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The Global Technology Revolution China

EXECUTIVE SUMMARY

Emerging Technology Opportunities for the Tianjin Binhai New Area (TBNA) and the Tianjin Economic-Technological Development Area (TEDA)

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with

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Sponsored by the Tianjin Binhai New Area and the
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A RAND INFRASTRUCTURE, SAFETY, AND ENVIRONMENT PROGRAM

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Preface

In 2007, the Tianjin Binhai New Area (TBNA) and one of its administrative zones—the Tianjin Economic-Technological Development Area (TEDA)—in northeast China asked the RAND Corporation to perform a technology-foresight study to help them develop and implement a strategic vision and plan for economic growth through technological innovation. This book describes the results of that study. The principal objectives were (1) to identify the most-promising emerging technology applications (TAs) for TBNA and TEDA to pursue as part of their plan for growth, (2) to analyze the drivers and barriers they would face in each case, and (3) to recommend action plans for each TA. For a more detailed discussion of the material described in this book, including further documentation and references, the reader is strongly recommended to review the in-depth analyses from this study (see Silberglitt and Wong, 2009).

In performing this study, RAND staff met with representatives of the communities of TBNA and TEDA stakeholders, both in China and in the United States. We also collected data both on site and by reviewing relevant international literature. Our methods, as well as additional data and analyses, were built on the foundation of the 2006 RAND report, *The Global Technology Revolution 2020*, Executive Summary: *Bio/Nano/Materials/Information Trends, Drivers, Barriers, and Social Implications* (GTR 2020 Executive Summary) and *The Global Technology Revolution 2020*, In-Depth Analyses: *Bio/Nano/Materials/Information Trends, Drivers, Barriers, and Social Implications* (GTR 2020 In-Depth Analyses) (together, GTR 2020).

This book should be of interest to executives, managers, planners, businesspersons, scientists, engineers, and residents of TBNA, TEDA, and other communities in China and the developing world more broadly. It should also be of interest to the international development community, as well as academic, government, and private-sector organizations and individuals interested in emerging-technology development, application, and implementation.

The RAND Transportation, Space, and Technology Program

This research was conducted under the auspices of the Transportation, Space, and Technology (TST) Program within RAND Infrastructure, Safety and Environment (ISE). The mission of RAND Infrastructure, Safety, and Environment is to improve the development, operation, use, and protection of society's essential physical assets and natural resources and to enhance the related social assets of safety and security of individuals in transit and in their workplaces and communities. The TST research portfolio encompasses policy areas including transporta-

tion systems, space exploration, information and telecommunication technologies, nano- and biotechnologies, and other aspects of science and technology policy.

Questions or comments about this report should be sent to the project leader, Richard Silberglitt (Richard_Silberglitt@rand.org). Information about the TST Program is available online (http://www.rand.org/ise/tech). Inquiries about TST research should be sent to the following address:

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Summary

This book summarizes the results of a study performed for the Tianjin Binhai New area (TBNA) and the Tianjin Economic-Technological Development Area (TEDA) within the municipality of Tianjin in northeast China. In 2006, China's State Council gave TBNA a mandate to become the country's next regional engine for economic growth, as well as a center for leading-edge research and development (R&D) and technology innovation and modern manufacturing. TEDA, established in 1984, is TBNA's industrial and manufacturing base.

To support their strategic planning for economic development through technological innovation, TBNA and TEDA managers asked RAND to conduct a foresight study to identify promising technology applications (TAs), identify capacity needs to implement these TAs, develop a strategy and action plan for each TA, and provide guidance concerning the inclusion of these TAs into their overarching strategic plan.

This book describes the selected TAs, the process used to select them, and each TA's capacity needs, drivers, barriers, and suggested implementation strategy. It also discusses their inclusion into an overarching strategic plan. The detailed action plans for each TA are described in the full report of the study (Silberglitt and Wong, 2009).

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The authors greatly appreciate the hospitality provided by the many members of the TBNA and TEDA communities who met with us during our visits to China, as well as their willingness to share with us their thoughts, experiences, and data and other information that were essential for our analyses. We are also extremely grateful to the TBNA and TEDA senior managers who met with us both in China and the United States; Mu Dan Ping, who provided us with an important perspective on the history and issues currently facing TBNA and TEDA; Qian Gu, Jianhui Hu, Xiaoyan Li, Xiao Wang, Xin Wang, Mengjie Wu, Shinyi Wu, and Henu Zhao for their invaluable assistance with Chinese translations; Yong Kang for his help in arranging an important set of meetings at Tsinghua University; Matthew Southerland for essential research into the English and Chinese literature; and our colleagues Susan Everingham, Julie Kim, Debra Knopman, and Martin Wachs for their sage advice and guidance. We also thank Lisa Spear for her expert administrative support in the development of this book.

We owe a special debt of gratitude to our peer reviewers, Steven Berner, William Blanpied, and Carl Dahlman, whose insightful analyses and suggestions provided the impetus for significant revisions and improvements to this book.

Abbreviations

CAS	Chinese Academy of Sciences
CATARC	China Automotive Technology and Research Center
CNANE	China National Academy of Nanotechnology and Engineering
EPA	U.S. Environmental Protection Agency
EU	European Union
GDP	gross domestic product
GMP	good manufacturing practice
IC	internal combustion
IPR	intellectual property rights
ISE	RAND Infrastructure, Safety and Environment
km	kilometer
NIBC	Nanotechnology Industrial Base Company
NVCC	Nanotechnology Venture Capital Company
PV	photovoltaic
R&D	research and development
RFID	radio-frequency identification
S&E	science and engineering
S&T	science and technology
sq km	square kilometer
TA	technology application
TBC	Tianjin Biochip Corporation
TBNA	Tianjin Binhai New Area
TEDA	Tianjin Economic-Technological Development Area

TST	Transportation, Space, and Technology
TU	Tianjin University

CHAPTER ONE

Introduction

Running along 150 kilometers (km) of coastline in the sprawling municipality of Tianjin in northeast China,[1] Tianjin Binhai New Area (TBNA) has taken on a pivotal role in China's national economic strategy. Tianjin municipal authorities first established this locality of approximately 2,200 square km (sq km) in 1994. At that time an arid, undeveloped area, TBNA was given the ambitious task of spurring industrial growth in Tianjin. In little more than a decade, it has become home to 1.4 million people, northern China's largest container port, and a broad base of industry and manufacturing.

In 2006, China's State Council named this industrial center in the municipality of Tianjin as a "special pilot zone" with a mandate to become the country's next regional engine for economic growth. In this capacity, it is to serve as a model of regional development and economic reform for other parts of China. Now reporting directly to the State Council, TBNA benefits from a host of favorable national-government policies and tax incentives designed to attract foreign and domestic investment and stimulate trade. It is expected to emerge as China's next economic powerhouse, invigorating the economy of the northeastern Bohai Rim region in the same manner as Shanghai and Suzhou did in the Yangtze River delta area and Guangzhou and Shenzhen in the Pearl River delta area before it.

The Tianjin Economic-Technological Development Area (TEDA) is one of three administrative zones in TBNA. It is also TBNA's industrial and manufacturing base and the center of TBNA's financial and commercial activities. TEDA is to play a key part in the economic growth envisioned for TBNA. Established in 1984, TEDA is today a bustling industrial-park complex. It possesses a robust manufacturing base, with pillar industries in electronics, automobiles and parts, food processing, and biopharmaceuticals. Many of the world's Fortune 500 companies, top Chinese firms, and other leading multinationals have strong presences in TEDA.

A Vision of the Future for TBNA and TEDA

In its directive, the State Council specified that TBNA focus its development efforts in three domains, eventually becoming a center in north China for the following three spheres:

- leading-edge research and development (R&D) and technology incubation

[1] A *municipality* in China is not a city in the Western sense of the term but rather an expansive administrative unit that extends from a populous urban core to cover a very large surrounding region. There are only four such municipalities in China, each of which holds the status of province and reports directly to the Chinese central government.

- first-class, modern manufacturing
- international shipping and logistics.

At the same time, along with economic development, the State Council intends for TBNA to lead efforts to address many of China's most urgent national problems. Steadily rising energy demands, a growing scarcity of usable water supplies, and gravely escalating urban pollution are among China's greatest concerns. With these needs in mind, TBNA, as a *pilot zone*, is to present an alternative to the traditional industrial economy, shaping a model of sustainable development and ecofriendly industry that will contribute to tackling all of these challenges.

Innovation in science and technology (S&T) stands at the core of this vision of economic and environmental development, particularly of cutting-edge R&D. TBNA will need to take definitive steps to pursue this goal, and TEDA will be at the forefront of this effort. Building on its existing manufacturing base, TEDA aims to transition from a successful industrial-park complex into a state-of-the-art science and engineering (S&E) center for high-impact emerging technologies. Other enterprises with relevant capacity located elsewhere in TBNA will follow suit. The desired end result is innovative R&D that meets international standards and positions TBNA as a global technology leader.

Achieving the Vision for TBNA and TEDA Through Foresight Analysis

Early in the process of developing a strategic plan for this ambitious transformation, senior managers from TBNA and TEDA found a 2006 report by the RAND Corporation, *The Global Technology Revolution 2020*, Executive Summary: *Bio/Nano/Materials/Information Trends, Drivers, Barriers, and Social Implications* (GTR 2020 Executive Summary) and *The Global Technology Revolution 2020*, In-Depth Analyses: *Bio/Nano/Materials/Information Trends, Drivers, Barriers, and Social Implications* (GTR 2020 In-Depth Analyses) (together, GTR 2020). This pair of reports is a comprehensive foresight analysis that identifies *technology applications* (TAs) most plausible by 2020, those countries capable of acquiring them, and their likely effects on society. The study focused on the applications made possible by emerging technology trends rather than on the technologies themselves because technologies on their own rarely deliver solutions to real-world problems. Instead, solutions derive from the ways in which technologies are put to beneficial use. Accordingly, GTR 2020 highlights TAs, such as cheap solar energy, instead of technologies, such as photovoltaic (PV) materials.

Having reviewed GTR 2020, TBNA and TEDA managers approached RAND to conduct a foresight study designed specifically for their purposes. They commissioned RAND to do the following:

- Identify promising emerging TAs for TEDA and other high-tech centers in TBNA to implement as a pivotal part of TBNA's overall strategic plan for economic growth.
- Identify the capacity needs to implement these TAs, as well as the critical drivers and barriers that might facilitate or hinder implementation.
- Develop a strategy and action plan for each TA.[2]

[2] In this summary, we describe the strategy for each TA. The detailed action plans can be found in the chapters on the individual TAs in Part Two of the companion report (Silberglitt and Wong, 2009).

- Provide guidance on how these TAs might fit into an overarching strategic plan for TBNA's economic development.

An Overview of the Most-Promising Technology Applications for TBNA and How We Selected Them

Seven innovative TAs emerged from our analysis as particularly promising for TBNA to pursue as it endeavors to fulfill the State Council's mandate:

- *cheap solar energy:* solar-energy systems inexpensive enough to be widely available to developing and undeveloped countries, as well as disadvantaged populations[3]
- *advanced mobile communications and radio-frequency identification (RFID)*[4]*:* multifunctional platforms for sensing, processing, storing, and communicating multiple types of data
- *rapid bioassays:* tests to quickly detect the presence or absence of specific biological substances with multiple simultaneous tests possible
- *membranes, fabrics, and catalysts for water purification:* novel materials to desalinate, disinfect, decontaminate, and help ensure the quality of water with high reliability
- *molecular-scale drug design, development, and delivery:* the abilities to design, develop, and deliver drug therapies at the nanoscale to attack specific tumors or pathogens without harming healthy tissues and cells and to enhance diagnostics
- *electric and hybrid vehicles:* automobiles available to the mass market with power systems that combine internal combustion (IC) and other power sources
- *green manufacturing:* the development and use of manufacturing processes that minimize waste and environmental pollution and optimize the use and reuse of resources.

To arrive at this selection, we began with the 12 TAs identified in GTR 2020 as those that China could acquire by 2020. We then combined this with a rigorous study of realities, circumstances, and issues in TBNA and in China more broadly, drawing on a diverse array of Chinese- and English-language sources:

- Chinese- and English-language documents describing the mission, history, and current status of TBNA and TEDA
- Chinese- and English-language literature on China's social, environmental, and economic needs and measures that the Chinese government has taken to date to address them
- on-site interviews that we conducted in TBNA, TEDA, Tianjin Port, the municipality of Tianjin more broadly, and the city of Beijing
- visits to S&T institutions that could provide capacity outside TBNA and TEDA, such as Tsinghua University and the Chinese Academy of Sciences (CAS)
- a two-day workshop that we held in TEDA with key figures from TEDA scientific institutions, firms, and management.

[3] This and the following definitions are based on those used in GTR 2020.

[4] RFID involves technologies that can store and wirelessly transmit information over short distances.

On the basis of that analysis, we narrowed down the top 12 TAs for China to the final selection of seven. These either come directly from GTR 2020 or are hybrids combining one or more of the top 12.

The Foundation for TBNA's Future Development in Science and Technology

The analysis on which we based our selection of TAs and, eventually, the strategies and action plans that we suggested for them, took into account four principal factors:

- TBNA and TEDA's missions, as mandated by China's State Council
- China's pressing national needs
- drivers and barriers to technological innovation in China as a whole and for TBNA more specifically
- relevant capacity currently available to TBNA and TEDA both locally and more broadly in R&D, manufacturing, and S&T commercialization.

TBNA and TEDA's Mission as a Special Pilot Zone for Economic and Environmental Development

In a relatively short time, TBNA and TEDA have successfully established a strong manufacturing base. With its three-pronged mandate for TBNA, the State Council is now calling for TBNA and TEDA to build on this base to develop a modern, high-tech manufacturing capacity that emphasizes R&D to produce goods that add value and create better-paying jobs. This type of manufacturing is knowledge-based; consequently, S&T will be a crucial part of this transformation. The capacity for S&T commercialization will also be vital so that the products that TBNA and TEDA design in their R&D efforts are highly marketable and can be manufactured using innovative production processes.

The part of the State Council's mandate that directs TBNA to become a center for international shipping and logistics is closely integrated with R&D and manufacturing objectives. Achieving this goal will require TBNA to operationalize cutting-edge supply-chain and logistics technologies emerging from current R&D.

A companion mandate for TBNA to experiment with reforms to the financial sector has helped identify preferred business areas for S&T development. In December 2007, TBNA signed an agreement with the China Development Bank to co-finance a RMB 2 billion (US$293 million) venture-capital fund to boost high-tech start-ups in TBNA.[5] This specifies favored areas for investment: electronics, bioengineering, new materials, new energy, environmental protection, and automated manufacturing.

The State Council's directive to TBNA to implement innovative environmental initiatives alongside economic development stems from the recognition that three decades of rapid economic growth have taken a grave toll on the environment in China. While economic development must continue, it must be sustainable. TBNA has already taken definitive first steps to meet the environmental directive with such initiatives as its circular economy and the Sino-

[5] As of November 5, 2008, the exchange rate was 0.146445 U.S. dollars per Yuan. RMB is Renminbi, the official Chinese currency, which is also frequently referred to as *Yuan*.

Singapore Tianjin Eco-City.[6] The first involves using and regenerating resources in sustained cycles that minimize industrial waste and pollution. The ecocity, with a planned population of 350,000, will be constructed and operate using advanced green technologies, guided by Singapore's experience with renewable energy, green manufacturing, low-pollution public transportation, and recycling of water and waste. These efforts are only the beginning of a push from TBNA to create a showcase of sustainable development and environmentally friendly manufacturing approaches. What TBNA successfully prototypes could eventually be put into use throughout China.

China's Pressing National Needs

Even as China's economy continues to grow and its rising middle class enjoys the higher standard of living that accompanies that growth, the country faces serious challenges:

- *Reduce rural poverty:* China's meteoric economic growth has dramatically decreased poverty in busy urban commercial areas. But poverty remains entrenched in much of rural China. The country needs TAs that can help create opportunities for rural dwellers, improve their standards of living, and reduce the pressure to migrate to urban centers for work.
- *Provide for a large and rapidly aging population:* Despite having curbed its population growth, China still has more than 1 billion residents, many of whom are elderly. At the same time, China is transitioning to a new social-welfare system that calls on working-age people to shoulder much of the cost of providing previously state-funded services. Consequently, TAs that help provide well-paying jobs are essential, as are medical innovations to help meet the special health requirements of senior citizens.
- *Meet the population's health and sanitation needs:* A population as large as China's presents daunting health-care needs. Noncommunicable diseases are now the primary concern, although certain communicable diseases remain a problem. The health-care burden is disproportionately high in rural areas. China needs TAs that can improve private and public health care and cost-effectively enhance the quality of water and sanitation, particularly in rural areas.
- *Meet growing energy demands:* China is one of the world's top energy consumers, and its needs are on a steady upward curve. Oil and gas for automobiles are in particularly high demand as ever-larger numbers of China's expanding middle class purchase cars. The country needs TAs that can tap alternative energy sources, reduce demand for oil, boost energy efficiency, and decrease industrial energy requirements.
- *Reverse water shortages:* Clean water is scarce in China overall. Shortages are especially severe in the north of the country, which suffers from very low rainfall and dwindling groundwater sources. Yet, residential and industrial demand shows no signs of abating, and supplies cannot keep pace. TAs that can provide access to clean water from a variety of sources are vital.
- *Reduce pollution:* China's economic boom has left it facing critical pollution levels. Acid rain, air pollution, urban sprawl, loss of arable land, and red tides are among the gravest problems. The country needs TAs that can help balance economic development with

[6] A *circular economy* uses energy, water, and raw materials in sustained cycles to minimize waste and pollution.

environmental protection by reducing toxins in automotive and industrial emissions, recycling resources, and increasing energy efficiency.
- *Sustain high economic growth:* China must continue to build and expand its economy to be able to solve national problems, create jobs, and enhance quality of life for its residents. The country is now at a crossroads at which knowledge-driven economic growth is critical to its future. At the core of this growth will be TAs that help China reduce its reliance on foreign technology sources, join the ranks of the world's leading S&T nations, and repair a national brand image damaged by a series of high-profile incidents indicating poor quality assurance.

Drivers and Barriers to Technological Innovation in China and TBNA

Widespread, sustainable implementation of any TA depends on the balance between the drivers that facilitate implementation and the barriers that hinder it. A single factor can be a driver or a barrier. Consider cost and financing: The availability of ample venture capital can make money a driver, but lack of funds can turn it into a barrier.

In our view, the factors that will most influence China's ability to successfully pursue cutting-edge R&D and technology innovation are as follows:

- the country's needs
- its national R&D policies
- other national policies that could generate demand (or, as appropriate, reduce demand) for certain TAs
- intellectual property rights (IPR) protection
- finance and banking laws and regulations
- local policies, laws, and regulations that could directly affect the ability of individuals and organizations to conduct cutting-edge R&D and commercialize innovative technologies
- human capital
- culture of R&D and innovation.

These same eight factors will most affect TBNA's ability to develop and implement the selected TAs. Some of these are clearly either a driver or a barrier throughout most of China. But occasionally, local circumstances make them stronger or weaker drivers or barriers in a particular organization or region (or for a specific TA) than they are elsewhere in the country.

Several of these factors are unmistakable barriers in TBNA and hold for all seven TAs. IPR protection, for example, remains a barrier in TBNA, as in China as a whole, to both homegrown innovation and the involvement of foreign capital and talent in new R&D and technology ventures. Finance and banking laws and regulations are also a barrier in TBNA, as they are in China generally, because they discourage investment of venture capital. But, for certain of the seven TAs, sources of venture capital available to TBNA for specific technologies mitigate this barrier to some degree. Lack of a culture of R&D and innovation is a third barrier in TBNA, as it is in China as a whole. It discourages the risk-taking in new ventures that is essential to pursuing and commercializing groundbreaking R&D.

TBNA has one driver that all seven TAs share: human capital. This stems from the strength of TBNA's current manufacturing base, the corresponding workforce, and the concentration of academic institutions in the municipality of Tianjin. However, young Chinese

people are tending to shy away from technical and vocational training, and domestic competition for S&E talent is heated. Both of these could be mitigating factors.

Capacity Currently Available to TBNA and TEDA

To fulfill the State Council's mandate, TBNA and TEDA will need capacity in three areas: (1) R&D, (2) manufacturing, and (3) S&T commercialization. Both local capacity—in TBNA, TEDA, and the municipality of Tianjin more broadly—and that from elsewhere in China and internationally will play a part.

In terms of R&D capacity, TBNA and TEDA have a growing number of institutions that provide cutting-edge research facilities and a professional cadre of highly trained scientists and engineers. But they face intense competition, both within China and abroad, for human capital of this caliber.

With regard to manufacturing capacity, TBNA and TEDA have a substantial industrial base that has been growing for the nearly 25 years since TEDA's inception. Investment by an array of Fortune 500 companies, a track record of increasing industrial output, and a rising gross domestic product (GDP) indicate the strength of this base. TBNA is also steadily improving the physical infrastructure—utilities, cargo facilities, and waste-management processes—that are vital to manufacturing capacity. But a potential shortage of the skilled laborers and technicians needed to work in manufacturing and, again, heightened competition for those on the job market are real challenges.

As for S&T commercialization, TBNA and TEDA operate a well-established network of research parks and technology incubators aimed at supporting emerging high-tech enterprises. Ample financial incentives help spur development and attract human capital. Yet, these enterprises face considerable challenges due to China's need to better protect IPR and reform finance and banking laws and policies. They also lack strong linkages between R&D institutions and commercial industry to facilitate the transfer of high-tech products to market.

CHAPTER TWO

A Close Look at the Seven Most-Promising Technology Applications

The seven TAs that appear to be most potentially fruitful for TBNA build on two highly influential emerging global trends in technology and industry. The first is micro- and nanoscale technology. The vast majority of the TAs identified in GTR 2020 involve advances in micro- or nanoscale technology and the integration of bio-, nano-, information, and materials technology. Similarly, six of the TAs recommended for TBNA involve technologies in this domain. Second, both industry and consumers today are moving clearly in the direction of green processes and technologies. Four of the TAs recommended for TBNA are focused on using energy, water, and other resources much more efficiently than has occurred in the past.

Cheap Solar Energy

Cheap solar energy has strong potential worldwide market demand. Driven by government incentives and renewable-energy subsidies—especially in Germany and Japan—the solar-electricity industry has grown at an average annual rate of 44 percent over the past five years. In 2007, it grew by 55 percent to nearly $13 billion. To sustain such growth, companies are now competing to make solar-energy systems less expensive and more efficient.

China needs to promote energy growth but, concurrently, to develop renewable-energy sources, improve air quality, and reduce pollution. Pursuing cheap solar energy is consistent with these needs because it would replace energy currently being generated mostly by coal-fired power plants.

There are three generations of solar-electric technologies. The first generation, based primarily on polycrystalline silicon, currently accounts for more than 90 percent of global sales. The emerging second- and third-generation systems are based on thin-film materials and novel nanoscale technologies. They have the potential to transform the industry, offering lower costs and potentially greater efficiency. The growth of the global market demand depends on them.

Available Capacity

The Tianjin area offers substantial capacity for TBNA to implement cheap solar-energy applications. The thin-film silicon research group at Nankai University, working in collaboration with the Beijing Solar Energy Institute, is one notable example. Another is the China National Academy of Nanotechnology and Engineering (CNANE) in TEDA. CNANE has the technical and instrumentation capacity on the nanoscale level required to conduct R&D on third-generation solar materials.

Drivers and Barriers

China's need to ensure energy growth while reducing harm to the environment and improving air quality is a driver for this TA. China's national R&D policies, including support for solar-energy demonstrations, and other national policies are also drivers.

Local policies and laws—in particular, building codes and regulations governing electric-utility connections to buildings—have often been barriers where solar-electricity systems have been implemented. This is because *balance-of-system* equipment, such as batteries and electrical inverters, as well as other safety and metering equipment that building inspectors and the local electric utility might require have presented a considerable ongoing expense. TBNA has the opportunity to mitigate these problems and perhaps even turn local policy and law into a driver by reviewing building codes and utility-interconnection regulations to ensure that the balance-of-system requirements for solar electricity provide needed safety without increasing costs.

Finance and banking laws and regulations do constitute a barrier as well. But this is to a somewhat lesser degree with cheap solar energy than with other TAs because TEDA's nanotechnology venture fund and the green venture-capital fund of Tsinghua University, Tsing Capital, are potential sources of investment funds for TBNA to pursue this TA.

Recommended Strategy

China already has a well-developed first-generation solar-electricity industry. Consequently, we believe that the best opportunity for TBNA and TEDA lies not in entering the first-generation market but rather in becoming an R&D and manufacturing center for second- and third-generation systems. The initial focus should be the global export market and, in the longer term, the domestic Chinese market, as it develops.

Advanced Mobile Communications and Radio-Frequency Identification

Mobile communication devices increasingly do much more than exchange voice data. They also serve as platforms that can sense, process, store, and communicate data in multiple forms. At the same time, RFID devices have become increasingly inexpensive and sophisticated. Already in widespread use in supply chains and a variety of commercial transactions, they are now poised for integration into mobile communication devices.

The demand for multifunctional wireless communications in both rural and urban markets is growing rapidly worldwide. This is particularly true in the Asia-Pacific region and China. In addition, with its mandate to become an international shipping and logistics center with the Tianjin Port as its hub, TBNA has a pressing need for advanced mobile-communication and RFID technologies that promise to streamline cargo logistics, reduce the cost of port operations, and increase shipping security.

Advanced mobile-communication and RFID systems are composed of many individual component technologies—for example, displays, memory, batteries and power storage, and sensors and antennas. Each of these constitutes an industry itself and will determine the future direction of wireless computing platforms. As global demand for this TA grows, the market for these component technologies will strengthen in kind.

Available Capacity

TEDA produced more than 105 million cell-phone handsets in 2006—approximately 10 percent of the mobile phones sold worldwide. Its extensive manufacturing base in this area includes Samsung's largest facility for manufacturing mobile phones. TBNA also has available capacity in component technologies. Two groups at Tianjin University (TU) are doing leading-edge R&D on display technologies. In addition, a TEDA firm manufactures the smallest hydrogen canister in the world (just the size of a AA battery), which can provide the hydrogen storage for fuel cells and mobile-phone chargers.

Drivers and Barriers

China's need to spur economic development and increase productivity is a driver for this TA. Advanced mobile communications will help supply the country's growing mobile-phone market and, accordingly, boost consumption. RFID applications for supply chains and logistics have the potential to enhance manufacturing and shipping considerably. China's national R&D policies supporting integrated-circuit, software, and network development are another driver.

Other national policies—especially China's resolve to date to not adopt international standards for mobile communication—may constitute a barrier.

Recommended Strategy

TBNA should aim to become an R&D and manufacturing center for mobile communication devices and RFID systems. It should focus initially on the domestic Chinese market and then broaden to the global market. In addition, it should build state-of-the-art R&D programs in two component technologies: displays and power sources. It should not, however, attempt to shape R&D trends in integrated circuits.

Rapid Bioassays

Global markets for better means of testing personal and public health and monitoring the environment are emerging rapidly. China has a particular need for state-of-the-art technology to help meet public-health and environmental challenges. Novel biochips to detect and analyze genes and proteins are enabling very fast tests for diseases and pathogens. The specificity and sophistication of these advanced bioassays has increased to the extent that some lab-on-a-chip systems can even perform as small-scale laboratories using miniaturized devices. These types of bioassays could identify or eliminate threats to public health, significantly improve patient outcomes, and accurately detect pathogens in the environment and the food supply.

Available Capacity

TEDA is home to one of China's five national biochip R&D centers, the Tianjin Biochip Corporation (TBC). This institute produces its own biochips, as well as reagents and other disposables used in bioassays. It also provides diagnostic bioassays to detect *Escherichia coli*, *Shigella*, and *Salmonella*. It has partnered with a global leader in the field, the U.S. company Affymetrix.

Drivers and Barriers

This TA has several drivers. One is China's need to improve public health, reduce environmental damage, and, especially, to improve the quality of the water supply. Another is China's national R&D policy, in which health, medicine, and biotechnology are focus areas. Other national policies (particularly those designed to regulate food and drugs more effectively) are a third.

Recommended Strategy

The long-term strategy is for TBNA to become a leading player in the global marketplace for state-of-the-art rapid bioassays. But its initial focus should be on using licensing and partnership agreements to attract leading companies to TBNA and TEDA. During this period, TBNA should build capabilities as a reseller of bioassay disposables and equipment. Eventually, companies in TBNA should start manufacturing these products themselves. The Chinese domestic market should be the first target, followed by the global market.

Membranes, Filters, and Catalysts for Water Purification

Ensuring affordable access to clean water is a major global challenge. This challenge is acute in China, one of the world's top five growth markets for water and wastewater technologies. It is especially weighty in the Bohai Rim region and TBNA, where usable water supplies are exceedingly scarce.

Technologies for purifying water are an important emerging area of S&T. Four applications are being developed:

- *desalination:* removing salt from sea water
- *disinfection:* removing microorganisms
- *decontamination:* removing toxic compounds
- *quality assurance:* detecting potentially harmful matter.

Novel nanomaterials can enhance current purification systems and may make them much more cost-effective. Examples include nanocomposite and biomimetic membranes,[1] filters made of fibrous media, filters with nanoscale porosity, nanoscale catalysts, and DNA-nanoparticle composites. The principal challenge will be to scale up materials from labs to commercial applications.

Available Capacity

TBNA is the home of Tianjin Motian Membrane Engineering and Technology Company. Motian has a 20-year track record of manufacturing water-filtration membranes for industrial, personal, water-utility, and medical uses, including desalination. CNANE has the capacity to conduct research on nanoscale filters and catalysts. TU's School of Chemical Engineering and Technology has a strong R&D program in desalination, including a desalination demonstration project, and is designing, fabricating, and testing nanoscale filters. TEDA's nanotechnology transfer and commercialization organizations, the Nanotechnology Industrial Base

[1] Those that mimic mechanisms found in nature.

Company (NIBC) and the Nanotechnology Venture Capital Company (NVCC), have named nanoscale water-purification filters as key targets for commercialization.

Drivers and Barriers

China's need to improve public and individual health and meet the demand for clean water is a driver for this TA. China's national R&D policies, which have earmarked R&D funding for water purification, and other national policies aimed at providing clean water for China's residents are two others.

Chinese government subsidies have kept the price of water lower than what it would cost to provide it by desalination or purification. These subsidies fall into the category of other national policies, making this a barrier as well as a driver.

Recommended Strategy

We suggest two long-term goals for TBNA: (1) to become a center for R&D in nanoscale membranes, filters, and catalysts and (2) to become a leader in manufacturing state-of-the-art membranes for purifying water. It is vital for TBNA to foster close relationships between research labs and private companies to facilitate commercialization.

Molecular-Scale Drug Design, Development, and Delivery

The demand for new, more-effective medical treatments, with lower needed doses and fewer adverse side effects, is growing both in China and globally. Molecular-scale drug therapies and diagnostics are based on recent developments at the intersection of nanotechnology and biotechnology. This young, very promising field of nanomedicine could serve this market. Four innovative applications are of particular interest:

- targeted carriers for drug delivery and imaging
- controlled-release platforms and materials
- novel methods of drug administration
- means of increasing solubility.

Available Capacity

In terms of R&D capacity, TEDA's nanotechnology center, CNANE, runs a pharmaceutical R&D program. TU and Nankai University have world-class research groups working together on an exciting new platform for drug delivery: carbon nanohorns. TEDA is also home to Tianjin SinoBiotech, a company developing biotechnology and gene therapies at the preclinical stage. There is a strong industrial base for pharmaceuticals in the municipality of Tianjin that includes several of the world's top pharmaceutical companies. Biopharma and bionanomaterials for drug delivery have been named as thrust areas for technology transfer and commercialization in TBNA.

Drivers and Barriers

One driver for this TA is China's need to improve public and individual health. China's national R&D policies are also a driver. They have thrusts in demonstration projects for commercially

producing vaccines and gene-modified medicines, improving modern traditional Chinese medicine, and enhancing capabilities for inventing and producing new drugs.

Other national policies are a barrier—specifically, regulations that make development more expensive and impede clinical testing and marketing of new drugs.

Recommended Strategy

TBNA should aim to become a center for R&D and manufacturing of drugs developed through bionanotechnology. It should focus initially on attracting investment from foreign enterprises and, in tandem, aggressively building homegrown R&D capacity. Eventually, it should direct R&D activities toward commercializing novel medical treatments and techniques.

Electric and Hybrid Vehicles

Current trends in the global marketplace, including concerns about the price of oil and global warming, suggest that vehicles using electric and hybrid technologies will assume an increasing market share. At the same time, China faces a severe problem with urban pollution. Among its national priorities are reducing automobile pollution and lowering demand for oil.

Hybrid vehicles are already a leading worldwide automotive market. The emergence of plug-in hybrids, which allow the batteries that power the electric motor to be recharged independently of the motor itself, has blurred the distinction between hybrid and electric vehicles. With this in mind, we created this combined TA. It encompasses four types of automobiles:

- purely electric vehicles
- traditional hybrids, in which an internal combustion engine recharges the batteries
- plug-in hybrids
- serial hybrids, in which an on-board power source charges the batteries.

Many of the components needed for this class of vehicle also have a growing market demand and strong potential for development. These include batteries, power electronics and electrical machines, power trains, internal combustion engines, and emission controls. Advances in battery technology, for example, are extending the range and improving the performance of electric and hybrid vehicles.

Available Capacity

To our knowledge, hybrid vehicles are not currently being manufactured in TBNA. But TBNA does have extensive capacity to conduct R&D on electric vehicles as well as to manufacture them. The Tianjin Qingyuan Electric Vehicle Company in TEDA builds electric cars, buses, and vans and has sold them globally.

TBNA also has capacity in electric-vehicle components. Qingyuan has an ongoing research collaboration with the U.S. Argonne National Laboratory in power-train technology and other component areas. One of the stakeholder companies in Qingyuan, EV Battery, is conducting battery research. CNANE, TEDA's nanotechnology center, has an active research program on nanoscale capacitors for electric vehicles. And in terms of S&T commercialization, the China Automotive Technology and Research Center (CATARC) conducts standards

and certification testing, which will be essential in developing a market for electric and hybrid vehicles. CATARC is headquartered in the municipality of Tianjin.

Drivers and Barriers

China's need to raise energy efficiency and reduce environmental damage is one driver for this TA. China's national policies that promote both the manufacture and purchase of fuel-efficient vehicles are another.

But other national laws and policies are barriers. Examples include tariffs on vehicles or auto parts coming into China, hybrid-component patents held by foreign firms, controls that keep fuel prices low in China, and restrictions on electric vehicles in large Chinese cities.

Recommended Strategy

Given the strong market potential of electric- and hybrid-vehicle components, we recommend that TBNA develop and expand collaborative R&D on subsystems and component technologies. At the same time, it should develop the capacity to manufacture hybrid vehicles and components for hybrid and electric vehicles. It should target the growing global market first and the Chinese market later.

Green Manufacturing

Both multinational corporations and consumers worldwide are increasingly embracing green manufacturing. In many developed economies, for example, governments have established national green-chemistry awards for industry. China is no exception: Green manufacturing plants are appearing in the country, and clean-technology venture capital has started to flow in. Mandates, such as the State Council's directive to TBNA to establish a circular economy, are other signs of this trend.

Four approaches are commonly employed in green manufacturing:

- *green chemistry:* environmentally benign chemical processes and products
- *green engineering:* feasible processes and products that minimize pollution and risks to health and the environment
- *inherently safe process design:* smaller quantities of hazardous material, less hazardous material, and alternative reaction routes or process conditions
- *good manufacturing practices (GMPs):* methods, facilities, and controls to make high-quality reproducible products that meet appropriate regulations and standards.

Available Capacity

Several companies located in TBNA already have programs in green chemistry and experience with green manufacturing. Several firms that have won the U.S. Environmental Protection Agency (EPA) Presidential Green Chemistry Challenge Awards, such as PPG Industries and Novozymes, operate facilities in TEDA. Otis Elevator has built the world's first green elevator-manufacturing plant in TEDA.

Drivers and Barriers

China's need to boost energy efficiency and reduce pollution and other environmental impacts is one driver for green manufacturing. Another is national policy designed to conserve resources and reduce pollution. In some cases, these policies explicitly support green manufacturing.

Cost can be a barrier, especially when an existing plant needs to be renovated or replaced to become green. But the competitive advantage that green manufacturing provides can, in many cases, mitigate this barrier.

Recommended Strategy

TEDA should become a center for green manufacturing in China. The initial focus should be on attracting to TBNA those companies at the leading edge of green chemistry and engineering. Over time, TBNA itself should start conducting R&D on new green manufacturing processes and, eventually, implement them in TBNA and TEDA. When designing green manufacturing initiatives, TBNA should emphasize new plants and focus on processes that offer cost savings.

CHAPTER THREE

Building for TBNA's Future: Integrating the Seven Action Plans into an Overarching Strategic Plan

We believe that the seven TAs should form a pivotal part of TBNA's strategic plan for transitioning into a state-of-the-art S&E center. All of the TAs are in line with promising global trends; are well suited to current capacities in TBNA, TEDA, and the municipality of Tianjin and build on existing pillar industries; and support Chinese government priorities.

Part of the overarching strategic plan should be geared toward addressing broad general challenges that currently stand as barriers to all seven TAs. One of these is protecting IPR. The plan should include measures to help TBNA and TEDA enforce existing laws in this domain. A second is getting people at different stages of technology development working together. Here, we recommend that TBNA and TEDA incorporate into the plan ample opportunities for cross-fertilization between research facilities and industry. Finally, it is vital that TBNA build a culture of R&D and innovation. The plan should contain elements that promote flexibility and risk-taking in TBNA and TEDA's funded ventures.

Beyond this, TBNA could use a three-pronged framework to integrate the specific action plans for the seven TAs into an umbrella strategic plan:

- Develop state-of-the-art R&D capacity in relevant areas.
- Update and expand the existing manufacturing base.
- Build capacity for S&T commercialization.

These three activities would need to be carried out in parallel. Each requires using and expanding existing local capacity and introducing new capacity. Novel advances should stem from and extend the existing capacity base while fresh R&D programs are started and new companies with state-of-the-art capabilities come in to bring overall capacity up to world-class standards. Each will also support the others.

Develop State-of-the-Art R&D Capacity in Relevant Areas

The strategic plan should lay out an agenda for each TA for (1) making optimal use of current local R&D capabilities, (2) expanding the outreach of existing R&D programs, and (3) beginning entirely new ones. Efforts in all three of these areas would need to go on in tandem. Existing local R&D programs include those of TEDA's nanotechnology center (CNANE) and of Tianjin and Nankai universities. TBNA could provide resources to expand these programs in areas that underpin the seven TAs—for example, bionanotechnology, nanofiltration, and microfluidics. A good model for expanding the outreach of existing research programs

is the collaboration between the Qingyuan Electric Vehicle Company and the U.S. Argonne National Laboratory. This is an excellent example of a public-private partnership, as well as a cross-cultural one.

A first step in building entirely new R&D programs could be to cement relationships with leading global companies developing second- and third-generation solar collectors, nanoscale filters and membranes, and nanoscale-formulated drugs. These companies could partner with appropriate research institutions in TBNA, TEDA, or the municipality of Tianjin more broadly. Building new programs could also involve attracting companies that already have cutting-edge R&D capabilities to establish a presence in TBNA.

Update and Expand the Existing Manufacturing Base

TBNA's strategic plan should include measures to ensure that manufacturing companies currently operating in TBNA and TEDA are using processes that take advantage of the most recent advances in both design and technology. For example, TBNA could provide a package of subsidies and awards to firms that apply green manufacturing principles. It should also establish the infrastructure that would make it easier for them to do so. At the same time, it should make provisions in the plan to institutionalize the training that TBNA's manufacturing workers need for these advanced processes.

Bringing in new companies with state-of-the-art manufacturing capabilities should be a vital part of this effort as well. TBNA could approach and provide a portfolio of incentives to global companies manufacturing second- and third-generation solar collectors, system components for advanced mobile communications, or lab-on-a-chip bioassays to establish plants in TBNA or TEDA.

Build Capacity for S&T Commercialization

The strategic plan should include initiatives aimed at ensuring that TBNA and TEDA's manufacturing plants and processes meet global standards. It might make mandatory, for instance, such certifications as the International Standards Organization standard 14001, a globally recognized environmental-management standard.

The plan should also lay out steps to position TBNA to serve the global marketplace. It should make a standard practice of using the local Tianjin market as a testing ground for products that could eventually be marketed elsewhere in China and worldwide. Provisions should be included to ensure that products tested and approved in TBNA are on par with accepted practices and standards in target global markets. Electric and hybrid vehicles, for example, would have to meet the most-restrictive U.S. and European Union (EU) standards for emissions and mileage performance. Bioassays to monitor food and water developed in TBNA would need to satisfy U.S. and EU standards for demonstrated levels of pathogen detection.

Selected Bibliography

For a more detailed discussion of the material described in this book, including further documentation and references, the reader is strongly encouraged to review our in-depth analyses in the following companion report:

Silberglitt, Richard, and Anny Wong, with S. R. Bohandy, Brian G. Chow, Noreen Clancy, Scott Hassell, David R. Howell, Gregory S. Jones, Eric Landree, and Parry Norling, *The Global Technology Revolution China, In-Depth Analyses: Emerging Technology Opportunities for the Tianjin Binhai New Area (TBNA) and the Tianjin Economic-Technological Development Area (TEDA)*, Santa Monica, Calif.: RAND Corporation, TR-649-TBNA/TEDA, 2009. As of publication date:
http://www.rand.org/pubs/technical_reports/TR649/
Also available electronically as CD-ROM supplement to this book.

China and Tianjin

American Association of Port Authorities, "World Port Ranking: 2006," c. 2007. As of May 21, 2008:
http://aapa.files.cms-plus.com/Statistics/worldportrankings%5F2006.xls

Angel, Robert, "Putting an Innovation Culture into Practice," *Ivey Business Journal*, January–February 2006. As of October 29, 2008:
http://www.iveybusinessjournal.com/view_article.asp?intArticle_ID=605

"China, Singapore Build Eco-City in Tianjin," Xinhua, May 8, 2008.

Fallows, James, "China Makes, the World Takes," *Atlantic*, July–August 2007, pp. 48–72. As of October 28, 2008:
http://www.theatlantic.com/doc/200707/shenzhen

International Energy Agency, and Organisation for Economic Co-Operation and Development, *World Energy Outlook 2007: China and India Insights*, Paris, 2007. As of October 29, 2008:
http://www.iea.org/Textbase/npsum/WEO2007SUM.pdf

Jang, Soonhee, patent counsel and regional intellectual-property counsel, Asia, Eli Lilly and Company, "Overview of Chinese Patent Law," presented at The Dragon and the Elephant: Understanding the Development of Innovation Capacity in China and India, National Academies, Washington, D.C., September 24–25, 2007. As of October 30, 2008:
http://www7.nationalacademies.org/step/Innovation_china_india_sep.07_soonhee_jang.pdf

Linton, Katherine, *China's R&D Policy for the 21st Century: Government Direction of Innovation*, U.S. International Trade Commission, February 2008. As of October 29, 2008:
http://papers.ssrn.com/sol3/papers.cfm?abstract_id=1126651

Malik, Khalid, "Bridging Development Gaps in Today's China," United Nations Development Programme China, Beijing, September 23, 2006. As of October 29, 2008:
http://www.undp.org.cn/modules.php?op=modload&name=News&file=article&catid=13&topic=16&sid=302&mode=thread&order=0&thold=0

McElwee, Charlie, "China Adopts Circular Economy Law," *China Environmental Law*, August 30, 2008. As of October 29, 2008:
http://www.chinaenvironmentallaw.com/2008/08/30/china-adopts-circular-economy-law/

McKinsey Global Institute, *Addressing China's Looming Talent Shortage*, October 2005. As of October 30, 2008:
http://www.mckinsey.com/mgi/publications/chinatalent.asp

"Northeast China Faces Water Shortage as Severe Drought Lingers," Xinhua, March 9, 2008.

Organisation for Economic Co-Operation and Development Directorate for Science, Technology and Industry, "OECD Reviews of Innovation Policy," last updated October 17, 2008. As of October 29, 2008:
http://www.oecd.org/sti/innovation/reviews

Serger, Sylvia Schwaag, and Magnus Breidne, "China's Fifteen-Year Plan for Science and Technology: An Assessment," *Asia Policy*, Vol. 4, July 2007, pp. 135–164. As of October 29, 2008:
http://www.nbr.org/publications/asia_policy/AP4/AP4%20Serger_Breidne%20RN.pdf

US-China Business Council, "Tianjin at a Glance," April 2006. As of September 15, 2008:
http://www.uschina.org/info/chops/2006/tianjin.html

TBNA and TEDA

Binhai New Area, "Development of the Tianjin New Coastal District (Binhai New Area)," June 10, 2008. As of October 30, 2008:
http://www.bh.gov.cn/eng/system/2008/06/10/010016455.shtml

Central People's Government of the People's Republic of China, 国家发展改革委负责人就〈国务院关于推进天津滨海新区开发开放有关问题的意见〉有关问题答中国政府网记者问〉["The Head of the National Committee of Development and Reform Responds to Questions Regarding 'Suggestions from the State Council of the People's Republic of China on the Related Issues of Promoting the Developing and Opening of the Tianjin Binhai New Area' from a Gov.cn Reporter"], July 25, 2006. As of August 21, 2008:
http://www.gov.cn/zwhd/2006-07/25/content_344924.htm

"LED City: TEDA Becomes First in China," *China CSR: Energy and Cleantech*, March 4, 2008. As of October 30, 2008:
http://www.chinacsr.com/en/2008/03/04/2141-led-city-teda-becomes-first-in-china/

People's Republic of China Ministry of Commerce, "天津经济技术开发区投资环境连续十年排第一>["Tianjin Economic-Technological Development Area Ranks First in Investment Environment for 10 Consecutive Years"], December 5, 2007. As of October 28, 2008:
http://chinawto.mofcom.gov.cn/aarticle/j/al/200712/20071205266059.html?2900825302=4194397658#

Sino-Singapore Tianjin Eco-City Administrative Committee, "About Eco-City," undated Web page. As of October 28, 2008:
http://www.eco-city.gov.cn/eco/shouye/zoujinshengtaicheng/shengtaichengjianjie/en/en.html

State Council, "Suggestion of the State Council of the People's Republic of China on the Related Issues of Promoting the Development and Opening-Up of the Tianjin Binhai New Area," May 26, 2006. As of October 28, 2008:
http://en.investteda.org/download/Suggestion.doc

TEDA Investment Promotion Center, *2003 Annual Report on the Economic and Social Development of Tianjin Economic-Technological Development Area*, c. 2004. As of September 19, 2008:
http://en.investteda.org/FactsFigures/#Annual%20Report

———, *2005 Annual Report on the Economic and Social Development of Tianjin Economic-Technological Development Area*, c. 2006. As of September 19, 2008:
http://en.investteda.org/FactsFigures/#Annual%20Report

———, *2007 Annual Report on the Economic and Social Development of Tianjin Economic-Technological Development Area*, c. 2008. As of September 19, 2008:
http://en.investteda.org/FactsFigures/#Annual%20Report

Tianjin Economic-Technological Development Area, "Investment Procedures: TEDA Investment Services Organizations," undated (a) Web page. As of October 30, 2008:
http://www.teda.gov.cn/cms/cms/website/english/invest/tiso.htm

———, "Why TEDA: Science and Technology," undated (b) Web page. As of October 29, 2008:
http://en.investteda.org/whyteda/science/carriers/t20050126_0671.htm

———, 《泰达年鉴2006年》 ["TEDA Annual Report 2006"], c. 2007. As of October 30, 2008:
http://www.teda.gov.cn/cms/cms/website/tedahome/zl/tdz/tdnj/2006.htm

———, 《泰达年鉴2007年》 ["TEDA Annual Report 2007"], c. 2008. As of October 30, 2008:
http://www.teda.gov.cn:80/cms/cms/website/tedahome/zl/tdz/tdnj/tdnj07/index.htm

Tianjin Port Development Holdings Limited, *One Stop, Non Stop: Annual Report 2007*, Hong Kong, c. 2008. As of October 28, 2008:
http://www.tianjinportdev.com/en/pdf/finreport2007a.pdf

TianJin Port Free Trade Zone and AirPort Industrial Park of Binhai New Area, undated (a) home page. As of October 30, 2008:
http://www2.tjftz.gov.cn/english/
in Chinese:
http://www2.tjftz.gov.cn/qygk/qyjs/

———, "Tianjin Binhai New Area," undated (b) Web page. As of October 30, 2008:
http://www2.tjftz.gov.cn/system/2006/10/05/010001294.shtml

"VC Fund to Back Binhai Economic Zone," Xinhua, December 25, 2007.

Technology Applications

Adis International, "'Easy' Diagnosis of Early Disease: Blood-Based Gene-Expression Tests for Breast Cancer and Alzheimer Disease," *Pharmaceutical and Diagnostic Innovation*, Vol. 3, No. 10, 2005, pp. 7–10.

Boberg, Jill, *Liquid Assets: How Demographic Changes and Water Management Policies Affect Freshwater Resources*, Santa Monica, Calif.: RAND Corporation, MG-358-CF, 2005. As of September 11, 2008:
http://www.rand.org/pubs/monographs/MG358/

Bullis, Kevin, "Making Electric Vehicles Practical," *Technology Review*, March 31, 2008a. As of November 18, 2008:
http://www.technologyreview.com/energy/20488/

Caruthers, Shelton D., Samuel A. Wickline, and Gregory M. Lanza, "Nanotechnological Applications in Medicine," *Current Opinion in Biotechnology*, Vol. 18, No. 1, February 2007, pp. 26–30.

Chan Kei-biu, chair and managing director of Surface Mount Technology (Holdings) Ltd., honorary chair of the Hong Kong Green Manufacturing Alliance, "A New Business Perspective: Turning Green Manufacturing into Your Competitive Advantage," presentation, January 19, 2005. As of April 30, 2008:
http://www.epd.gov.hk/epd/misc/env_management_sme/e_e/eng/doc/presentation/3_hkeia.pdf

Craighead, Harold, "Future Lab-on-a-Chip Technologies for Interrogating Individual Molecules," *Nature*, Vol. 442, July 27, 2006, pp. 387–393.

Eighth International Symposium on Green Chemistry in China 2007 Organization Committee, Institute of Green Chemistry and Fine Chemicals, "8th International Symposium on Green Chemistry in China," undated Web page. As of May 1, 2008:
http://www.bjut.edu.cn/college/hjnyxy/8isycc/home.html

European Union, Directive 2002/95/EC of the European Parliament and of the Council of 27 January 2003 on the restriction of the use of certain hazardous substances in electrical and electronic equipment, February 13, 2003a. As of November 17, 2008:
http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=CELEX:32002L0095:EN:HTML

———, Directive 2002/96/EC of the European Parliament and of the Council of 27 January 2003 on waste electrical and electronic equipment, February 13, 2003b. As of November 18, 2008:
http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=CELEX:32002L0096:EN:HTML

Faber, Paul, "RFID Strategy: RFID Developments in China," *Industry Week*, September 18, 2007. As of November 14, 2008:
http://www.industryweek.com/ReadArticle.aspx?ArticleID=14982

Fan, Xiaobin, Juan Tan, Guoliang Zhang, and Fengbao Zhang, "Isolation of Carbon Nanohorn Assemblies and Their Potential for Intracellular Delivery," *Nanotechnology*, Vol. 18, No. 19, May 16, 2007, pp. 1–6.

Frew, Sarah E., Stephen M. Sammut, Alysha F. Shore, Joshua K. Ramjist, Sara Al-Bader, Rahim Rezaie, Abdallah S. Daar, and Peter A. Singer, "Chinese Health Biotech and the Billion-Patient Market," *Nature Biotechnology*, Vol. 26, No. 1, January 2008, pp. 37–53.

Gallagher, Kelly Sims, *Roundtable on Barriers and Incentives for Hybrid Vehicles in China: A Roundtable Report*, Cambridge, Mass.: Energy Technology Innovation Project, Belfer Center for Science and International Affairs, Kennedy School of Government, Harvard University, September 6, 2006. As of November 18, 2008:
http://belfercenter.ksg.harvard.edu/files/report_hybrid_roundtable_final_9_6_06.pdf

Gu, Frank X., Rohit Karnik, Andrew Z. Wang, Frank Alexis, Etgar Levy-Nissenbaum, Seungpyo Hong, Robert S. Langer, and Omid C. Farokhzad, "Targeted Nanoparticles for Cancer Therapy," *Nano Today*, Vol. 2, No. 3, June 2007, pp. 14–21.

Harwanegg, Christian, and Reinhard Hiller, "Protein Microarrays for the Diagnosis of Allergic Diseases: State-of-the-Art and Future Development," *Clinical Chemistry and Laboratory Medicine*, Vol. 43, No. 12, 2005, pp. 1321–1326.

Hering, Garrett, "Land of Opportunity," *Photon International*, December 2007, pp. 66–72.

Hirsch, Leon R., Andre M. Gobin, Amanda R. Lowery, Felicia Tam, Rebekah A. Drezek, Naomi J. Halas, and Jennifer L. West, "Metal Nanoshells," *Annals of Biomedical Engineering*, Vol. 34, No. 1, January 2006, pp. 15–22.

Holliday, Charles O., Stephan Schmidheiny, and Philip Watts, *Walking the Talk: The Business Case for Sustainable Development*, Sheffield: Greenleaf, 2002.

"Hybrids from China and What They Could Mean," *Hybrid Cars*, October 15, 2007. As of November 18, 2008:
http://www.hybridcars.com/carmakers/chinese-hybrids.html

International Technology Roadmap for Semiconductors, "ITRS Sponsors," last updated October 10, 2008. As of May 28, 2008:
http://www.itrs.net/sponsors.html

Kaur, Satinderpal, Renuga Gopal, Wun Jern Ng, Seeram Ramakrishna, and Takeshi Matsuura, "Next-Generation Fibrous Media for Water Treatment," *MRS Bulletin*, Vol. 33, January 2008, pp. 21–26.

Lempert, Robert J., Parry Norling, Christopher G. Pernin, Susan A. Resetar, and Sergej Mahnovski, *Next Generation Environmental Technologies: Benefits and Barriers*, Santa Monica, Calif.: RAND Corporation, MR-1682-OSTP, 2003. As of November 18, 2008:
http://www.rand.org/pubs/monograph_reports/MR1682/

McDonald, Joe, "China to Launch Trial of 3G Phones," ABC News, March 28, 2008. As of May 27, 2008:
http://abcnews.go.com/Technology/wireStory?id=4541783

Meridian Institute, *Overview and Comparison of Conventional and Nano-Based Water Treatment Technologies, Global Dialogue on Nanotechnology and the Poor: Opportunities and Risks*, background paper for the International Workshop on Nanotechnology, Water, and Development, Chennai, India, October 10–12, 2006. As of September 11, 2008:
http://www.merid.org/nano/watertechpaper/

Millikin, Mike, "China's BYD Unveils Second Plug-In Hybrid Model at Geneva Motor Show; Plans to Begin Sales in Europe in 2–3 Years," *Green Car Congress*, March 5, 2008. As of May 29, 2008: http://www.greencarcongress.com/2008/03/chinas-byd-unve.html

Nystedt, Dan, "Samsung Develops RFID Chip for Cell Phones," *PC World*, November 27, 2007. As of May 26, 2008: http://www.pcworld.com/article/139972/samsung_develops_rfid_chip_for_cell_phones.html

Peer, Dan, Jeffrey M. Karp, Seungpyo Hong, Omid C. Farokhzad, Rimona Margalit, and Robert Langer, "Nanocarriers as an Emerging Platform for Cancer Therapy," *Nature Nanotechnology*, Vol. 2, December 2007, pp. 751–760.

Sandia National Laboratories, Environmental Resources Team, Water Treatment Engineering and Research Group, Desalination and Water Purification Research and Development Program, *Desalination and Water Purification Technology Roadmap: A Report of the Executive Committee, Discussion*, Denver, Colo.: Bureau of Reclamation, Denver Federal Center, Water Treatment Engineering and Research Group, report 95, January 2003. As of November 17, 2008: http://www.usbr.gov/pmts/water/publications/reportpdfs/report095.pdf

Saxl, Ottilia, "Taking a Leaf Out of Nature's Book: Harvesting Solar Light," *NanoNow*, Vol. 3, September 2007, pp. 27–29.

Shannon, Mark A., and Raphael Semiat, "Advancing Materials and Technologies for Water Purification," *MRS Bulletin*, Vol. 33, January 2008, pp. 9–15.

Slaoui, Abdelilah, and Reuben T. Collins, "Advanced Inorganic Materials for Photovoltaics," *MRS Bulletin*, Vol. 32, No. 3, March 2007, pp. 211–218. As of October 30, 2008: http://www.mrs.org/s_mrs/doc.asp?CID=9554&DID=200080

U.S. Environmental Protection Agency, "Green Chemistry: Award Winners," last updated August 26, 2008d. As of November 18, 2008: http://www.epa.gov/greenchemistry/pubs/pgcc/past.html

Vainrot, Nataly, Moris S. Eisen, and Raphael Semiat, "Membranes in Desalination and Water Treatment," *MRS Bulletin*, Vol. 33, January 2008, pp. 16–20.

Wagner, Volker, Anwyn Dullaart, Ann-Katrin Bock, and Axel Zweck, "The Emerging Nanomedicine Landscape," *Nature Biotechnology*, Vol. 24, No. 10, October 2006, pp. 1211–1217.

Whitesides, George M., "Overview: The Origins and the Future of Microfluidics," *Nature*, Vol. 442, July 27, 2006, pp. 368–373.

Zhao, Yuwen, Xinhua Geng, Wenjing Wang, Xudong Li, and Ying Xu, "R&D Activities of Silicon-Based Thin-Film Solar Cells in China," *Physica Status Solidi (a)*, Vol. 203, No. 4, March 2006, pp. 714–720.

Technology Foresight

Antón, Philip S., Richard Silberglitt, and James Schneider, *The Global Technology Revolution: Bio/Nano/Materials Trends and Their Synergies with Information Technology by 2015*, Santa Monica, Calif.: RAND Corporation, MR-1307-NIC, 2001. As of October 31, 2008: http://www.rand.org/pubs/monograph_reports/MR1307/

European Commission, *The European Foresight Monitoring Network, Collection of EFMN Briefs:* Part 1, Luxembourg: Office for Official Publications of the European Communities, EUR 23095 EN, 2008.

Silberglitt, Richard, Philip S. Antón, David R. Howell, Anny Wong, S. R. Bohandy, Natalie Gassman, Brian A. Jackson, Eric Landree, Shari Lawrence Pfleeger, Elaine M. Newton, and Felicia Wu, *The Global Technology Revolution 2020*, Executive Summary: *Bio/Nano/Materials/Information Trends, Drivers, Barriers, and Social Implications*, Santa Monica, Calif.: RAND Corporation, MG-475-NIC, 2006. As of October 28, 2008: http://www.rand.org/pubs/monographs/MG475/

Silberglitt, Richard, Philip S. Antón, David R. Howell, Anny Wong, Natalie Gassman, Brian A. Jackson, Eric Landree, Shari Lawrence Pfleeger, Elaine M. Newton, and Felicia Wu, *The Global Technology Revolution 2020*, In-Depth Analyses: *Bio/Nano/Materials/Information Trends, Drivers, Barriers, and Social Implications*, Santa Monica, Calif.: RAND Corporation, TR-303-NIC, 2006. As of October 28, 2008: http://www.rand.org/pubs/technical_reports/TR303/

全球技术革命

执行摘要

中国

天津滨海新区（TBNA）与天津经济技术开发区（TEDA）面临的新兴技术机遇

Richard Silberglitt • Anny Wong

其他作者

S. R. Bohandy • Brian G. Chow • Noreen Clancy • Scott Hassell
David R. Howell • Gregory S. Jones • Eric Landree • Parry Norling

由天津滨海新区与天津经济技术开发区提供资助

Transportation, Space, and Technology

A RAND INFRASTRUCTURE, SAFETY, AND ENVIRONMENT PROGRAM

本研究的发起者为天津滨海新区（TBNA）与天津经济技术开发区（TEDA），并在兰德公司基础设施、安全与环境研究中心（TST）的交通、空间与技术项目组（TST）的资助下开展。

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前言

关于本报告

2007 年，位于中国东北的天津滨海新区（TBNA）及其行政区天津经济技术开发区（TEDA）委托兰德公司（RAND Corporation）展开一系列技术上的前瞻研究，帮助他们制定和实施一项战略性的远景规划，以通过技术创新达到经济的增长。本报告描述了这些研究的结果。主要目的包括：（1）指出适合滨海新区与开发区的最有前景的新兴技术应用（TAs），作为其发展规划的一部分；（2）分析他们在各种状况下将面临的动力与障碍；（3）针对每种技术应用推荐行动计划。如要阅读关于本书内容更详细的讨论，以及进一步获得文献和参考资料信息，我们强烈推荐您查阅本研究的深度分析部分。（参见 Silberglitt and Wong, 2009）

在展开研究的过程中，兰德公司的研究者与滨海新区和开发区的相关代表在中国和美国都进行了商谈。我们也通过现场调研以及查阅相关的国际文献收集了数据。我们的方法、数据及分析都基于兰德公司 2006 年的报告：*全球技术革命 2020*，执行摘要：*生物/纳米/材料/信息领域的趋势*、*动力*、*阻碍与社会意义*（GTR 2020 Executive Summary）；全球技术革命 2020，深度分析：*生物/纳米/材料/信息领域的趋势*、*动力*、*阻碍与社会意义*（GTR 2020 In-Depth Analyses）。两部分合称为 GTR 2020。

这份报告对于滨海新区、开发区、中国其他地区与更多发展中国家的执行总管、管理者、规划者、商业人士、科学家、工程师和当地居民都具有一定的参考意义。报告在新兴技术的发展、应用与实施方面也对国际发展组织、学术机构、政府、私人部门与个人具有参考意义。

兰德公司的交通、航天与技术项目组

本研究是在兰德公司基础设施、安全与环境部门（ISE）的交通、航天与技术项目组（TST）的赞助下开展的。兰德公司基础设施、安全与环境部门的使命在于，改善对社会重要有形资产和天然资源的开发、运作、利用与保护，提

高与迁移中、工作地和社区内的个人的安全保障相关的社会资产。TST 的研究涵盖了交通系统、空间探索、信息与通信技术、纳米与生物技术的政策领域，以及科技政策的其他方面。

如果关于本报告有问题或评论，请与项目负责人 Richard Silberglitt（Richard_Silberglitt@rand.org）联系。关于交通、航天与技术项目组的信息可以在线查看（http://www.rand.org/ise/tech）。关于该项目组研究的咨询信函请发送至如下地址：

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摘要

本书是对受中国东北部直辖市天津市内的天津滨海新区（TBNA）和天津经济技术开发区（TEDA）委托展开的一项研究的成果概述。2006 年，中国国务院给滨海新区指定任务，即成为国家的下一个区域经济增长引擎，同时成为前沿的研究开发（R&D）以及技术创新和现代制造中心。天津经济技术开发区建于 1984 年，是滨海新区的工业和制造业基地。

为了更好地给技术创新带动的经济增长制定战略规划，滨海新区和开发区的管理者委托兰德公司开展一项前瞻性研究，以识别具有前景的技术应用（TAs），指出实施这些技术应用所需的能力，为每项应用制定战略与行动计划，并对如何将这些应用融入一个整体战略规划提出指导意见。

本书描述了选出的技术应用，选择应用的过程，实施每项应用需要的能力、实施动力、障碍，以及实施战略建议。同时探讨了如何将各项技术应用纳入整体性战略规划。本研究的完整版报告（Silberglitt and Wong, 2009）叙述了针对每项技术应用的具体行动计划。

致谢

本报告的作者十分感谢在中国访问时滨海新区与开发区的许多成员的热情招待，以及他们乐意与我们分享重要的想法、经验、数据与其他信息来配合我们的分析。我们也非常感谢滨海新区和开发区的高层管理者们，他们在中国和美国都与我们进行了交流；感谢 Mu Dan Ping 给我们提供了一个关于滨海新区和开发区的历史和正面临问题的重要观点；感谢 Qian Gu，Jianhui Hu，Xiaoyan Li，Xiao Wang，Xin Wang，Mengjie Wu，Shinyi Wu 以及 Henu Zhao 在中文翻译上的宝贵协助；感谢 Yong Kang 帮助我们安排了一系列与清华大学的会谈；感谢 Matthew Southerland 对中英文文献的重要研究；以及我们的同事 Susan Everingham，Julie Kim，Debra Knopman 和 Martin Wachs 的明智建议和指导。我们同样感谢 Lisa Spear 在报告撰写过程中提供的专业性行政支持。

我们特别要感谢同行审稿人 Steven Berner，William Blanpied 以及 Carl Dahlman。他们富有洞察力的分析和建议促使我们对报告进行大力修订和改进。

缩写

CAS	中国科学院 Chinese Academy of Sciences
CATARC	中国汽车技术研究中心 China Automotive Technology and Research Center
CNANE	国家纳米技术与工程研究院 China National Academy of Nanotechnology and Engineering
EPA	美国环保局 U.S. Environmental Protection Agency
EU	欧盟 European Union
GDP	国内生产总值 gross domestic product
GMP	药品生产质量管理规范 good manufacturing practices
IC	内燃机 internal combustion
IPR	知识产权 intellectual property rights
ISE	基础设施、安全与环境 Infrastructure, Safety, and Environment
km	公里 kilometer
NIBC	纳米技术产业基地公司 Nanotechnology Industrial Base Company
NVCC	天津纳米创业投资公司 Nanotechnology Venture Capital Company
PV	光伏 photovoltaic
R&D	研发 research and development
RFID	射频识别 radio-frequency identification
S&E	科学与工程 science and engineering
S&T	科学与技术 science and technology
sq km	平方公里 square kilometer
TA	技术应用 technology application
TBC	天津生物芯片技术有限责任公司 Tianjin Biochip Corporation
TBNA	天津滨海新区 Tianjin Binhai New Area
TEDA	天津经济技术开发区 Tianjin Economic-Technological Development Area

TST	交通、航天与技术 Transportation, Space, and Technology
TU	天津大学 Tianjin University

第1章 导言

天津滨海新区（TBNA）沿着中国东北部大型直辖市[1]天津的 150 公里海岸线而建，在国家的经济发展战略中扮演了关键性角色。天津市于 1994 年首次划设了约 2200 平方公里的新区区域。当时，滨海新区作为一片贫瘠与未开发的土地，被赋予了刺激天津工业增长的宏伟使命。仅仅十年间，这里已成为 140 万人口的常住地，中国北方最大的集装箱港，以及工业和制造业的大型基地。

2006 年，国务院将天津市的这一工业中心命名为“特别试验区”，并委以成为国家下一个地区经济增长引擎的重任。在此背景下，滨海新区将对中国其他地方的区域发展与经济改革起到榜样作用。现在滨海新区直接向国务院汇报工作，并受益于一系列国家政府为吸引国内外投资与促进贸易提供的有利政策和税收优惠。天津滨海新区被预计成为中国下一个经济发动机，如同之前上海、苏州对长江三角洲地区，广州、深圳对珠江三角洲地区发挥的作用一样，激励西北环渤海地区的经济发展。

天津经济技术开发区（TEDA）属于滨海新区的三个行政区之一，同时也是新区的工业制造业基地和金融商业活动中心。开发区将在滨海新区的经济增长远景中发挥关键性作用。开发区建于 1984 年，如今已成为繁忙的综合型工业园。园区拥有一个健全的制造业基地，基地包括了电子、汽车及零部件、食品加工和生物制药方面的支柱产业。许多世界财富五百强企业、中国顶尖企业、其他重要跨国公司都在开发区内有显著的活动。

对滨海新区和开发区的未来展望

作为滨海新区的直接管辖者，国务院明确提出新区将发展重心放在三个领域，并最终在以下三方面成为中国北方的中心：

- 先进的研究开发（R&D）与技术孵化器
- 一流的现代制造业
- 国际运输和物流业

与此同时，在经济发展之外，国务院还意图使滨海新区成为解决许多国内紧迫问题的带动者。稳定增长的能源需求，逐渐稀缺的可利用水资源，以及严重升级的城市污染属于中国最为关注的问题。考虑到这些需求，滨海新区作为一个试验区，需要提出与传统工业经济不同的发展方案，形成可持续发展与环境友好性工业的一个典范模式，该模式有助于应对所有这些挑战。

科学技术（S&T）创新，尤其是前沿的研发创新，处于这一经济和环境发展远景的核心。为了实现这一目标，滨海新区将有必要采取切实的步骤，开发区则将是其中的最前线。在其已有的制造基地的基础上，开发区旨在由一个成

[1] 中国的“直辖市”与西方“市”的概念不同，是一个范围广阔的行政单位，由一个人口密集的城市核心向外延伸到非常大的周边地区。中国仅有四个直辖市，与省同级，直接向中央政府汇报工作。

功的综合型工业园转变为最先进的重大新兴技术的科学与工程（S&E）中心。分布在滨海新区其他地方的具有相关能力的其他企业将跟随其后。期望的最终结果是，研发创新达到国际标准，滨海新区占据全球技术领跑者的地位。

通过前瞻分析实现滨海新区和开发区的远景

天津滨海新区和开发区的高层官员在为这次宏伟转型制定战略规划的早期，发现了兰德公司（RAND Corporation）于 2006 年撰写的报告：全球技术革命 2020，执行摘要：*生物/纳米/材料/信息领域的趋势*、*动力*、*阻碍与社会意义*（GTR 2020 Executive Summary）；全球技术革命 2020，深度分析：*生物/纳米/材料/信息领域的趋势*、*动力*、*阻碍与社会意义*（GTR 2020 In-Depth Analyses）。这两部分合称为 GTR 2020。报告是一项综合性的前瞻分析，指出了 2020 年之前最有望实现的技术应用（Technology Applications, TAs），有能力获得这些技术的国家，以及它们可能对社会产生的影响。研究重点关注新兴的技术潮流引向的应用而非技术本身，因为技术自身很少为现实世界的问题提供解决方案。相反，解决方案来自于技术被投放于实益用途的过程。因此，GTR 2020 强调如廉价太阳能等技术应用，而非光伏（PV）材料这样的技术。

在了解 GTR 2020 的报告内容后，滨海新区和开发区的管理者联系兰德公司，以针对园区的目标开展一系列的前瞻性研究。兰德公司被委托进行如下工作：

- 为开发区和滨海新区的其他高技术中心指出最有前景的新型技术应用，作为滨海新区的整个经济增长战略规划的关键部分进行实施；
- 指出实施这些技术应用所需的能力，以及可能促进或阻碍实施过程的关键性动力和阻力；
- 为每项技术应用制定战略和行动计划；[2]
- 为这些技术应用如何融入滨海新区经济发展的总体战略规划提供指导。

对于滨海新区最富前景的技术应用概述及其选择理由

根据我们的分析，对于力图完成国务院委任的滨海新区来说，七种创新性的技术应用特别具有前景：

- *廉价太阳能：*足够低廉的太阳能系统，能够广泛应用于发展中或欠发达国家以及弱势群体[3]；
- *先进的移动通信和无线射频识别（RFID）：*感应、处理、储存及交流信息的多功能平台；无线射频识别包括了信息储存及短程无线传输技术；
- *快速生物检测：*迅速检测特定生物物质的存在与否的测试，并能同时进行多项测试；
- *用于水净化的薄膜、过滤器与催化剂：*淡化、消毒、净化并高度可靠地

[2] 概要部分将对各技术应用的战略进行描述。具体的行动计划详见报告第 II 部分中针对各类应用的章节。
[3] 此处及以下定义都基于 GTR 2020。

确保水质的新型材料；
- *分子级药物的设计、开发与给药：*在纳米层次设计、开发与给药的能力，在不损害健康的组织与细胞的同时抗击特定的肿瘤或病原体，并改进诊断方法；
- *电动与混合动力汽车：*具有结合内燃与其他动力源的动力系统的可供于大众市场的汽车；
- *绿色制造：*能够最小化浪费和环境污染以及优化资源的使用和再利用的制造过程的开发及应用。

为了做出以上选择，我们首先从 GTR 2020 指出的中国在 2020 年以前能够获得的 12 项技术应用开始考虑。接下来，我们结合了对滨海新区及整个中国的现实情况、环境和问题的严格研究，该研究参考了中文和英文文本的多种资料：

- 描述滨海新区和开发区的使命、历程和现状的中英文材料；
- 关于中国的社会、环境和经济需求以及中国政府为满足需求已采取的措施的中英文文献；
- 在滨海新区、经济技术开发区、天津港、整个天津市以及北京市开展的现场访谈；
- 对在滨海新区和开发区之外能提供支持的科技机构的走访，包括清华大学和中国科学院；
- 在开发区举行为期两天的研讨会，参与对象为开发区的科研机构、企业和管理部门的关键人物。

在此分析的基础上，我们将中国最优先考虑的十二项技术应用进一步收缩到七项。它们有的直接来自 GTR 2020 报告，有的是对十二项应用中若干项的混合。

滨海新区未来科学技术发展的基础

我们选择技术应用，以至提出战略和行动计划建议，都将四个主要因素考虑在内：

- 国务院对滨海新区和开发区要求的使命；
- 中国迫切的国家需求；
- 技术创新在中国普遍面临的动力和障碍，以及在滨海新区特有的动力和障碍；
- 滨海新区和开发区目前可以获得的在本地或更广范围内进行研发、生产和科技产业化的实力。

滨海新区和开发区作为经济和环境发展特别试验区的使命

在相对较短的时间里，滨海新区和开发区成功地建立了一个强大的制造业基地。作为对滨海新区“三管齐下”的要求之一，国务院现在要求新区和开发区进一步建设此基地，以建立现代化、高技术的生产能力，其中强调对创造附

加值和高薪就业机会的产品生产的研究开发。这类生产以知识为基础，因此，科学技术将是这个转型过程中至关重要的部分。科技产业化的能力也非常关键，这样新区和开发区通过研发设计出的产品具有高度可销售性，并能使用创新性的制造工艺进行生产。

国务院还要求滨海新区成为国际运输和物流中心，这部分要求与研发和生产的目标是紧密结合的。为了实现这一目标，滨海新区需要使目前研发活动中出现的尖端的供应链和物流技术具备可操作性。

一个相伴随的要求，即滨海新区进行金融部门改革的试验，促进确定了科技开发的首选商业领域。2007 年 12 月，滨海新区与国家开发银行签订了一项协议，共同资助 20 亿人民币（折合 2.93 亿美元[4]）的风险投资基金，以推动新区内的高新技术创业。基金指定了优先投资的领域：电子、生物工程、新材料、新能源、环境保护，以及自动化生产。

由于认识到三十年的迅速经济增长给中国带来了沉重的环境代价，国务院要求滨海新区在经济发展同时实施创新性的环境保护计划。经济发展必须继续，但也必须具有可持续性。滨海新区已经切实采取相应环境保护要求的第一步措施，包括循环经济计划和中国-新加坡天津生态城（Sino-Singapore Tianjin Eco-City）计划。[5]前一个计划是指对资源进行可持续循环地使用和再生产，以使工业废弃物和污染减到最低。计划容纳 35 万人口的生态城将采用先进的绿色技术建造和运行，而新加坡将在可再生能源、绿色制造、低污染公共交通及水和废弃物再循环方面提供经验指导。这些努力仅仅是滨海新区推动建设可持续发展和环境友好型制造方法的示范样本的开端。滨海新区提供的成功模式将最终推广到全中国。

中国迫切的国家需求

就在中国经济保持增长，新兴的中产阶层随之享受到更高的生活水准的同时，国家也面临着严峻的挑战：

- 减少农村贫困：中国迅猛的经济增长显著地减低了繁忙的城市商业区的贫穷状况，但广大农村仍然保持着贫困。中国需要的技术应用要有助于为农村居民创造机遇、提高生活水平，减轻他们迁移至城市中心寻找工作的压力。
- 准备应对迅速老龄化的庞大人群：尽管抑制住了人口增长，但中国仍有超过 10 亿的居民，其中许多是老年人。与此同时，中国正在向新的社会福利体制过渡，该体制要求处于就业年龄段的人群承担起大多数以前由政府提供的服务的成本。因此，有助于提供高薪就业机会的技术应用是最重要的，例如医疗上的创新有助于应对老年居民特有的健康需求。
- 满足人口的健康与卫生需求：中国拥有的如此庞大的人口对医疗保健的需求量也是惊人的。尽管部分传染性疾病仍是待解决的问题，目前最主要的关注点还是非传染性疾病。医疗保健上的负担在农村地区不成比例地偏高。中国需要的技术应用要能够改善私人和公共的医疗体系，并且成本有效地提高水和环境卫生的质量，尤其是对于农村地区。

[4] 2008 年 11 月 5 日，人民币对美元汇率为 0.146445 美元/人民币元。

[5] “循环经济”（Circular Economy）对能源、水和原材料进行可持续循环使用，以最小化浪费和污染。

- 满足日益增长的能源需求：中国是世界上最大的能源消耗国之一，而且能源需求呈稳步上升的曲线。随着正在扩大的中产阶层群体中越来越多人购买汽车，对机动车所需的石油和天然气有特别高的需求。中国需要的技术应用要能够开辟替代能源，降低石油需求，提高能源效率，同时减少工业的能源需求。
- 扭转水资源的缺乏：总体而言，清洁水在中国是稀缺资源。对降雨量极少、地下水源缩减的中国北方来说，短缺的状况尤为严重。然而，居民用水和工业用水需求丝毫没有减少的迹象，因而水供应难以跟上。能够从多种来源获取清洁水的技术应用至关重要。
- 减少污染：中国的经济腾飞也使其面临严重的污染状况。酸雨、大气污染、城市过分扩张、耕地减少、赤潮现象都属于最严重的问题。中国需要的技术应用要通过减少汽车和工业排放中的有毒物质、资源循环利用和提高能效，促进经济发展与环境保护的平衡。
- 维持经济高速增长：中国必须继续建设和发展自身经济，以解决国内问题、创造就业机会、提高国民生活质量。国家现在正处在一个重要关口，知识驱动的经济增长对于未来具有关键的意义。其中，增长的核心将是这样的技术应用，它们有助于中国减少对国外技术依赖性，跻身世界前沿科技国家，以及改变由一系列倍受关注的事件导致的民族品牌缺乏质量保障的形象。

全国范围和滨海新区内技术创新的动力和障碍

任何技术应用获得大范围、可持续的实施都取决于促进实施的动力和妨碍实施的阻力之间的平衡。某个单一因素可能成为动力或者障碍。例如成本和融资：如果能获得足够的风险投资，则资金会成为动力，而缺乏资助则使其成为障碍。

在我们看来，以下因素对中国成功实现尖端研发和技术创新的能力具有最大的影响：

- 国家需求
- 国家的研发政策
- 其他能够创造对某些技术应用的需求（或酌情降低需求）的国家政策
- 知识产权（IPR）保护
- 金融和银行法律法规
- 地方政策、法律和规范，能够直接影响个人和机构进行尖端研发和创新性技术的产业化的能力
- 人力资本
- 研发和创新文化

这八个因素对于滨海新区开发和实施选定的技术应用的能力也同样具有最大的影响。对中国大部分地区来说，其中一些因素明显属于动力或障碍两者之一。但个别时候，不同的当地情况使这些因素在某个组织或地区（或对于某特定的技术应用）相较于其他地区成为更强或更弱的动力或障碍。

其中，若干因素对于滨海新区而言是明白无误的障碍，且适用于全部七种技术应用。例如，在滨海新区以至全国范围内，知识产权保护问题对于本土创

新以及外国的资本人才参与新研发和技术创业来说，都始终是一种障碍。同样，金融和银行法律法规的缺失阻碍了风险资本的投入，对于滨海新区以至全国也是一种障碍。但对于某些技术应用来说，滨海新区在一些特定技术上拥有风险投资来源，这从一定程度上弱化了该障碍。缺少研发和创新文化是滨海新区以至整个中国面临的第三项障碍，它抑制了新的技术创业中的冒险行为，而这对于从事突破性研发并进行商业化是至关重要的。

人力资本对于滨海新区而言是七种技术应用共有的动力。这来自于滨海新区现有制造基地的实力、相应的劳动力，以及天津市分布密集的研究机构。然而，中国的年轻人倾向于避开技术和职业培训，而国内对科学和工程人才的竞争非常激烈。两方面因素都削弱了这一动力。

滨海新区和开发区目前拥有的能力

为了完成国务院的要求，滨海新区和开发区需要获得三方面的能力：（1）研究开发；（2）生产制造；（3）科技产业化。来自本地的能力——滨海新区、开发区和整个天津市内——与来自国内其他地方或国外的能力都将在其中发挥作用。

在研发能力方面，滨海新区和开发区拥有数量不断增长的提供尖端研究设备的机构，以及一支由训练有素的科学家和工程师组成的专业队伍。但园区也面临着国内外对这一层次人才的激烈竞争。

在生产能力方面，开发区近 25 年的建设为滨海新区和开发区奠定了坚实的工业基础。这一基础的实力体现在一批财富 500 强企业的投资、工业产值增长的业绩记录，以及上升的国内收入总值（GDP）等方面。滨海新区还在不断完善建设对于生产能力所必需的基础设施——电力、货运设施和废弃物处理工艺。但生产所需的熟练工人和技师的潜在短缺，以及劳动市场上对这类人的更激烈竞争，都是真正的挑战。

在科技产业化方面，滨海新区和开发区运行着一个研究园区和技术孵化器的良好网络，其目标在于支持新兴的高技术企业。充足的财政激励有利于促进企业发展和吸引人才。但是，由于中国更好地保护知识产权以及改革金融和银行法规政策的需要，这些企业面临相当大的挑战。同时，研发机构和商业性工业界之间也缺少有力的联系来促进高科技产品向市场转化。

第2章 对七种最具前景的技术应用的进一步分析

这七种对滨海新区呈现出最大的潜在效益的技术应用，建立在技术和工业界兴起的两个影响巨大的全球性趋势的基础上。首先是微米和纳米级技术。GTR 2020 报告中提出的大多数技术应用都包含微米和纳米级的技术进展以及生物、纳米、信息和材料技术的整合。类似地，给滨海新区建议的技术应用中的六种应用包含了这一领域的技术。第二个趋势在于，当今的产业界和消费者都明显地向绿色制造过程和技术的方向发展。为滨海新区选择的技术应用中的四种应用都着力于比以往更加有效地利用能源、水和其他资源。

廉价太阳能

廉价太阳能在世界市场上具有很强的潜在需求。受政府激励政策和可再生能源补贴的推动——特别是在德国和日本——太阳能发电产业在过去的五年内达到了 44％的平均增长率。2007 年，产业增幅为 55％，达 130 亿美元。为保持增长，相关企业正在竞相降低太阳能系统的价格，提高其效率。

中国需要推进能源发展，但同时也须发展可再生能源，改善空气质量，以及减少污染。发展廉价太阳能技术与这些需求是一致的，因为它能替代目前主要由燃煤电厂提供的能源。

太阳能发电技术可分为三代。主要基于多晶硅的第一代技术占现有全球销售额的 90%多。正在发展中的第二代和第三代系统基于薄膜材料及新型纳米级技术，能提供更低的成本和更高的效率，具有促进产业转型的潜力。全球市场需求的增长取决于这两代技术。

现有实力

天津地区为滨海新区实施廉价太阳能应用提供了切实的能力。南开大学的研究小组与北京市太阳能研究所合作，从事薄膜材料的研发，即是一个著名的例子。另一例是位于天津经济技术开发区的国家纳米技术与工程研究院（CNANE）。该研究院具有研发第三代太阳能材料所需的纳米级的技术和安装能力。

动力与障碍

中国须在减少环境污染、改善空气质量的前提下保证能源发展的需求是给这项技术应用的动力。包括支持太阳能示范项目的研发政策以及其他国家政策也具有推动作用。

地方政策和法律——特别是建筑规范与建筑电气设施的监管制度——往往是阻碍实施太阳能发电系统的因素。这是因为，房屋验收者与地方电力公司可能要求的系统平衡设备（如电池和变频器）以及其他的安全和计量设备造成相当大的花销。如果重新审视建筑标准与电气设施连接的规范，保证针对太阳能

发电的系统平衡设备要求在提供安全保障的同时没有增加成本，那么滨海新区有机会缓解这些问题，甚至有可能将其转化为动力。

金融和银行法律法规确实也是一项障碍。但对于廉价太阳能而言，其程度相较其他技术应用有所减轻，因为天津经济技术开发区的纳米科技风险基金以及清华大学的绿色风险投资基金“青云创投”都是滨海新区发展这项技术应用的潜在投资基金来源。

战略建议

中国的第一代太阳能发电产业已经发展得很成熟。因此，我们认为滨海新区和开发区的最大机遇不在于进入第一代太阳能市场，而是成为第二和第三代系统的研发和制造中心。首先着眼于全球出口市场，伴随更长期的发展而进入中国国内市场。

先进的移动通信和无线射频识别（RFID）

移动通信设备逐渐已不局限于语音数据的交换，而能作为感应、处理、存储和传送多种新式数据的平台。与此同时，无线射频识别（RFID）设备已经愈发的廉价与精密。这类设备已经在供应链与多种商务交易的领域得到广泛应用，目前正准备整合入移动通信设备。

全球范围内，城市和农村市场对于多功能无线通信的需求正迅速增长。亚太地区和中国尤其如此。另外，滨海新区有义务成为以天津港为枢纽的国际运输和物流中心，因此迫切需要发展先进的移动通信和 RFID 技术，从而优化货运物流，降低港口运营成本，并加强运输安全性。

先进的移动通信设备和 RFID 系统均由多种独立的组件技术构成——如显示器、存储器、电池和电量存储、传感器和天线。每种技术都形成了自身的产业，并将决定无线计算平台的未来发展方向。随着对这种技术应用的全球需求增长，这些组件技术的市场也会相应扩大。

现有实力

2006 年，天津经济技术开发区生产了超过 1.05 亿移动电话耳机——约为全球移动电话销售量的 10%。开发区的综合性生产基地包括韩国三星公司最大的移动电话工厂。滨海新区在组件技术上也具备实力。天津大学（TU）的两个研究团队正在进行前沿的显示器技术的研发工作。此外，开发区内的一家企业还生产世界上最小的储氢罐（只有 AA 电池的大小），能为手机充电器和燃料电池提供氢储备。

动力与障碍

中国对刺激经济发展和提高生产力的需求是对这项技术应用的推动力。先进的移动通信有助于供给国家日益增长的移动电话市场，从而促进消费。RFID 在供应链和物流上的应用具有大幅度改进生产与运输的潜力。中国支持集成电路、软件与网络发展的研发政策是另一种动力。

其他国家政策——尤其是中国至今对于移动通信国际标准的抵制——可能

成为阻碍。

战略建议

滨海新区应旨在成为移动通信设备和 RFID 系统的研发和制造中心。首先着眼于国内市场，然后扩展到全球市场。同时，应在显示器和电源两种组件技术上建设最先进的研发项目。然而，滨海新区不应试图在集成电路领域设定研发趋势。

快速生物检测

针对检测个人健康和公共卫生以及进行环境监测的更优良技术的全球市场正在迅速壮大。中国尤其需要最先进的应对公共卫生和环境挑战的技术。检测分析基因和蛋白质的新型芯片使迅速测试疾病和病原体成为可能。生物检测技术的针对性和精密性已经发展到一定高度，即某些芯片实验室（Lab-on-a-Chip）利用微型设备，可以作为小规模的实验室发挥功用。这些类型的生物检测技术能够识别或消除公共卫生面临的威胁，大幅度地提高患者治疗效果，并准确识别环境或食品供应中的病原体。

现有实力

天津经济技术开发区是中国五个国内生物芯片研发基地之一，天津生物芯片技术有限公司的所在地。该公司自行生产生物芯片，并生产化学试剂和其他用于生物检测的一次性器材。此外，公司还提供用来检测大肠杆菌、志贺氏杆菌和沙门氏菌的诊断性生物检测设备。公司与本领域的全球领先企业美国昂飞公司（Affymetrix）是合作伙伴。

动力与障碍

这种技术应用有若干推动力。其一为中国对改进公共卫生、减少环境不良影响的需求，特别还有对提高水供应质量的需求。其二为国家研发政策，卫生、医学和生物技术被视为重点支持领域。其他国内政策（尤其是针对更有效地进行食品和药物监管的政策）是第三种动力。

战略建议

滨海新区的长期战略应是在全球市场上成为最先进的快速生物检测技术的领跑者。但开始的重点应在于利用技术许可和合作协议来吸引领先企业进入滨海新区和开发区。在此期间，滨海新区应当建设生物检测器材和设备的转售者的能力。最后，滨海新区的企业应开始自行生产这些产品。中国国内市场应是初步的目标，其后为全球市场。

用于水净化的薄膜、过滤器与催化剂

保障在可承受成本内获取洁净水是一个全球性的挑战。对于是全世界水和污水处理技术的前五大增长市场之一的中国来说，这个挑战尤为严峻。而在可利用水资源极度稀缺的环渤海地区和滨海新区，问题更为严重。

水净化技术是一个重要的新兴科技领域，现有四个方面的应用：

- *脱盐*：从海水中去除盐分
- *消毒*：去除微生物
- *净化*：去除有毒物质
- *质保*：检测潜在的有害物质

新的纳米材料能够改进目前的滤膜系统，并大大增加成本效益。例如纳米合成和仿生薄膜[1]，纤维介质的过滤器，纳米渗透过滤器，纳米级催化剂，以及DNA-纳米颗粒合成物等。主要的挑战在于新材料如何从实验室走向规模化的商业应用。

现有实力

天津经济技术开发区是天津膜天（Motian）膜工程科技有限公司的所在地。Motian 公司为工业、私人、水利设施和医疗领域生产水过滤膜（包括反渗透脱盐）已有 20 年的历史。国家纳米技术与工程研究所（CNANE）具有开展纳米过滤器与催化剂研究的能力。天津大学化学工程技术学院拥有一个很强的脱盐研发项目，包括一个淡化水的示范项目，并在设计、制造和测试纳米过滤器。作为开发区内从事纳米技术转让与产业化的机构，纳米科技工业基地公司（NIBC）和纳米科技风险投资公司（NVCC）将纳米级水净化过滤器作为产业化的核心目标。

动力与障碍

中国对改善公共卫生与个人健康、满足清洁水供应的需要是这项技术应用的推动力之一。国家拨款资助净化水技术的研发政策，以及其他旨在为国民提供清洁水的政策则是另外两个动力。

政府的补贴使水价低于脱盐和净化带来的成本。这些补贴作为其他国家政策的一部分，使国家政策在具有推动作用的同时也有阻碍性。

战略建议

我们为滨海新区设立两项长期目标：（1）成为纳米薄膜、过滤器与催化剂技术的研发中心；（2）成为生产最先进的水净化膜的领跑者。对于滨海新区来说，至关重要的一点是要加强研究实验室与企业的紧密联系，以促进技术的商业应用。

分子级药物的设计、开发与给药

[1] 模拟自然界机理的薄膜。

中国和全世界都在增加对更新、更有效、更低剂量和副作用更小的药物疗法的需求。分子级药物疗法和诊断法基于纳米技术和生物技术的交叉领域的最新进展。这一年轻而富有前景的纳米医学领域能够满足上述市场需求。其中，四类创新性应用受到特别关注：

- 给药及成像的靶向性载体
- 药物可控释放的平台和材料
- 药物投放的新方法
- 增加药物可溶性的手段

现有实力

在研发能力方面，天津经济技术开发区的纳米科技中心，中国纳米技术与工程研究院（CNANE）正在开展一项药物研发。天津大学和南开大学拥有世界一流的研究团队，他们正合作开发一种振奋人心的新型给药平台：碳纳米角。天津溥瀛生物技术有限公司也位于开发区，该公司正在开发生物技术和处在临床前试验阶段的基因疗法。天津市具有一个强大的制药工业基地，其中包括若干个世界顶尖的制药企业。生物医药与用于给药的纳米生物材料被称为滨海新区技术转移和产业化的重点领域。

动力与障碍

这项技术应用的推动力之一是中国对改善公共卫生与个人健康的需求。国家的研发政策也是一个推动力。政策支持的重点包括：疾病疫苗和转基因药物的商业生产示范项目，完善现代中医药，以及提高新药发明和生产的能力。

其他国家政策则有阻碍作用——特别是一些监管制度，提高了研发的成本，阻碍了新药的临床试验与营销。[2]

战略建议

滨海新区应旨在成为生物纳米技术制药的研发和制造中心。首先着眼于吸引外商投资，随后积极地建设本地研发能力。最后，引导研发活动走向新型疗法和技术的商业化。

电动与混合动力汽车

根据当前全球市场的趋势，同时考虑到油价和全球变暖问题，使用电力和混合动力技术的车辆的市场份额将会增加。与此同时，中国面临严重的城市污染问题。减少尾气污染和降低石油需求属于国家优先考虑的问题。

混合动力汽车已经成为一个领先的全球性汽车市场。插入式混合电动车的出现使电池可以脱离汽车本身独立充电，进而电动车与混合动力车之间不再有明显差别。考虑到这一点，我们提出了这个结合型的技术应用，包括四种汽车

[2] 尽管存在这些问题，*Nature Biotechnology*（自然生物技术）的最近一篇文章仍将中国的生物技术制药评价为“正开始起飞”（Frew, et al., 2008）。这篇报告的详细数据来自与 22 家中国本土健康生物技术企业的访谈，包括天津溥瀛生物技术公司。报告撰写者指出，这仅占“本行业数千家企业”的很小一部分。

类型：

- 纯电动汽车
- 传统混合动力车，利用内燃引擎进行充电
- 插入式混合动力车
- 串联混合动力车，利用车载能量源进行充电

这类汽车需要的许多组件同样也具有增长的市场需求以及发展的巨大潜力。其中包括电池、电力电子和电机、传动系统、内燃机和排放控制装置。以电池为例，其技术的进步正在扩大电动和混合动力车的行驶距离，并改善其性能。

现有实力

据我们所知，混合动力车尚未在滨海新区进行生产。但滨海新区确实具备了进行电动汽车研发和制造的综合实力。天津经济技术开发区内的天津清源电动车辆有限公司生产电动轿车、公交车和卡车，并向全球销售。

滨海新区也具备生产电动汽车零件的能力。清源公司正在与美国阿贡国家试验室（Argonne National Laboratory）在传动系统技术及其他零件领域进行合作研究。EV Battery 公司作为清源公司的利益相关者之一，正在开展电池研究。开发区的纳米科技中心，国家纳米技术与工程研究院（CNANE）在电动车的纳米级电容器方面有积极的研究项目。而在科技产业化方面，中国汽车技术研究中心（CATARC）从事标准和认证测试，其对于发展电动与混合动力汽车市场具有重要意义。CATARC 的总部位于天津市。

动力与障碍

中国对提高能效与减少环境污染的需求是这项技术应用的一个推动力。促进节油车辆的制造和购买的国家政策是另一个推动力。

但其他一些国家法律和政策具有阻碍作用。例如汽车部件的进口关税，国外公司把持的混合动力车的零件专利，国家控制的低油价，大城市对电动车辆的限制等。

战略建议

考虑到电动车和混合动力车的巨大市场潜力，我们建议，滨海新区在这类汽车的子系统和零件技术方面发展和扩大合作研发。与此同时，应当发展混合动力汽车的生产能力以及电动和混合动力车的零件生产能力。目标应首先对准全球市场，然后指向国内市场。

绿色制造

世界范围内的跨国公司与消费者都越发认同绿色制造。例如许多发达国家的政府已经为工业界设置了国家绿色化学奖励。中国也不例外：绿色制造工厂开始在国内出现，清洁技术的风险投资也开始注入。国家指令，例如国务院对

滨海新区建立循环经济的要求，则是这股趋势的另一个标志。

绿色制造的方法包括四个方面：

- 绿色化学：对环境友好的化学流程和产品；
- 绿色工程：将污染以及对健康和环境的风险最小化的可行性流程和产品；
- 本质安全的流程设计：降低有害材料的含量，减少使用有害材料，以及替代性的反应路径或工艺条件；
- 生产质量管理规范/优良制造（GMPs）：制造符合标准规范的高质量可再生产品的方法、设施和控制流程。

现有实力

滨海新区的一些公司（比如奥的斯，摩托罗拉）已经在绿色化学方面设立项目并将绿色制造投入应用。部分获得美国环保署（EPA）颁发的总统绿色化学挑战奖的企业也在开发区建立了分厂，如 PPG 工业集团和诺维信公司。美国奥的斯电梯公司在开发区建造了世界上第一座绿色电梯生产厂。

动力与障碍

中国需要提高能源效率，并减少污染和其他对环境的不良影响，这对于发展绿色制造是一个推动力。另一个动力是着眼于节约资源和减少污染的国家政策。其中，部分政策明确地支持绿色制造。

成本问题，尤其是已有工厂“变绿”的更新与替换成本可能成为障碍。但在许多情况下，绿色制造能够提供竞争优势，从而减弱其阻碍作用。

战略建议

天津经济技术开发区应当成为中国的绿色制造中心。首先应着力于将绿色化学和工程的领先企业引进滨海新区。随着时间推移，滨海新区自身应展开新的绿色制造工艺的研发，并最终在新区和开发区内进行实施。在制定绿色制造计划时，滨海新区应强调新工厂的建设，并重点关注节省成本的工艺流程。

第3章

建设滨海新区的未来：将七个行动计划整合为一项总体的战略规划

我们认为，在滨海新区向最先进的科学和工程中心转变的战略规划中，七种技术应用应该构成一个枢轴性部分。所有这些技术应用和有前景的全球趋势都保持一致，很好地切合了滨海新区、开发区和天津市当前的实力并建立在已有支柱性产业的基础上，而且支持中国政府优先考虑的议题。

总体战略规划的一部分应当用来解决目前阻碍全部七种技术应用的普遍性挑战。其中之一是保护知识产权。规划应该包括帮助滨海新区和开发区加强这一领域的现行法律的措施。第二点是让在技术开发不同阶段工作的人们进行合作。我们建议滨海新区和开发区在规划中纳入这部分内容，即为研究机构和工业界之间的合作提供充足的机会。最后非常重要的一点是，滨海新区需构建研发和创新的文化。规划应包括促进滨海新区和开发区资助的创业活动的灵活性和冒险精神。

除此之外，滨海新区可以利用三管齐下的框架，将针对每种技术应用的行动计划整合到一个总体的战略规划中：

- 在相关领域发展最先进的研发能力
- 更新并拓展已有的生产基地
- 构建科学技术产业化的能力

这三个方面需要同步进行。每个部分都需要利用和扩展已有的本地能力，并引入新的能力。在开始新的研发项目、拥有最先进能力的新公司的加入将整体实力提升到世界一流水平的同时，新的进步应该源于并扩展已有的能力基础。另外，三个方面还应互相支持。

在相关领域发展最先进的研发能力

战略规划应该为每种技术应用设置三方面的议程：（1）最优化的利用本地的研发能力；（2）扩展现有研发项目的范围；（3）开展全新的研发项目。这三个方面的努力需要相继展开。现有的本地研发包括位于开发区的纳米技术中心（CNANE）、天津大学和南开大学的项目。滨海新区可以提供资源，从而在支持七种技术应用的领域扩充这些项目——例如生物纳米技术、纳米过滤和微流体技术。在扩展现有研发项目的范围方面，国家纳米技术与工程研究院清源电动车公司与美国阿贡国家实验室（Argonne National Laboratory）的合作是一个好的典型。这在公共-私人部门合作与跨文化合作上都是出色的范例。

开展全新的研发项目的第一步是巩固与有关企业的联系，这些全球性企业在开发第二、第三代太阳能集热器，纳米级过滤设备和薄膜，以及纳米制药等方面处于领先位置。这些企业可以与滨海新区、开发区或整个天津市内的合适

的研究研究机构合作。建设新项目还包括吸引已经拥有尖端的研发能力的企业进驻滨海新区。

更新并拓展已有的生产基础

滨海新区的战略规划应当包含有关措施，以确保目前在新区和开发区运营的企业利用设计和技术上的最新进展。例如，滨海新区可以给采用绿色制造工艺的企业提供一套补贴和奖励。还可以建设相关设施，从而为企业采用绿色制造提供便利。同时，滨海新区应该在规划中做出相应的规定，将采用先进生产流程所需进行的工人培训制度化。

此外，引进新的拥有最先进生产能力的企业也是至关重要的一个方面。针对生产第二和第三代太阳能集热器、先进移动通信设备的系统组件或芯片实验室生物检测设备的全球企业，滨海新区可以与之进行接触，并提供一套激励制度，鼓励他们到新区和开发区建厂。

构建科学技术产业化的能力

战略规划应该包含有关计划，以确保滨海新区和开发区的制造工厂和流程达到国际标准。例如，可以对进行 ISO 14001（全球认可的环境管理标准）等认证做强制要求。

规划还应设置相关步骤，将滨海新区定位于为国际市场服务。新区应利用天津本地市场作为将销往国内其它地方以至全世界的产品的试验场地，制定一套标准做法。其中应当包含有关规定，以保证通过试验的产品符合全球目标市场接受的通行规则和标准。例如，电动和混合动力汽车在排放量和里程性能上需要达到最为严格的美国和欧盟（EU）标准。滨海新区开发的食物和水的生物检测技术将需要满足美国和欧盟关于病原体检测展示水平的标准。

参考文献选编

为阅读关于本书内容更详细的讨论，以及进一步获得文献和参考资料信息，我们强烈建议读者查阅如下报告的深度分析部分：

Silberglitt, Richard, and Anny Wong, with S. R. Bohandy, Brian G. Chow, Noreen Clancy, Scott Hassell, David R. Howell, Gregory S. Jones, Eric Landree, and Parry Norling, *The Global Technology Revolution China, In-Depth Analyses: Emerging Technology Opportunities for the Tianjin Binhai New Area (TBNA) and the Tianjin Economic-Technological Development Area (TEDA)*, Santa Monica, Calif.: RAND Corporation, TR-649-TBNA/TEDA, 2009.（报告中文名称：*全球技术革命 – 中国，深度分析：天津滨海新区（TBNA）与天津经济技术开发区（TEDA）面临的新兴技术机遇*）

截至出版日期：http://www.rand.org/pubs/technical_reports/TR649/

报告的电子版同时收录于本书附带的 CD-ROM 光盘。

中国和天津

American Association of Port Authorities, "World Port Ranking: 2006," c. 2007. As of May 21, 2008: http://aapa.files.cms-plus.com/Statistics/worldportrankings%5F2006.xls

Angel, Robert, "Putting an Innovation Culture into Practice," Ivey Business Journal, January–February 2006. As of October 29, 2008: http://www.iveybusinessjournal.com/view_article.asp?intArticle_ID=605

"China, Singapore Build Eco-City in Tianjin," (Xinhua) China Daily, May 8, 2008. As of October 29, 2008: http://www.chinadaily.com.cn/bizchina/2008-05/08/content_6670430.htm

Fallows, James, "China Makes, the World Takes," Atlantic, July–August 2007, pp. 48–72. As of October 28, 2008: http://www.theatlantic.com/doc/200707/Shenzhen

International Energy Agency, and Organisation for Economic Co-Operation and Development, World Energy Outlook 2007: China and India Insights, Paris, 2007. As of October 29, 2008: http://www.iea.org/Textbase/npsum/WEO2007SUM.pdf

Jang, Soonhee, patent counsel and regional intellectual-property counsel, Asia, Eli Lilly and Company, "Overview of Chinese Patent Law," presented at The Dragon and the Elephant: Understanding the Development of Innovation Capacity in China and India, Washington, D.C.: National Academies, September 24–25, 2007. As of October 30, 2008: http://www7.nationalacademies.org/step/Innovation_china_india_sep.07_soonhee_jang.pdf

Linton, Katherine, China's R&D Policy for the 21st Century: Government Direction of Innovation, U.S. International Trade Commission, February 2008. As of October 29, 2008:

http://papers.ssrn.com/sol3/papers.cfm?abstract_id=1126651

Malik, Khalid, “Bridging Development Gaps in Today’s China,” United Nations Development Programme China, Beijing, September 23, 2006. As of October 29, 2008: http://www.undp.org.cn/modules.php?op=modload&name=News&file=article&catid=13&topic=16&sid=302&mode=thread&order=0&thold=0

McElwee, Charlie, “China Adopts Circular Economy Law,” China Environmental Law, August 30, 2008. As of October 29, 2008: http://www.chinaenvironmentallaw.com/2008/08/30/china-adopts-circular-economy-law/

McKinsey Global Institute, Addressing China’s Looming Talent Shortage, October 2005. As of October 30, 2008: http://www.mckinsey.com/mgi/publications/chinatalent.asp

“Northeast China Faces Water Shortage as Severe Drought Lingers,” (Xinhua) China Daily, March 9, 2008. As of October 29, 2008: http://www.chinadaily.com.cn/bizchina/2008-03/09/content_6520390.htm

Organisation for Economic Co-Operation and Development Directorate for Science, Technology and Industry, “OECD Reviews of Innovation Policy,” last updated October 17, 2008. As of October 29, 2008: http://www.oecd.org/sti/innovation/reviews

Serger, Sylvia Schwaag, and Magnus Breidne, “China’s Fifteen-Year Plan for Science and Technology: An Assessment,” Asia Policy, Vol. 4, July 2007, pp. 135–164. As of October 29, 2008: http://www.nbr.org/publications/asia_policy/AP4/AP4%20Serger_Breidne%20RN.pdf

US-China Business Council, “Tianjin at a Glance,” April 2006. As of September 15, 2008: http://www.uschina.org/info/chops/2006/tianjin.html

TBNA 和 TEDA

Binhai New Area, “Development of the Tianjin New Coastal District (Binhai New Area),” June 10, 2008. As of October 30, 2008: http://www.bh.gov.cn/bh/system/2008/06/10/010016455.shtml

Central People’s Government of the People’s Republic of China, 国家发展改革委负责人就〈国务院关于推进天津滨海新区开发开放有关问题的意见〉有关问题答中国政府网记者问〉[The head of the National Committee of Development and Reform responds to questions regarding “suggestions from the State Council of the People’s Republic of China on the related issues of promoting the developing and opening of the Tianjin Binhai New Area” from a Gov.cn reporter] July 25, 2006. As of August 21, 2008: http://www.gov.cn/zwhd/2006-07/25/content_344924.htm

“LED City: TEDA Becomes First in China,” China CSR: Energy and Cleantech, March 4, 2008. As of October 30, 2008: http://www.chinacsr.com/en/2008/03/04/2141-led-city-teda-becomes-first-in-china/

People’s Republic of China Ministry of Commerce, “天津经济技术开发区投资环境连续十年排第一＞[Tianjin Economic-Technological Development Area ranks first in investment environment for 10 consecutive years] December 5, 2007. As of October 28, 2008:

http://chinawto.mofcom.gov.cn/aarticle/j/al/200712/20071205266059.html?2900825302=4194397658#

Sino-Singapore Tianjin Eco-City Administrative Committee, "About Eco-City," undated Web page. As of October 28, 2008:
http://www.eco-city.gov.cn/eco/shouye/zoujinshengtaicheng/shengtaichengjianjie/en/en.html

State Council, "Suggestion of the State Council of the People's Republic of China on the Related Issues of Promoting the Development and Opening-Up of the Tianjin Binhai New Area," May 26, 2006. As of October 28, 2008: http://en.investteda.org/download/Suggestion.doc

TEDA Investment Promotion Center, 2003 Annual Report on the Economic and Social Development of Tianjin Economic-Technological Development Area, c. 2004. As of September 19, 2008: http://en.investteda.org/FactsFigures/#Annual%20Report

———, 2005 Annual Report on the Economic and Social Development of Tianjin Economic-Technological Development Area, c. 2006. As of September 19, 2008:
http://en.investteda.org/FactsFigures/#Annual%20Report

———, 2007 Annual Report on the Economic and Social Development of Tianjin Economic-Technological Development Area, c. 2008. As of September 19, 2008:
http://en.investteda.org/FactsFigures/#Annual%20Report

Tianjin Economic-Technological Development Area, "Investment Procedures: TEDA Investment Services Organizations," undated (a) Web page. As of October 30, 2008:
http://www.teda.gov.cn/cms/cms/website/english/invest/tiso.htm

———, "Why TEDA: Science and Technology," undated (b) Web page. As of October 29, 2008:
http://en.investteda.org/whyteda/science/carriers/t20050126_0671.htm

———, 《泰达年鉴 2006 年》 [TEDA annual report 2006], c. 2007. As of October 30, 2008:
http://www.teda.gov.cn/cms/cms/website/tedahome/zl/tdz/tdnj/2006.htm

———, 《泰达年鉴 2007 年》 [TEDA annual report 2007], c. 2008. As of October 30, 2008:
http://www.teda.gov.cn:80/cms/cms/website/tedahome/zl/tdz/tdnj/tdnj07/index.htm

Tianjin Port Development Holdings Limited, One Stop, Non Stop: Annual Report 2007, Hong Kong, c. 2008. As of October 28, 2008: http://www.tianjinportdev.com/en/pdf/finreport2007a.pdf

TianJin Port Free Trade Zone and AirPort Industrial Park of Binhai New Area, undated (a) home page. As of October 30, 2008: http://www2.tjftz.gov.cn/english/
in Chinese:
http://www2.tjftz.gov.cn/qygk/qyjs/

———, "Tianjin Binhai New Area," undated (b) Web page. As of October 30, 2008:
http://www2.tjftz.gov.cn/system/2006/10/05/010001294.shtml

"VC Fund to Back Binhai Economic Zone," (Xinhua) China Daily, December 25, 2007. As of October 28, 2008: http://www.chinadaily.com.cn/bizchina/2007-12/25/content_6345780.htm

技术应用

Adis International, "'Easy' Diagnosis of Early Disease: Blood-Based Gene-Expression Tests for Breast Cancer and Alzheimer Disease," Pharmaceutical and Diagnostic Innovation, Vol. 3, No. 10, 2005, pp. 7–10.

Boberg, Jill, Liquid Assets: How Demographic Changes and Water Management Policies Affect Freshwater Resources, Santa Monica, Calif.: RAND Corporation, MG-358-CF, 2005. As of September 11, 2008: http://www.rand.org/pubs/monographs/MG358/

Bullis, Kevin, "Making Electric Vehicles Practical," Technology Review, March 31, 2008a. As of November 18, 2008: http://www.technologyreview.com/energy/20488/

Caruthers, Shelton D., Samuel A. Wickline, and Gregory M. Lanza, "Nanotechnological Applications in Medicine," Current Opinion in Biotechnology, Vol. 18, No. 1, February 2007, pp. 26–30.

Chan Kei-biu, chair and managing director of Surface Mount Technology (Holdings) Ltd., honorary chair of the Hong Kong Green Manufacturing Alliance, "A New Business Perspective: Turning Green Manufacturing into Your Competitive Advantage," presentation, January 19, 2005. As of April 30, 2008: http://www.epd.gov.hk/epd/misc/env_management_sme/e_e/eng/doc/presentation/3_hkeia.pdf

Craighead, Harold, "Future Lab-on-a-Chip Technologies for Interrogating Individual Molecules," Nature, Vol. 442, July 27, 2006, pp. 387–393.

Eighth International Symposium on Green Chemistry in China 2007 Organization Committee, Institute of Green Chemistry and Fine Chemicals, "8th International Symposium on Green Chemistry in China," undated Web page. As of May 1, 2008: http://www.bjut.edu.cn/college/hjnyxy/8isycc/home.html

European Union, Directive 2002/95/EC of the European Parliament and of the Council of 27 January 2003 on the restriction of the use of certain hazardous substances in electrical and electronic equipment, February 13, 2003a. As of November 17, 2008: http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=CELEX:32002L0095:EN:HTML

———, Directive 2002/96/EC of the European Parliament and of the Council of 27 January 2003 on waste electrical and electronic equipment, February 13, 2003b. As of November 18, 2008: http://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=CELEX:32002L0096:EN:HTML

Faber, Paul, "RFID Strategy: RFID Developments in China," Industry Week, September 18, 2007. As of November 14, 2008: http://www.industryweek.com/ReadArticle.aspx?ArticleID=14982

Fan, Xiaobin, Juan Tan, Guoliang Zhang, and Fengbao Zhang, "Isolation of Carbon Nanohorn Assemblies and Their Potential for Intracellular Delivery," Nanotechnology, Vol. 18, No. 19, May 16, 2007, pp. 1–6.

Frew, Sarah E., Stephen M. Sammut, Alysha F. Shore, Joshua K. Ramjist, Sara Al-Bader, Rahim

Rezaie, Abdallah S. Daar, and Peter A. Singer, “Chinese Health Biotech and the Billion-Patient Market,” Nature Biotechnology, Vol. 26, No. 1, January 2008, pp. 37–53.

Gallagher, Kelly Sims, Roundtable on Barriers and Incentives for Hybrid Vehicles in China: A Roundtable Report, Cambridge, Mass.: Energy Technology Innovation Project, Belfer Center for Science and International Affairs, Kennedy School of Government, Harvard University, September 6, 2006. As of November 18, 2008: http://belfercenter.ksg.harvard.edu/files/report_hybrid_roundtable_final_9_6_06.pdf

Gu, Frank X., Rohit Karnik, Andrew Z. Wang, Frank Alexis, Etgar Levy-Nissenbaum, Seungpyo Hong, Robert S. Langer, and Omid C. Farokhzad, “Targeted Nanoparticles for Cancer Therapy,” Nano Today, Vol. 2, No. 3, June 2007, pp. 14–21.

Harwanegg, Christian, and Reinhard Hiller, “Protein Microarrays for the Diagnosis of Allergic Diseases: State-of-the-Art and Future Development,” Clinical Chemistry and Laboratory Medicine, Vol. 43, No. 12, 2005, pp. 1321–1326.

Hering, Garrett, “Land of Opportunity,” Photon International, December 2007, pp. 66–72.

Hirsch, Leon R., Andre M. Gobin, Amanda R. Lowery, Felicia Tam, Rebekah A. Drezek, Naomi J. Halas, and Jennifer L. West, “Metal Nanoshells,” Annals of Biomedical Engineering, Vol. 34, No. 1, January 2006, pp. 15–22.

Holliday, Charles O., Stephan Schmidheiny, and Philip Watts, Walking the Talk: The Business Case for Sustainable Development, Sheffield: Greenleaf, 2002.

“Hybrids from China and What They Could Mean,” Hybrid Cars, October 15, 2007. As of November 18, 2008: http://www.hybridcars.com/carmakers/chinese-hybrids.html

International Technology Roadmap for Semiconductors, “ITRS Sponsors,” last updated October 10, 2008. As of May 28, 2008: http://www.itrs.net/sponsors.html

Kaur, Satinderpal, Renuga Gopal, Wun Jern Ng, Seeram Ramakrishna, and Takeshi Matsuura, “Next-Generation Fibrous Media for Water Treatment,” MRS Bulletin, Vol. 33, January 2008, pp. 21–26.

Lempert, Robert J., Parry Norling, Christopher G. Pernin, Susan A. Resetar, and Sergej Mahnovski, Next Generation Environmental Technologies: Benefits and Barriers, Santa Monica, Calif.: RAND Corporation, MR-1682-OSTP, 2003. As of November 18, 2008: http://www.rand.org/pubs/monograph_reports/MR1682/

McDonald, Joe, “China to Launch Trial of 3G Phones,” ABC News, March 28, 2008. As of May 27, 2008: http://abcnews.go.com/Technology/wireStory?id=4541783

Meridian Institute, Overview and Comparison of Conventional and Nano-Based Water Treatment Technologies, Global Dialogue on Nanotechnology and the Poor: Opportunities and Risks, background paper for the International Workshop on Nanotechnology, Water, and Development, Chennai, India, October 10–12, 2006. As of September 11, 2008: http://www.merid.org/nano/watertechpaper/

Millikin, Mike, “China’s BYD Unveils Second Plug-In Hybrid Model at Geneva Motor Show;

Plans to Begin Sales in Europe in 2–3 Years," Green Car Congress, March 5, 2008. As of May 29, 2008: http://www.greencarcongress.com/2008/03/chinas-byd-unve.html

Nystedt, Dan, "Samsung Develops RFID Chip for Cell Phones," PC World, November 27, 2007. As of May 26, 2008:
http://www.pcworld.com/article/139972/samsung_develops_rfid_chip_for_cell_phones.html

Peer, Dan, Jeffrey M. Karp, Seungpyo Hong, Omid C. Farokhzad, Rimona Margalit, and Robert Langer, "Nanocarriers as an Emerging Platform for Cancer Therapy," Nature Nanotechnology, Vol. 2, December 2007, pp. 751–760.

Sandia National Laboratories, Environmental Resources Team, Water Treatment Engineering and Research Group, Desalination and Water Purification Research and Development Program, Desalination and Water Purification Technology Roadmap: A Report of the Executive Committee, Discussion, Denver, Colo.: Bureau of Reclamation, Denver Federal Center, Water Treatment Engineering and Research Group, report 95, January 2003. As of November 17, 2008:
http://www.usbr.gov/pmts/water/publications/reportpdfs/report095.pdf

Saxl, Ottilia, "Taking a Leaf Out of Nature's Book: Harvesting Solar Light," NanoNow, Vol. 3, September 2007, pp. 27–29.

Shannon, Mark A., and Raphael Semiat, "Advancing Materials and Technologies for Water Purification," MRS Bulletin, Vol. 33, January 2008, pp. 9–15.

Slaoui, Abdelilah, and Reuben T. Collins, "Advanced Inorganic Materials for Photovoltaics," MRS Bulletin, Vol. 32, No. 3, March 2007, pp. 211–218. As of October 30, 2008:
http://www.mrs.org/s_mrs/doc.asp?CID=9554&DID=200080

U.S. Environmental Protection Agency, "Green Chemistry: Award Winners," last updated August 26, 2008d. As of November 18, 2008: http://www.epa.gov/greenchemistry/pubs/pgcc/past.html

Vainrot, Nataly, Moris S. Eisen, and Raphael Semiat, "Membranes in Desalination and Water Treatment," MRS Bulletin, Vol. 33, January 2008, pp. 16–20.

Wagner, Volker, Anwyn Dullaart, Ann-Katrin Bock, and Axel Zweck, "The Emerging Nanomedicine Landscape," Nature Biotechnology, Vol. 24, No. 10, October 2006, pp. 1211–1217.

Whitesides, George M., "Overview: The Origins and the Future of Microfluidics," Nature, Vol. 442, July 27, 2006, pp. 368–373.

Zhao, Yuwen, Xinhua Geng, Wenjing Wang, Xudong Li, and Ying Xu, "R&D Activities of Silicon-Based Thin-Film Solar Cells in China," Physica Status Solidi (a), Vol. 203, No. 4, March 2006, pp. 714–720.

技术前瞻

Antón, Philip S., Richard Silberglitt, and James Schneider, The Global Technology Revolution: Bio/Nano/Materials Trends and Their Synergies with Information Technology by 2015, Santa

Monica, Calif.: RAND Corporation, MR-1307-NIC, 2001. As of October 31, 2008: http://www.rand.org/pubs/monograph_reports/MR1307/

Silberglitt, Richard, Philip S. Antón, David R. Howell, Anny Wong, S. R. Bohandy, Natalie Gassman, Brian A. Jackson, Eric Landree, Shari Lawrence Pfleeger, Elaine M. Newton, and Felicia Wu, The Global Technology Revolution 2020, Executive Summary: Bio/Nano/Materials/Information Trends, Drivers, Barriers, and Social Implications, Santa Monica, Calif.: RAND Corporation, MG-475-NIC, 2006. As of October 28, 2008: http://www.rand.org/pubs/monographs/MG475/

Silberglitt, Richard, Philip S. Antón, David R. Howell, Anny Wong, Natalie Gassman, Brian A. Jackson, Eric Landree, Shari Lawrence Pfleeger, Elaine M. Newton, and Felicia Wu, The Global Technology Revolution 2020, In-Depth Analyses: Bio/Nano/Materials/Information Trends, Drivers, Barriers, and Social Implications, Santa Monica, Calif.: RAND Corporation, TR-303-NIC, 2006. As of October 28, 2008: http://www.rand.org/pubs/technical_reports/TR303/