.

From 2000 to 2005 China increased business expenditures on R&D 8.36% as a percentage of GERD and from 2005 to 2010 it only increased by 6.13% (see Table 11). Even if China does not meet its MLP goal of spending 2.5% of GDP on R&D by 2020, due to its rapid economic growth it already is and will continue to be a world leader in aggregate spending on R&D. In examining the evidence available, it is apparent that "Indigenous Innovation" is irrelevant to increasing spending on R&D.

Table 11. Business Expenditure on R&D (BERD) as a Percentage of Total National GERD

	2000	2005	2010
China	59.96	68.32	74.45
Brazil	44.73	48.29	47.88
India	N/a	N/a	N/a
s. Korea	74.05	76.85	74.80
Russia	70.86	67.98	60.51

Source: Adams, Pendlebury, and Stembridge, *Building BRICKS* (New York: Thompson Reuters, 2013).[109]

3. Patent Filing Statistics after 2006

In 2012, China became the world leader in patent filings. If numbers of patent filings were all that counted in measuring levels of innovation, it would seem that "Indigenous Innovation" was a sweeping success becoming China's new economic engine (see Table 12). From 2006 to 2010, patent applications in China increased by 16.7%. From 2009 on China showed double digit year-on-year growth in the number of patent filings. China now has filed six times as many patents as it did 10 years ago. Thomson Reuters projects that, by 2015, China will publish 493,000 patent applications annually.[110] Even though China is the current leader in numbers of patents filed annually, it is still new to the scene of international patent filing and, as of 2011 only holds 9% of the PCT patents (see Figure 10).

[109] Adams, Pendlebury, and Stembridge, *Building BRICKS* (New York: Thompson Reuters, 2013), 7.

[110] "China Leads the World," (New York: Thompson Reuters, 3 January 2012), Accessed 16 March 2013, http://thomsonreuters.com/content/news_ideas/articles/science/china-leads-the-world.

Table 12. Trends in the Number of PCT Patent Filings for Selected Countries, 2006–11.

	2006	2007	2008	2009	2010	2011
China	72.3	100	112.2	144.8	225.4	300.7
United States	94.9	100	95.6	84.4	83.3	90.4
Japan	97.4	100	103.7	107.4	115.9	140.1
Germany	93.9	100	105.8	94.3	98.6	105.4
Korea	84.2	100	111.8	113.7	136.9	147.9

Source: OECD Science, Technology and Industry Outlook 2012, data from WIPO Statistics Database, May 2012.[111]

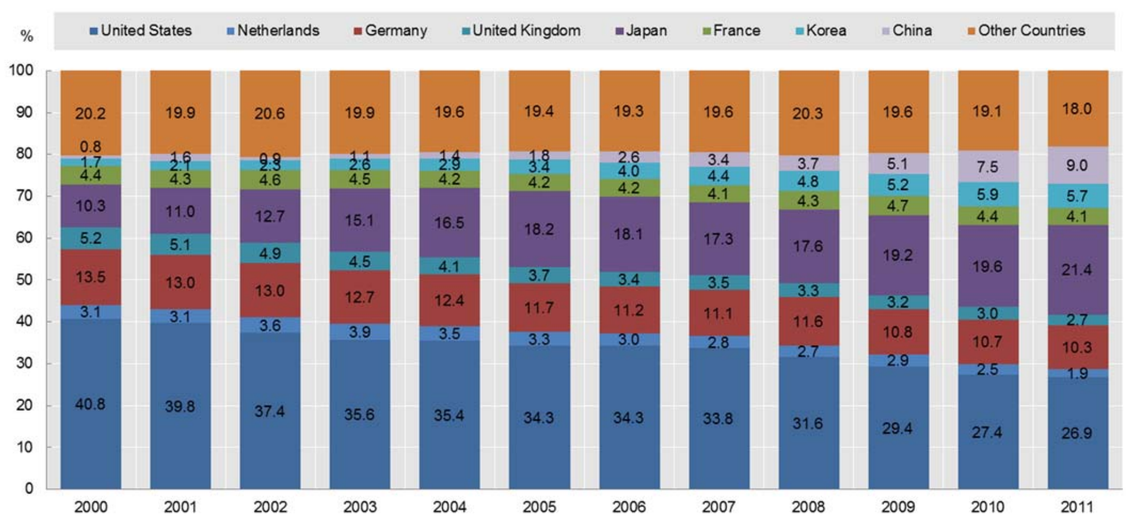

Figure 10. Country Shares in Total PCT Filings, 2000–2011

Source: OECD Science, Technology and Industry Outlook 2012; data from WIPO Statistics Database, May 2012.[112]

Although its share of international patents is growing, the United States, Japan and Germany, still lead China in total numbers of patents held. As with the many cited statistics, high output does not mean and is not a substitute for high quality. Currently, many of the domestic patents filed by China are not invention patents but are imitation type "utility" patents which are much easier to file and are considered lower quality. Another problem with the claims that high patent numbers equates to higher levels of innovation, is that the numbers of Chinese patents are likely inflated due to government

111 OECD, *Science, Technology and Industry Outlook 2012*, OECD, 2012.

112 Ibid.

subsidies to pay for patent filings. In efforts to get Chinese companies to both innovate and protect intellectual property, the government has paid for companies' patent applications. Although China is rising in patent quantity and quality, it still has a way to go to reach parity with developed nations. "Indigenous Innovation" is aiding in improvements in patent filing but this factor of innovation is not producing the endogenous economic growth China seeks.

4. Talent Pool of S&T Scientists after Implementation of "Indigenous Innovation"

China currently graduates more undergraduate level engineers annually than the United States, Japan, Germany, France, Taiwan and South Korea combined. Almost twice as many engineering Ph.D.s graduate from China than from the United States each year. In 2009, China had approximately 98 million people with degrees in higher education (see Table 13). From 2000 to 2005, the number of postgraduate students rose from 300,000 to close to 900,000; from 2005 to 2009, the numbers rose to 1.4 million. These figures indicate that numbers of postgraduate students have increased at a steady rate, increasing by about 600,000 every five years.[113]

Despite this steady growth, the total graduate student enrollment rate remained relatively low at 24.2%. This is still lower than the United States even with the overwhelming numbers of graduates in China.[114] This is yet another instance where the size of the population seems to distort the numbers and percentages. Even though China has rapidly increased the numbers of students and graduates receiving S&T degrees, it still suffers both from an equal diffusion of education, and from a general lack of quality among its graduates. Experts estimate that as few as one-tenth of China's engineering and IT graduates are prepared or have the ability to work in the global outsourcing environment.[115] China's graduates still lag behind those graduating from top Western

113 USCC, *Assessing China's Efforts to Become an "Innovation Society" – A Progress Report, Hearing Before The U.S.-China Economic and Security Review Commission*, 112 Cong. 2, (2012) (Statement of Robert D. Atkinson, President, Information Technology and Innovation Foundation).

114 Hu Angang, *China in 2020: A new Type of Superpower* (Washington, D.C: The Brookings Institution, 2011), 86–87.

115 Bergsten, et al., *China - the Balance Sheet* (New York: Public Affairs, 2007), 103.

universities. For this reason, China still allows its top performers to attend international universities in hopes that they will return, bringing not only knowledge acquired but more importantly the creative spark that they fail to replicate in their own graduates. As China seeks greater access to Western technology and to improve its own capacity, it has sought to fix the “brain drain” problem. China now offers top-paying jobs and significant other incentives to returning diaspora. The combination of approaches increasing the depth of the bench of available scientists to innovate appears to be working. China employs more people in S&T research today than any other country.[116]

Sometimes the pressure for returning Western-educated-scientists to produce results ends in falsified findings or phony products. In one instance, Chen Jin, a returning American-trained engineering Ph.D. caved to the pressure to create a native microprocessor. Chen had worked for Motorola after earning his doctorate; later, after he returned to China and started working at Jiaotong University, he passed off a Motorola chip as his own design. Chen was showered with titles and billions in research grants. He created several of his own companies and only after several years of this charade, did some of his work associates reveal his lies. China’s reputation as a leader in science was tarnished after lauding so publicly Chen’s “achievements.” Following this and other scandals, both MOST and CAS established procedures and policies to prevent plagiarism, fraud, and other moral issues that had become common in China’s science community.[117]

One of the often-recognized shortcomings of China’s education system is its emphasis on rote memorization and lack of training in critical thinking and problem solving. China’s push to educate such great numbers of people has not reflected the demand and needs of the market. According to the 2012 World Economic Forum’s *Global Competitiveness Report*, China ranked seventh globally in primary education

[116] Anil K. Gupta, and Wang Haiyan, “China as an Innovation Center? Not so Fast; An Impressive Volume of Patent Filings Conceals Serious Challenges to Beijing’s R&D Aspirations,” *Wall Street Journal (Online)*, July 28, 2011, ProQuest (879544375).

[117] David Barboza, “In a Scientist’s Fall, China Feels Robbed of Glory,” *New York Times, Technology*, May 15, (2006), Accessed 22 March, 2013, http://www.nytimes.com/2006/05/15/technology/15fraud.html?pagewanted=all; The Lancet, “Reforming Research in China,” *The Lancet*, 369 (2007): 880, Accessed March 26, 2013, doi: 10.1016/S0140–6736(07)60419-X.

enrollment. Despite this high ranking in numbers of students, China still ranked 35th globally in quality of math and science education.[118] Despite great disparities in quality of education based on geographical location, China has greatly improved the levels of education of its people as a whole (see Table 13). While other programs and policies have done more for elevating S&T education than "Indigenous Innovation," this indicator continues to rise. Based on the flat trajectory in the rate of increases in numbers of college graduates, coupled with "Indigenous Innovation" heavy focus on other measures, it is simple to conclude that China is increasing its innovative capability through education but this has had little to do with "Indigenous Innovation."

Table 13. Educational Enrollment Indicators, 1990–2020

	1990	2005	2009	2015	2020
Senior secondary education					
Students at school (million)	n.a.	40.00	46.41	45.00	47.00
Students in vocational education (million)	0.22	n.a.	21.95	22.50	23.50
Gross enrollment rate (percent)	21.9	52.7	79.2	87.0	90.0
Higher education'					
Students at school (million)	3.82	24.00	29.79	33.50	35.50
Gross enrollment rate (percent)	3.4	21.0	24.2	36.0	40.0
Undergraduate at school (million)	1.97	8.49	14.06	15.20	16.20
Graduate at school (million	0.09	0.98	1.41	1.70	2.00
Education received by newly recruited labor (years)	9.45	11.3	12	12.7	13.5
Continuing education on the job (million)	n.a.	n.a.	170	290	350
People with a higher education (million)	16	70	98	145	195

Source: Angang, *China in 2020*, (2011).[119]

5. Academic and Scholarly Articles Published Post–2006

According to Thompson Reuters, in the last five years there has been an 80% increase in the amount of annually published Chinese scientific literature. China is now second only to the United States in numbers of annually published scientific papers.[120] The Royal Society of the U.K. projects that China's total research paper publications will exceed the numbers of U.S. published papers sometime this year. The same report

[118] World Economic Forum, "The Global Information Technology Report 2009–2010" (2010), Accessed March 20, 2013. http://www.weforum.org/reports/global-information-technology-report-2009–2010.

[119] Angang, *China in 2020*, (2011); China Education Yearbook 2010.

[120] "China Leads the World."

forecasts that this trend is likely to continue with China's technical-paper global-publishing share increasing to 22% by 2020 (see Figure 11).

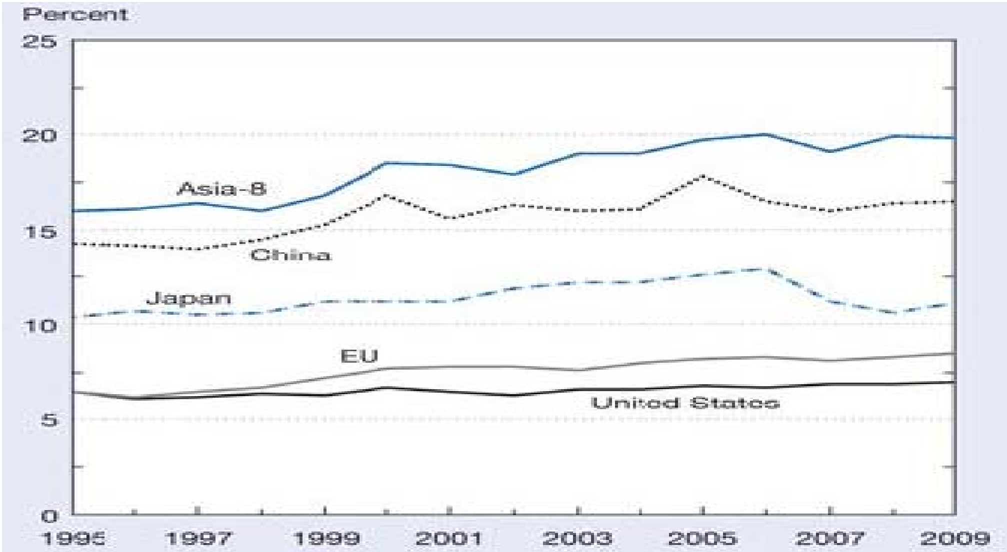

Figure 11. Engineering Articles as a Share of Total S&T Articles

Source: National Science Foundation, *Science and Engineering Indicators* 2012.[121]

Although some authors critique the quality of Chinese scholarly articles due to low numbers of citations, Chinese articles themselves are being cited increasingly. Thompson Reuters publishes a normalized citation impact report, which currently ranks China above the United States. Some of the past citation data was skewed because Chinese scientists preferred to cite international articles and not their domestic peers. At the same time, Chinese articles were not widely distributed internationally, limiting access and opportunity for Western scientists to cite them. In many areas, such as the material and natural sciences, China is now a world leader. [122]

In 2013, Thompson Reuters published a report that showed China's progress in improving both quantity and quality of research papers. China increased its publication of research papers by 600% from 2000 to 2010, and the quality of these reports showed

121 National Science Foundation, *Science and Engineering Indicators* (2012), http://www.nsf.gov/statistics/seind12/.

122 *2013 Global R&D Funding Forecast* (Rockaway, NJ: Advantage Business Media, R&D Magazine, Battelle, December 2012), 29.

through citation statistics. Over 1000 of these papers were cited in the top 1% of their respective subject areas. [123] "Indigenous Innovation's" contribution to higher publishing statistics is difficult to measure; however, it has had a likely significant impact in the increasing numbers. One issue however is that the incentives used to boost paper publishing likely introduced an inflated number of articles that does not correlate directly to the actual level of innovation.

6. Numbers of High-tech Exports

According to the U.S. Census Bureau the U.S. trade deficit in high-tech goods with China reached $94 billion in 2010. After China took the world-wide lead in high-tech exports in 2006, the same year as the implementation of "Indigenous Innovation," it expanded 80% to reach $492.4 billion by 2010 (see Table 14). The rate of increase from the five years prior to 2006 amounted to a 368% increase in high-tech exports. This slowdown in exports could be attributed to decline in world demand following the 2008 housing bubble collapse in the United States and the subsequent recession. During this post-2006 period, it is difficult to directly assess how much "Indigenous Innovation" contributed to high-tech exports.[124]

Table 14. Numbers of High Tech Exports 2006–2012

	2006	2007	2008	2009	2010	2011	2012
High-Tech Exports in billions of U.S.$	273.13	302.77	340.12	309.60	492.4	**	**

** data not yet available

Source: The World Bank, *World Databank*, 2013.[125]

[123] "Thomson Reuters Report Finds That Investment In Scientific Research, Innovation and Education Close Gap Between "Brick" And G7 Nations," Thompson Reuters Press Release, (19 February 2013), accessed 19 February 2013, http://thomsonreuters.com/content/press_room/science/thomson_reuters_report_finds_that_investment_in_scientific_research_innovation_and_education_close_gap_between_brick_and_g7_nations.

[124] The World Bank, *World Databank*, 2013, Accessed 23 March 23, 2013, http://databank.worldbank.org/data/views/reports/tableview.aspx; Yuqing Xing, "The People's Republic of China's High-Tech Exports," 3.

[125] The World Bank, *World Databank*, (2013), Accessed 23 March 23, 2013, http://databank.worldbank.org/data/views/reports/tableview.aspx.

According to Yuqing Xing, an expert on economics and China, the current method of measuring high-tech exports and imports does not have the expected relation to innovation or corresponding inputs such as investments in R&D. This is why, in 2006, while only contributing 1.5% of GDP to R&D and with a GDP only one-fifth the size of the United States, China nevertheless still surpassed the entire world in high-tech exports. If high-tech exports (as they are currently measured) were a good indicator of innovation, there would have been no way possible that this could have happened. The reality of China's large numbers of high-tech exports is that 80%–90% of them originated as sophisticated components in other countries, to be assembled in China and then exported. China's primary contribution to the majority of high-tech exports is labor. The innovation base that creates the majority of the value added in these products resides in the United States, Taiwan, Japan and South Korea. A primary example given by Xing is a 2009 Apple iPhone, which retailed at $179 but the value added by China only accounted for $6.50.[126]

Another study, "Does Innovation Matter for Chinese Hightech Exports?" conducted by Fu, Wu, and Tang (2010), claims that the theory correlating innovation to high-tech exports is false. In examining multiple high-tech firms, they found that domestic firms with increased efforts in innovation did not experience any higher production output. Of the international firms analyzed with high production output they found that the "Indigenous Innovation" policy did not help them in creation of value-added products. A counter to this argument might be that R&D and innovation activities have a much longer incubation period than the timeline in which these companies were observed. Value added from R&D conducted today might not show up in products for several years—Steve Jobs started working on the iPad nearly 10 years before it was released. It is incorrect to disregard the value of R&D and investment in innovation even if the results are slow to materialize. Many ideas are scrapped before they become inventions or products.[127]

126 Yuqing Xing, "The People's Republic of China's High-Tech Exports," 3–6.

127 Dahai Fu, Yanrui Wu and Yihong Tang, "Does Innovation Matter for Chinese Hightech Exports? a Firm-Level Analysis," MPRA Paper No. 30012 (2011), 3–7.

The effectiveness of relying upon the volume of high-tech exports to measure innovation is probably best summed up in *China: the Balance Sheet*: "evaluating the extent to which China is becoming a technological superpower involves far more than simply identifying China as the location in which seemingly more sophisticated products are assembled."[128] If high-tech exports were measured more accurately accounting for global production chains and the value added of each nation's contribution to a product, then high-tech exports would be a more valid measure of a nations levels innovation. Currently, the examination of pre and post "Indigenous Innovation" high-tech export statistics shows that "Indigenous Innovation" neither helped not hindered production of these goods; supporting the hypotheses that "Indigenous Innovation" is irrelevant to economic growth (see Figure 12).

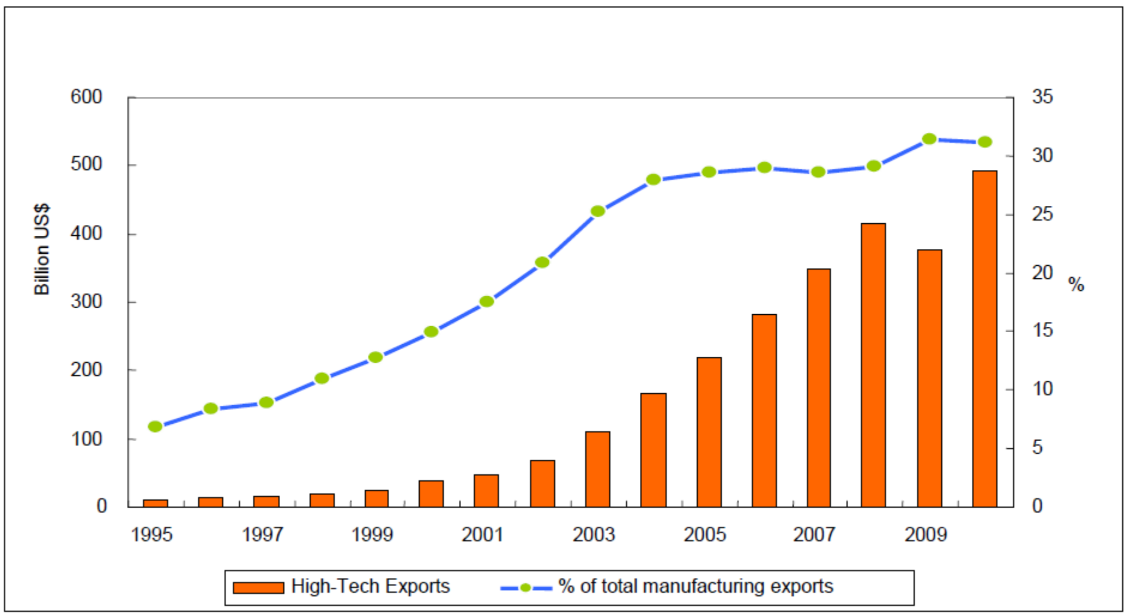

Figure 12. The PRC's High-Tech Exports 1995–2010

Source: Yuqing Xing, "The People's Republic of China's High-tech Exports: Myth and Reality," *ADBI Working Paper*, (2012).[129]

128 Bergsten, et al., *China–the Balance Sheet* (New York: Public Affairs, 2007), 103.

129 Yuqing Xing, "The People's Republic of China's High-Tech Exports," 357.

7. Assessment of Indicators Post 2006 and Post 2013

Of the five different relevant indicators of innovation measured both before and after 2006, three showed that "Indigenous Innovation" was irrelevant to their present outcome. These three indicators are: Expenditures on R&D because the percentage rate of increase has slowed; S&T Talent Pool because the rate of increases in numbers was steady across the implementation of "Indigenous Innovation;" and numbers of high-tech exports because the current measurement techniques are not adequately accounting for actual national levels of innovation.

Of all the indicators, S&T talent pool increases was the most closely tied to increasing actual innovation and TFP. Although imperfect, it is probably one of the best measures of innovation. Even with the issues of the current Chinese education system it is rapidly improving and producing impressive results. However, just as innovation is not created overnight, these increases in education levels and numbers were the product of modernization plans long before the call for "Indigenous Innovation."

D. CONCLUSIONS REGARDING CHINA'S EFFORTS IN BECOMING AN INNOVATION BASED SOCIETY

> [Our new policies and plans have] led CAS to narrow the science gap with leading countries; however, the innovation gap has still not been narrowed much.
>
> —Xielin Liu, Director of the Research Center, of Management of Innovation, at the Chinese Academy of Sciences

China is the likely location of the next innovation center, replacing Silicon Valley, according to a 2012 global tech innovation survey conducted by KPMG. Of those surveyed, 43% believed that Silicon Valley would no longer be the lead innovation center by 2016. The majority of respondents (45%) named China as the likely host to the next innovation center.[130] Regardless of the opinions of those in survey polls, China still has a very narrow view of innovation, and has a long road ahead to catch up with the innovation levels of Western nations. China continues to seek after breakthrough or new product innovation, and misses supporting other important types of innovation such as incremental innovation, production chain and system innovation. Another symptom of China's narrow focus is that it fails to build a breadth of capabilities.

China's corporate innovation is lagging far behind top nations. In 2012, China did not have a single company make Thomson Reuters' report on the top 100 globally innovative companies. China now leads the world in total numbers of patents; however, most of these (94%) are patents held only in China and this report is based on international patent statistics. Conversely, the United States protects 50% of its intellectual property internationally.[131] This indicates that China is still slow to expand globally.

China has failed to create any globally recognized brands however domestic filings of trademarks have surged since 2000, expanding to 450% by 2011. The numbers of Chinese trademark applications are now greater than applications of any other nation.[132] One reason for the Chinese government's emphasis on "Indigenous Innovation" and consumption is likely an aim to capitalize on rapidly expanding consumerism. China's domestic market is rapidly growing and expected to reach $4.3 trillion by 2015.[133] What China continues to miss is the capitalization on bringing the many new ideas (patents) to commercial application and production. This remains a

130 The KPMG survey consisted of the polling of 668 global technology leaders, one-third from the U.S. and Canada, 14% from China, and 9% from Israel. The remaining 50% were from Asia and EMEA. Included in those surveyed were: technology startups (32%), mid-market enterprises (37%), large tech companies (23%), and the rest from venture capital firms and angel investors. The survey included a large percentage of responses from corporate leadership, with CEOs alone comprising 20% of those polled. Entrepreneurs, M&A directors, corporate development and strategy execs were also polled.--- Ben Rooney, "China to Over Take Silicon Valley Claims Report," *Tech Europe – Wall Street Journal Online,* June 27, (2012).

131 *Thomson Reuters 2012 Top 100 Global Innovators: Honoring The World Leaders In Innovation Findings And Methodology 2012* (New York: Thompson Reuters, 2012), 9.

132 "China Leads the World," (New York: Thompson Reuters, 3 January 2012), Accessed 16 March 2013, http://thomsonreuters.com/content/news_ideas/articles/science/china-leads-the-world.

133 "China Leads the World."

problem due to the weak link between research institutions/universities and industry/corporations.

China is set to overtake the U.S. as the world's biggest economy in 2016 in terms of purchasing power parity (PPP), according to a March 2013 report by the Organisation for Economic Co-operation and Development (OECD).[134] According to research conducted by Booz and Company, surveying multi-national and Chinese corporations, innovation in China has reached the tipping point where compared to investments in other locations, investment in R&D in China is value-added. Their research further showed that innovation in China has gotten beyond market adaptation and is now in the realm of idea generation and fundamental research.[135] Despite these expected outcomes, this thesis demonstrates that China currently still falls considerably short of developed nations in terms of innovation.

In an interesting and relevant study conducted just this year, General Electric examined 50 countries for their comparative levels of innovation, examining 25 factors or indicators of innovation in three categories. It is not surprising that a large multinational corporation would have a much more sophisticated measure of innovation than those accepted and used by most governments. For each factor, all 50 countries in the study were compared and given a ranking. Then, based on these rankings, they were grouped into four group rankings that identified the countries in the top quartile, and bottom quartile. The 25 countries that by ranking happened to fall into the middle two quartiles were not identified for each factor. In summary, the overall rankings showed which countries made the top quartile and which made the bottom quartile. China did not rank well despite its focus and efforts on innovation—placing somewhere in the middle 25 countries. In the rankings of individual factors, China only ranked in the top quartile three times. The factors where China made the top cut were: *Burden of Government Regulations* (not a positive ranking), *Government Procurement of Advanced Technology,*

[134] Simon Rabinovitch, "OECD: China Forecast to Overtake U.S. by 2016," *Financial Times*, March 22, (2013), Accessed March 23, 2013. http://www.cnn.com/2013/03/22/business/china-us-oecd-2016/.

[135] *Innovation China's Next Advantage? 2012 China Innovation Survey* (Joint Report by: Benelux Chamber of Commerce, China Europe International Business School, Wenzhou Chamber of Commerce and Booz & Company, 2012), 6.

and *High Tech Exports as a percentage of Total Manufacturing Exports.* In summary, China was in the bottom three quarters of every factor but two. This reinforces the conclusion that China is not close to meeting its goals in "Indigenous Innovation."

Looking forward to the future and the goals for the end of the MLP, it is of value to project what changes we will need to see over the seven years in order for these objectives to be met. Increases in R&D will need to be diffused down to the local government levels with research grants and money awarded based on merit and scientific peer review. An increasing portion of funding needs to be applied to basic research. Patent Filings need to have a more rigorous review and include more invention type patents instead of utility patents. The Chinese education system needs to reform in a manner that allows for more creativity, independent thinking and problem solving. S&T articles are on track with numbers and quality increasing and are only lacking perhaps in citation frequency and breadth of subject matter. High-tech export numbers although cited by many, will not be a relevant measure of innovation in the global market until the metrics are reformed. Without these changes, China will not become an innovative society on par with developed nations by 2020.

An assessment of all the evidence available prior to and after the pronouncement of "Indigenous Innovation" points to a mixed outcome involving theories two (*Indigenous Innovation becomes China's new economic engine*) and three (*Indigenous Innovation is Irrelevant for Chinese Growth*). Although these two theories seem quite different in their hypotheses, the mixed result is relevant for the following two reasons: 1. "Indigenous Innovation" is having an effect on innovation in China but the measured outputs have yet to translate to outcomes. The economic benefits that China is seeking through endogenous growth will take longer than their initial goals of the 2005–2020 MLP. 2. Much of the innovation that will occur in China over the next 10–20 years is likely to come from market driven forces and not from central planning in the form of the "Indigenous Innovation" policy.

IV. CONCLUSION

Given the seven years that have passed since the implementation of “Indigenous Innovation,” this thesis has provided a preliminary assessment of the effectiveness and impact of these policies to promote innovation. This thesis asserts two of the three possible effects of “Indigenous Innovation” on China’s economic performance are more likely. The three possible outcomes are first, *Indigenous Innovation Flops,* which asserts that “Indigenous Innovation” is not an effective policy, does not bring the desired economic growth, and needlessly disrupts international trade, investments, and commerce by what has been deemed by some as “techno-national” policies. The second possibility, *Indigenous Innovation becomes China’s new economic engine*, posits that “Indigenous Innovation” is successful in bringing sustainable economic growth replacing the old economy dominated by foreign direct investment and low-tech manufacturing. The third possibility, *Indigenous Innovation is Irrelevant for Chinese Growth*, suggests that “Indigenous Innovation” policies had a negligible impact on China’s continued economic development and level of innovation. The changes that have allowed for continued growth of China were already happening and would have continued to happen without this policy.

China’s “Indigenous Innovation” policy has made some minor contributions to raising the levels of innovation and economic growth in China but will likely fall short of the lofty goals of the 2006–2020 MLP. “Indigenous Innovation” is not yet the new economic engine China hoped it would be, but it is a broad strategic approach that will have long lasting effects in the future. Innovation is driving growth in China, however as shown by the details of patent filing statistics, this innovation is mostly market-driven incremental innovation and not the invention or new product innovation that China is seeking. China is likely to reach its innovation benchmarks but not until 10 years after its initial target dates. If China can adjust its policy to focus more on the university-private enterprise R&D nexus and ease societal/cultural pressures to be risk averse and failure avoidant, then it could possibly achieve its goals for innovation. It will only be a matter of time before China has its own “Google” or “Apple” like global-tech-giants with regular breakthrough innovations contributing to endogenous growth. The remainder of this chapter focuses on the effect of “Indigenous Innovation” on U.S.-China relations and then follows with the final summary of the thesis.

A. EFFECT ON U.S.–CHINA RELATIONS

Many financial experts argue whether China’s pursuit of economic growth through its innovation strategies will inevitably lead to a souring of relations with the United States. Some scholars argue that competiveness in economics and innovation is zero-sum and there can only be one winner.[136] Labor unions and their backers often use the overinflated statistics of the “high-tech” trade to stoke the fires of techno-nationalism.[137]

China has infused massive amounts of cash into R&D, trained record numbers of engineers, and offered many incentives to companies and individuals who invent and patent. Despite all of the PRC’s plans and efforts, innovation, at the level that it seeks, in goals set forth in “Indigenous Innovation” will remain beyond its grasp for the near future.

1. Evaluation of Dialogue Prior to 2006

Even prior to the establishment of “Indigenous Innovation” China was growing at astounding rates and professionals in the fields of international relations, economics and or political economics were discussing the implications of China’s rise (see Figure 13). The majority of the theories discussed regarding a rising China fell along the lines of Realist IR theory and Liberalism IR theory. Prior to 2006 China had already gained acceptance to the WTO its trade numbers were increasing as was its rate of growth.

Liberal theorists argued that globalization was good and that the more connections and international organizations China was participating in the better. In a

[136] Gideon Rachman, "Think again: American decline," *The Domestic Sources of American Foreign Policy: Insights and Evidence*, (2012), 47.

[137] Robert E. Scott, “The China Toll: Growing U.S. trade deficit with China cost more than 2.7 million jobs between 2001 and 2011, with job losses in every state,” *EPI Briefing Paper* 345, (AUG 23, 2012), 2.

2005 article by Youngjin Zhang of the British Foreign Policy Institute, China is characterized as occupying a difficult position in terms of global governance. Where on one hand it is unknown how willing China is to taking on the responsibility of global economic governance, on the other hand China, in its unique roles as a non-democratic state, the largest emerging market and a rising economic power, is a challenge for international institutions to handle.

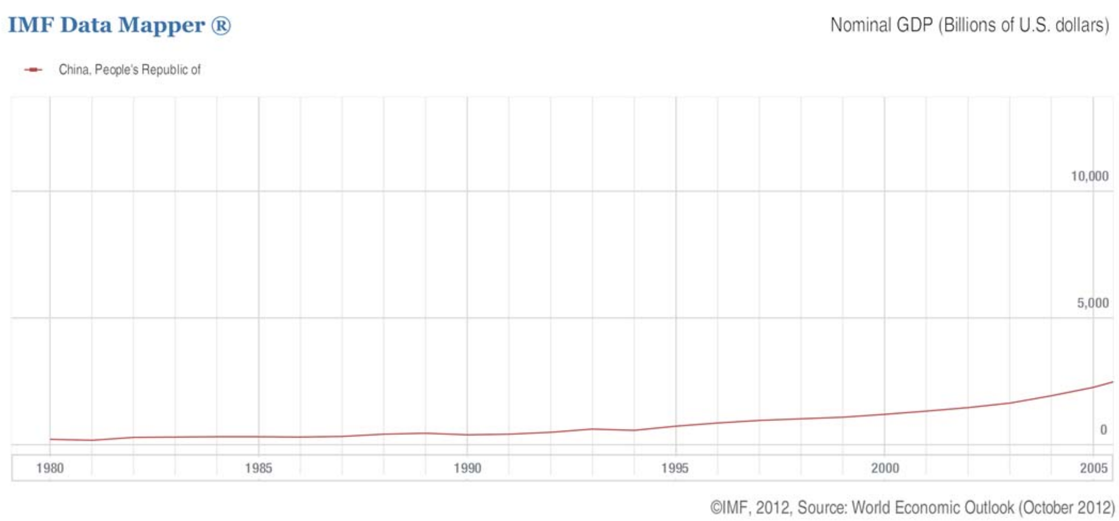

Figure 13. China 1980 – 2005 Nominal GPD Growth

Source: IMF Data Mapper; World Economic Outlook 2012.[138]

On the other side of the spectrum Realists see China's rise as a direct challenge to U.S. power either in economic terms or hard power military capacity terms. In the USCC 2005 report to Congress, the commission found that overall the U.S.-China relation was trending negatively and without course correction was heading to conflict. The USCC further asserted that the United States must challenge China directly on issues where the two disagreed.

138 IMF Data Mapper; World Economic Outlook 2012, (2012), Accessed March 23, 2013, http://www.imf.org/external/datamapper/.

The USCC outlined the major economic concerns extant at the time that continue to echo to the present. Manufacturers were under increasing competitive pressures from China exacerbated by an undervalued Renminbi (RMB), Chinese government subsidies supporting export production, repressive labor practices, and weak intellectual property rights enforcement. In addition to the competitive concerns of manufacturing was the growing U.S.–China trade deficit, which in 2005 reached $201.6 billion.[139]

2. Evaluation of Clashes Regarding "Indigenous Innovation" Policies

Following the announcement of "Indigenous Innovation" the usual voices crying out regarding Sino-U.S. relationship inequality, voiced their concerns that China was moving to techno-nationalism and mercantilism and was breaking its promises made through the WTO. Among the loudest of these voices is the U.S. Chamber of Commerce that stated: "the plan is considered by many international technology companies to be a blueprint for technology theft on a scale the world has never seen before." Citing plans for tweaking and adaption of Western technologies as well as to block Western products from government procurement catalogs and the mandate for foreign firms to turnover technology in order to gain market access. The U.S.-China Economic and Security Review Commission in their yearly report as well as in published hearings regularly denounced "Indigenous Innovation" due to its discriminatory nature.

These more protectionist policies under the "Indigenous Innovation" label were protested by the U.S. China Business Council, the U.S. Trade Representative, the President of the United States, U.S. Commerce Secretary, U.S. Ambassador to China, and representatives from the State and Treasury Departments. Within the first few years following its implementation, every time a bilateral meeting took place "Indigenous Innovation" and its discriminatory policies were highlighted.

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[139] Vikas Bajaj, "U.S. Trade Deficit Hit Record High in 2005," *New York Times*, February 10, (2006), Accessed February 13, 2013. http://www.nytimes.com/2006/02/10/business/worldbusiness/10iht-usecon.html?_r=0.

3. Examination of Changes to Policy or Law Related to or Affected by "Indigenous Innovation" Policies

Even though there was great concern by international corporations and government leaders following the roll-out of "Indigenous Innovation," the actual practices of the plan were not nearly as calamitous or damaging as many originally thought, nor have its outcomes been particularly threatening, as is assessed in this thesis. Following several years of complaints from both Chinese firms, MNCs and Western government leaders, China caved on some of the more rigorous parts of "Indigenous Innovation." The U.S. Trade Representative reported in 2011 that China's state council had announced a new measure requiring provincial and local governments to stop using Government Purchase Catalogs or any other measures tying "Indigenous Innovation" to any government procurement preferences.[140]

Much of the initial angst over "Indigenous Innovation" has waned over time. Tensions surrounding "Indigenous Innovation" have eased substantially following China's promises to drop the requirements to hand-over intellectual property in exchange for market access, as well as the roll-back of requirements for indigenous content as a pre-condition for placement of products in Government Purchase Catalogs. There probably would not have been so much attention given and protests made over the policy if it were not for the economic slump among Western nations in the years after its implementation.

4. Examination of Current Dialogue at Bilateral Meetings

Current bilateral exchanges at the Strategic and Economic Dialogue (S&ED) no longer focus directly on "Indigenous Innovation" but some of its related issues. At the 2012 S&ED both sides discussed best practices for innovation policies, possibly to avoid the pitfalls of past policies. Also on the table for discussion were: improving methods for measuring innovation, sub-national innovation policies, support to international R&D,

[140] USTR. *2011 U.S.-China Joint Commission on Commerce and Trade* Outcomes (November 2011), Accessed March 20, 2013. http://www.ustr.gov/about-us/press-office/fact-sheets/2011/november/2011-us-china-joint-commission-commerce-and-trade-ou.

enforcement of IPR laws and regulations. [141] Other recent bilateral exchanges related to economics have focused on the protection of intellectual property which continues to plague China.

China has struggled to change a “copy and tweak” culture developed over years of copying technology. This problem has sucked much of the life out of China’s “Indigenous Innovation” plans to invest heavily in R&D. Chinese firms have been slow to spend money on expensive R&D efforts when it is cheaper to buy technologies. These companies fear that they will be wasting time and money developing technology that will not be protected by IPR. This has held China back from developing a stronger innovative capacity. This is one reason China lags in its goal to increase investments in R&D to 2.5% of GDP by 2020. For this same reason international corporations are wary of conducting joint ventures in China. China dominates the world in several specialized technologies that were obtained unscrupulously through joint ventures. Two examples of this are high speed rail from Japanese companies and wind turbines from General Electric. China recognizes the issues with IPR but it is something that will take time to fix. It will be a significant shift from the way business has been conducted for many years.

B. SUMMARY

An assessment of the global economic shifts over the last 10 years shows unprecedented growth in China quickly catching up and surpassing all but the United States in annual GDP. China has accumulated an unprecedented $3.2 trillion of foreign exchange reserves. In addition to holding the greatest amount of U.S. foreign debt, China’s trade surplus with the United States jumped from $83.05 billion in 2001 to $276.5 billion in 2011.[142] According to Goldman Sachs China will earn nearly double U.S. GDP by 2050 (see Figure 14). This large deficit and trade imbalance cannot be

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[141] U.S. Department of the Treasury, *Joint U.S.-China Economic Track Fact Sheet- Fourth Meeting of the U.S. China Strategic and Economic Dialogue* (May 4, 2012), Accessed March 11, 2013, http://www.treasury.gov/press-center/press-releases/Pages/tg1567.aspx.

[142] Robert D. Atkinson, “Enough is Enough: Confronting Chinese Innovation Mercantilism,” The Information Technology & Innovation Foundation, (February 2012), 5.

attributed to China's innovation policies nor does it necessarily indicate that China seeks to dominate the United States through "absolute advantage."[143] Many of the "worries" of U.S. citizens regarding China's "Indigenous Innovation" are based on distortions and misperceptions. Many critics exaggerate the potential impacts of "Indigenous Innovation" most likely due to the current economic climate.[144]

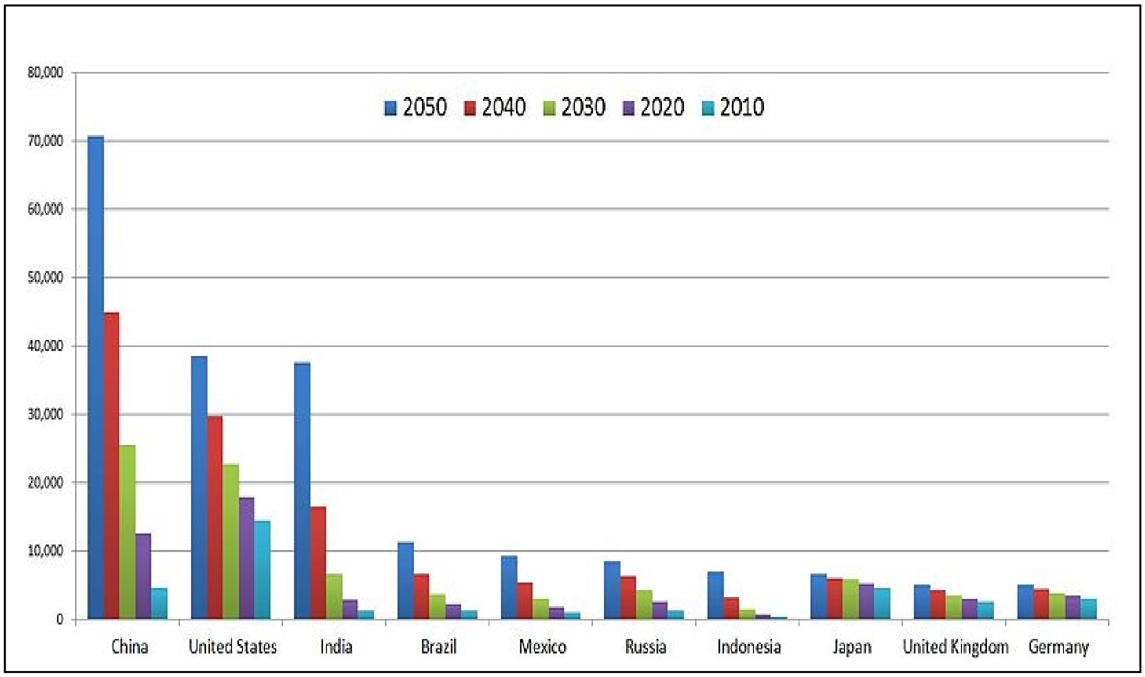

Figure 14. The Ten Largest Economies in the World in 2050, Measured in GDP (billions of $ - 2006).

Source: Goldman Sachs. *BRICs and Beyond.* Goldman Sachs Global Economics Group, 2007.[145]

The Chinese Communist Party, in order to maintain legitimacy and power over its 1.3 billion citizens, is forced to maintain a delicate balance regarding economic growth and international relations. Accusations and counteraccusations regarding economic policy have dominated headlines over the last several years. Both China and the United

143 Ibid.

144 Scott Kennedy, "Indigenous innovation: Not as scary as it sounds," *China Economic Quarterly*, (September 2010).

145 Goldman Sachs, *BRICs and Beyond*, Goldman Sachs Global Economics Group, (2007).

States despite increasing interdependence continue to experience volatility in managing international relations particularly with regards to economic practices. When dealing with these hotly contested issues it is important not to label China or the Chinese government as an entity with monolithic intentions or motives whether they be malign or benevolent. It is vital to recognize that both comprise many individuals and entities each with their own motives and agendas.[146] Constructive dialogue through international organizations and bilateral exchanges have proven their efficacy with the changes to "Indigenous Innovation" policies. Despite differences between the two nations, increased tensions have not translated to military conflict and U.S. China relations and interdependence have never been stronger.[147]

The ways which innovation contributes to economic growth and the distribution of profit has changed significantly with globalization. The diffusion of the global production chain and the increasing levels of interdependency blur the traditional divisions of the value-added chain.[148] These changes have led to distorted perceptions of comparative advantage in innovation when using traditional metrics such as export numbers of so-called high-technology products. These distorted perceptions in turn can lead to inflamed rhetoric and potential conflict.

China has experienced continued growth in innovation since the start of its push for "Indigenous Innovation" but this has not happened in the way that its leaders may have envisioned. The concepts of innovation for China laid out in the bifurcated approach of top-down and bottom-up approaches have laid the groundwork for continued innovation for future years but much of the innovation over the last seven years has come from efforts prior to "Indigenous Innovation." It will take significant reforms to Chinese society to loosen the censorship, and break-out of the conformist culture that holds China back from becoming an innovation superpower.[149]

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146 Edward S. Steinfeld, *Playing our Game: Why China's Economic Rise Doesn't Threaten the West* (Oxford; New York: Oxford University Press, 2010), 168.

147 Fred C. Bergsten, Charles Freeman, Nicholas R. Lardy, and Derek J. Mitchell, *China's Rise: Challenges and Opportunities* (Washington, DC: Peterson Institute, 2008), 30.

148 Edward S. Steinfeld, *Playing our Game*, 154–164.

149 Gary Shapiro, "Can China Eclipse the U.S. on Innovation?" *Forbes*, (July 11, 2012).

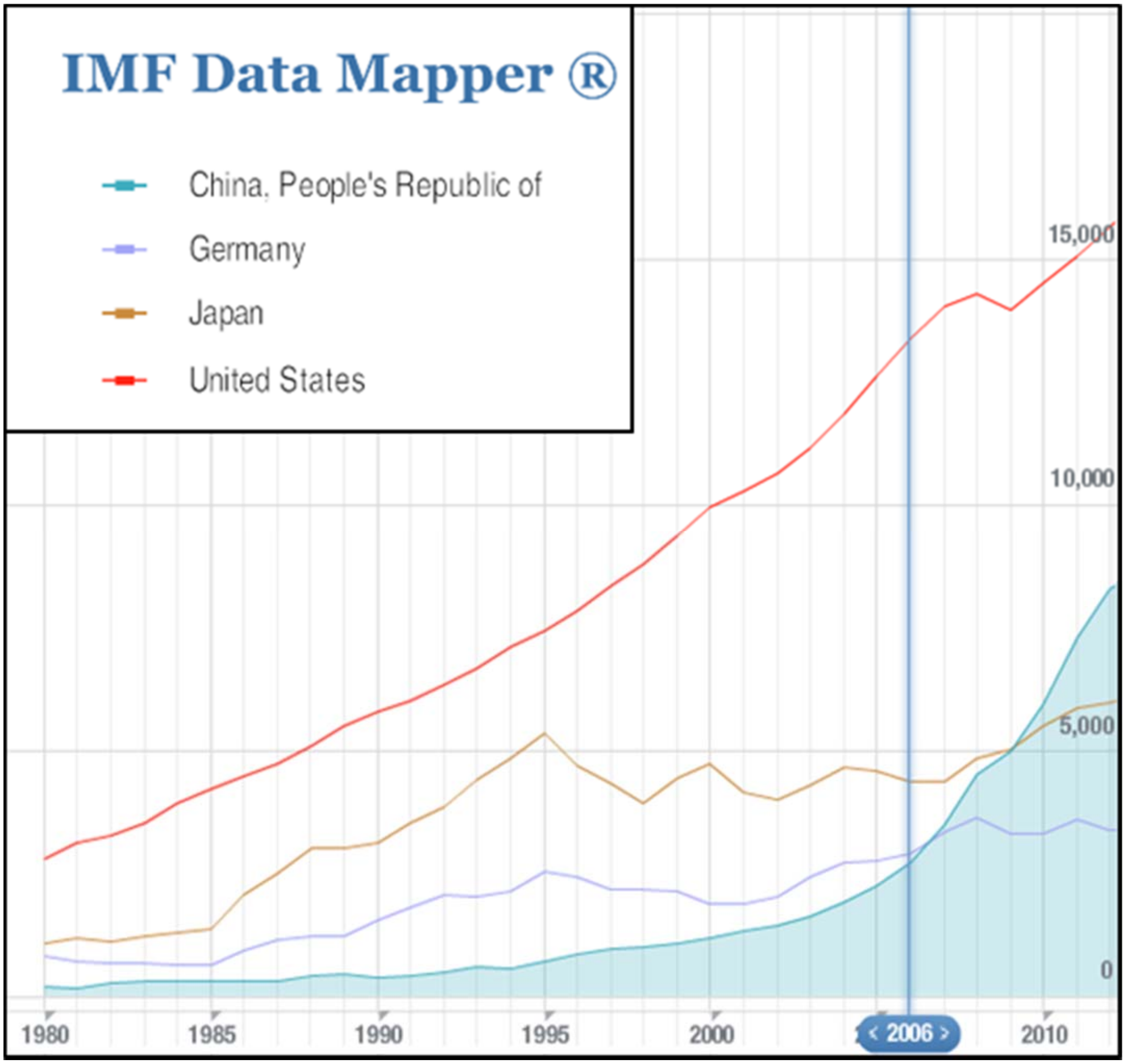

Figure 15. Pre and Post "Indigenous Innovation" Nominal GDP in Billions of Dollars

Source: IMF Data Mapper; World Economic Outlook (2012).[150]

Despite the best-laid plans and considerable spending, China's "Indigenous Innovation" plan has yet to produce significant novel products or ideas. Innovation is taking place in China but this does not equate to invention. China has not developed an equivalent idea or process to match or surpass the iPod or Silicon Valley. Instead, innovation in China has been along the lines of second-generation innovation or

150 IMF Data Mapper; World Economic Outlook 2012, (2012), Accessed March 23, 2013, http://www.imf.org/external/datamapper/.

improvements upon existing ideas and processes. This innovation has led to some growth and will continue to boost the already massive manufacturing industry in China. Innovation continues to remain essential to economic growth; however it must be evaluated within the context of the globalized market economy and approached through cooperative strategies.[151]

China, despite its efforts, will not be the leading nation for science and technology innovation in the next 20 years. China will continue to see significant growth fueled through innovation efforts aimed at improving on existing technologies and ideas. This growth will continue to present a challenge to the existing globally dominating economy of the United States.

Although The MLP containing China's "Indigenous Innovation" plan still has eight more years until its end in 2020, therefore this thesis, is a mid-point assessment. A complete assessment of the effectiveness of "Indigenous Innovation" will have to be done after 2020 and again after 2050 to assess the benchmarks set forth for these years. As shown by the evidence presented "Indigenous Innovation" is not on track to *become China's new economic engine* by 2020 and in many respects *Indigenous Innovation has been Irrelevant for Chinese Growth* over the last seven years.

The actions taken under the umbrella of "Indigenous Innovation" will eventually bring China forward as a high tech leader but it is unlikely that it will perform on par with the United States any time in the next 20 years. Many other factors in economic competition raise fears of China soon dominating world economics but most of these are over-exaggerated and not related to "Indigenous Innovation."

[151] U.S.-China Economic and Security Review Commission, "*Assessing China's Efforts to Become an "Innovation Society" – A Progress Report,*" Hearing Before The U.S.-China Economic and Security Review Commission, One Hundred Twelfth Congress, Second Session sess., (MAY 10, 2012), 34–35.

China’s Indigenous Innovation policy, despite its shortcomings, has indeed contributed to economic growth and will continue to contribute to significant economic growth in the future. If China adjusts its policy to focus on the university-private enterprise R&D nexus it will achieve the level of innovation it seeks at a more rapid rate and will eventually see more breakthrough innovation contributing to endogenous growth.

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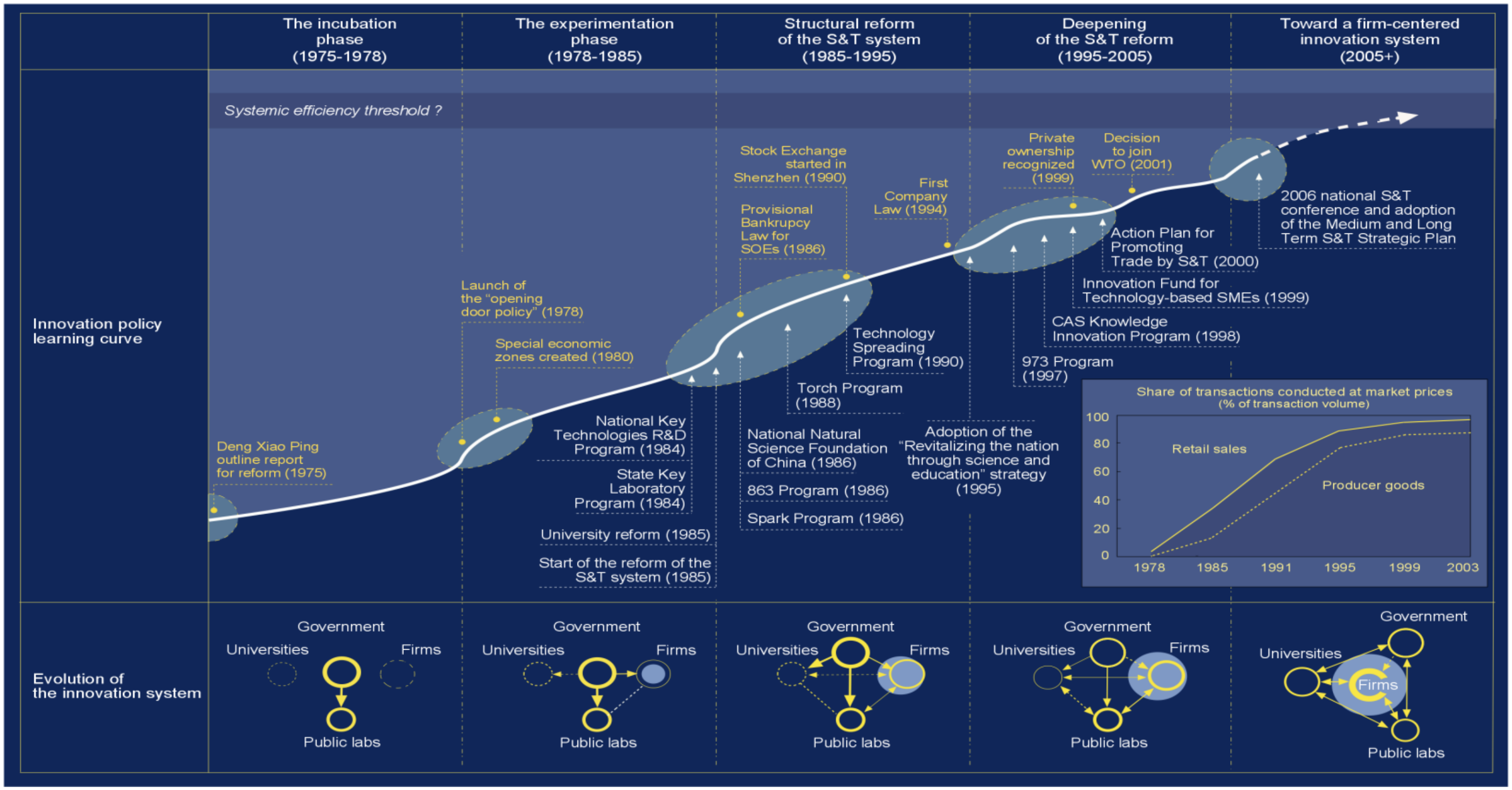
APPENDIX

A. STAGES OF NIS REFORM



Source: OECD, 2008.[152]

152 Liu Li, "The Evolution of China's Science and Technology Policy, 1975–2007," in *OECD Reviews of Innovation Policy: China*, 2008.

B. DESCRIPTION OF 16 MEGAPROJECTS

(Source: McGregor, China's Drive for 'Indigenous Innovation).[153]

1. Core electronic components, high-end general use chips and basic software products

- This project focuses on the development of microwave and millimeter-wave devices, high-end general chips, and basic software products, including operating systems, database management systems and middleware.
- It also emphasizes securing more patents and increasing indigenous innovation for computers and computer systems and basic software products with networking and national security applications.

2. Large-scale integrated circuit manufacturing equipment and techniques

- China will focus on achieving the mass application of 90nm manufacturing equipment and attempt to localize a number of key technologies and components. It also plans to develop a wide array of equipment for manufacturing 65nm circuits, while making breakthroughs in R&D of key technologies for 45nm and below.
- A key aim is to develop many core technologies for the manufacture of very large scale integrated (VLSI) circuits, and building an innovation system for China's integrated circuit (IC) manufacturing industry.

3. New generation broadband wireless mobile communication networks

- China hopes to develop a new generation of broadband wireless mobile communication networks with large-scale communication capacities, as well as low cost and wide coverage broadband wireless communication access systems. Short-distance wireless communication systems and sensor networks also fall under the scope of this project.
- China seeks to increase the number of Chinese patents in international technology standards and widen the application for these technologies while achieving an industry output of more than RMB 100 billion.

153 James McGregor, "China's Drive for 'Indigenous Innovation:' A Web of Industrial Policies," U.S. Chamber of Commerce, (2010), 16. http://www.uschamber.com/reports/chinas-drive-indigenous-innovation-web-industrial-policies.

4. Advanced numeric-controlled machinery and basic manufacturing technology

- This project calls for the study of two-to-three types of large high-precision computerized numerically controlled machine tools, and the development of key high-precision CNC (computer numerically controlled) machine tools and other basic equipment required by the aerospace, space shipbuilding, automotive and energy production equipment sectors.
- China also seeks to make advancements in the R&D of CNC machine tools, and build research centers and training facilities to promote the development of medium and high-grade CNC machine tools.

5. Large-scale oil and gas exploration

- This project emphasizes the study of high-precision seismic exploration and exploitation technologies for oil, gas and coal-bed gas in western China.
- Also of critical importance are technologies suited for exploration and exploitation of deep sea oil and gas resources, as well as resources with access complicated by difficult geological conditions.
- China hopes to improve design and manufacturing capabilities for a broad range of related technology with the aim of raising oil and natural gas discovery rates by 10 to 20 percent, respectively, and achieving an oil recovery ratio of 40 to 50 percent.

6. Large advanced nuclear reactors

- With this project China's goal is to combine imported technology and indigenous innovation to achieve advancements in a third generation of pressurized-water nuclear reactor power plants.
- China also wants to complete standard designs and develop key technologies to build the first series of pilot high-temperature gas-cooled nuclear reactor power plants. This includes 200 MW high-temperature gas-cooled nuclear reactor power plant construction pilot projects.

7. Water pollution control and treatment

- China will select various types of river basins for zoning based on the ecological function of the water source, and study key technologies to control and prevent water pollution, and treat lake contaminants for the remediation of water resources.

- China also aims to makes advancements in technologies to protect, process and distribute drinking water, and create a system to monitor water pollution and water quality improvement.

8. Breeding new varieties of genetically modified organisms

- The main goals of this special project are to obtain indigenous intellectual property rights for a series of valuable new genetically modified organisms (GMOs), and to breed new classifications of disease resistant, high-yield, high-quality GMOs to improve research and scientific capabilities in support of agricultural industrialization and sustainable development.
- The implementation of the gene modification special project has significant strategic importance for increasing indigenous innovation in China's agricultural science and technology capabilities, improving agricultural efficiency and crop yield, and in increasing China's global agricultural competitiveness.

9. Pharmaceutical innovation and development

- China is placing a significant emphasis on domestic drug innovation. The goals of the project include advancing technologies for the identification, verification and manufacture of 30 to 40 new chemical and bio pharmaceuticals.
- China seeks to increase capabilities to test the efficacy and safety of new drugs.
- China also aims to develop new Traditional Chinese medicines with verified quality and reliability.

10. Control and treatment of AIDS, hepatitis, and other major diseases

- The aim of this project is to achieve breakthroughs in the R&D of key technologies for new vaccines and pharmaceuticals. In doing so, China hopes to independently develop 40 types of unique diagnostic reagents, and 15 vaccines.
- China also will attempt to design standards for Chinese and Western medicine- based prevention and cure plans.

11. Large aircraft

- China will institute feasibility studies for developing the key technologies required for the domestic production of large aircraft.
- Key focuses will include the design, R&D and manufacture of power systems and testing systems for large aircraft.

12. High-definition earth observation system

- China hopes to develop an all-weather and full-time earth observation system with advanced high-definition observation systems at satellite, aircraft and stratospheric levels.
- An additional focus of this project is to establish an Earth observation data center and to improve the quality of space-related data produced in China.

13. Manned spaceflight and lunar probe programs

- China seeks to make advancements in key technologies required for extra- vehicular activities for astronauts, and for the Rendezvous and Docking (RVD) for spacecraft.
- A central focus of this project will be to establish a man-operated, orbiting space laboratory.
- Laying the foundation for a lunar probe program is also a focus of this project. The plan includes developing satellites for moon exploration, the creation of an orbital- moon exploration program, as well as general advancements in technologies for lunar exploration.

14–16. Undisclosed, believed to be classified military projects

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