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MAY 2015

China 2025

Research and Innovation Landscape

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Contents

Main abbreviations

CIA Cross Impact Analysis
CLA Casual Loop Analysis
EC European Commission
FQ Focal Question
PLA People's Liberation Army
SOE State Owned Enterprise
TIA Trend Impact Analysis
NOC National Oil Companies
EOR Enhanced Oil Recovery
CCP China's Communist Party
MNC Multi National Companies
WTO World Trade Organization

Change is the only constant: No man can step in the same river twice

Heraclitus
Greek Philosopher

Stavros Mantzanakis
Managing Director, Phemonoe Lab
CEO, Emetris Consulting

Epaminondas Christofilopoulos
Head of International Cooperation, PRAXI/FORTH

DRAGON-STAR is funded by FP7, aiming to support the Chinese participation in Horizon 2020, the reciprocity originating from the signed EU-China Scientific Cooperation Agreement, the bilateral cooperation in scientific, technological and industrial research and innovation fields, and the ongoing EU - China Innovation Cooperation Dialogue.

Abstract

> Here we are today typing using "Made in China" computers, another signal of the rapid changes taking place globally, with China becoming a rising star.

Ten years ago this report would have been written on American laptops, probably designed and engineered by IBM, while we would be cooperating talking on our European mobile phones. However, the company that changed the PC market sold its manufacturing arm to Lenovo in 2004. At the same time, Nokia and Erikson cellular phones have practically disappeared while Huawei, Xiaomi and Lenovo are gaining increasing market shares in the smart phones market. So here we are today typing and communicating using "Made in China" computers and mobile phones, another signal of the rapid changes taking place globally, with China becoming a rising innovation star, driven by homemade technological innovations.

The current report aims to produce plausible versions of the future for the research and innovation environment in China in 2025. The aim is to contribute to the bilateral dialogue between the EU, the Member States and China, towards setting up a long-term cooperation strategy for mutual benefit and prosperity.

The overall work was structured around a single focal question: **"What are the main factors that will affect the Research (R) & Innovation (I) Environment in China until 2025?"**. A combination of desk-study analysis, a Delphi study, as well as a Crowd-sourcing platform, have been utilized to reveal 16 critical drivers that play a substantial role in transforming the R&I landscape in China. A cross impact analysis has revealed the interrelation between the different factors, and highlighted the strong role of Governance and of the National Economy on the future developments.

Taking into account those drivers, as well as some critical uncertainties, four plausible scenarios for the future of the Chinese research & innovation landscape, have been composed. Scenarios are not predictions; it is simply not possible to predict the future with certainty, they are a powerful learning tool that helps us to perceive futures, today. Scenarios challenge our mindsets and oblige us to consider a set of potentially uncomfortable futures.

The four composed scenarios for China, are all set at 2025, and aim to help us suspend the disbelief in all plausible futures and allow us to think that any of them might take place, and prepare for them:

Yin & Yang – strong successful central governance combined with greater openness and a flourishing economy determines a cutting edge research community in 2025.

Blue Jasmine – strong and open governance fights to revive the national economy that is hit by a global crisis and the relocation of foreign manufacturing industries, characterizes the situation in 2025.

Dungeons & Dragons – Less open governance, and an insufficient court system support SOEs based development which seems to still to be successful in 2025.

The Breathless Queen – An overdrawn toxic China, characterized by a collapsed national economy and a dismantled society, seems to be the greatest global disappointment in 2025.

The study was performed by the Phemonoe Lab (Emetris) and PRAXI/FORTH in the context of the "Dragon-Star" project which was funded by the European Commission.


2025

Introduction - methodology

What are the main factors that will affect the Research Environment in China the next 10 years?

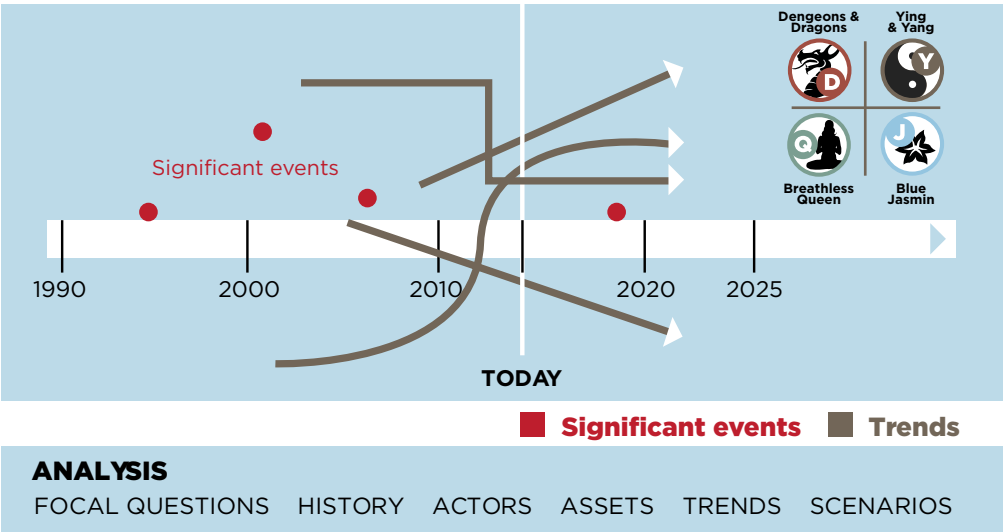
The performed trend scanning is focused on a single main focal question, which is "What are the main factors that will affect the Research Environment in China the next 12 years?" The answer on this question will provide input so as on a later stage we will be able to reply to a more complex question, which is "where will the Research of China be in 2025?".

The current trends scanning represents the all the preparatory work, that aims to produce several plausible scenarios about the Future of Research in China in 2025. An important part of the work was the identification of the main (obvious and less obvious) factors that will shape the research environment in China during the next 12 years.

The performed foresight was mainly based upon the scenario methodology for understanding the rapidly changing and complex (research) environment in China, in order to produce plausible images for the Future of Research in China in 2025.

It should be however underlined that a scenario is not a forecast! It is a method for imagining possible futures that will assist an organization to take the right strategic decisions. It provides the tools to identify and understand strong trends, as well as weak signals, which will shape the future environment.

Another aspect that was also studied in parallel is the identification of the innovation areas and technological sectors, as well as geographical areas that will bloom in the years to come. A major source of information on this topic was provided by KAIROS Future (see ANNEX 2), that has provided an extensive analysis.

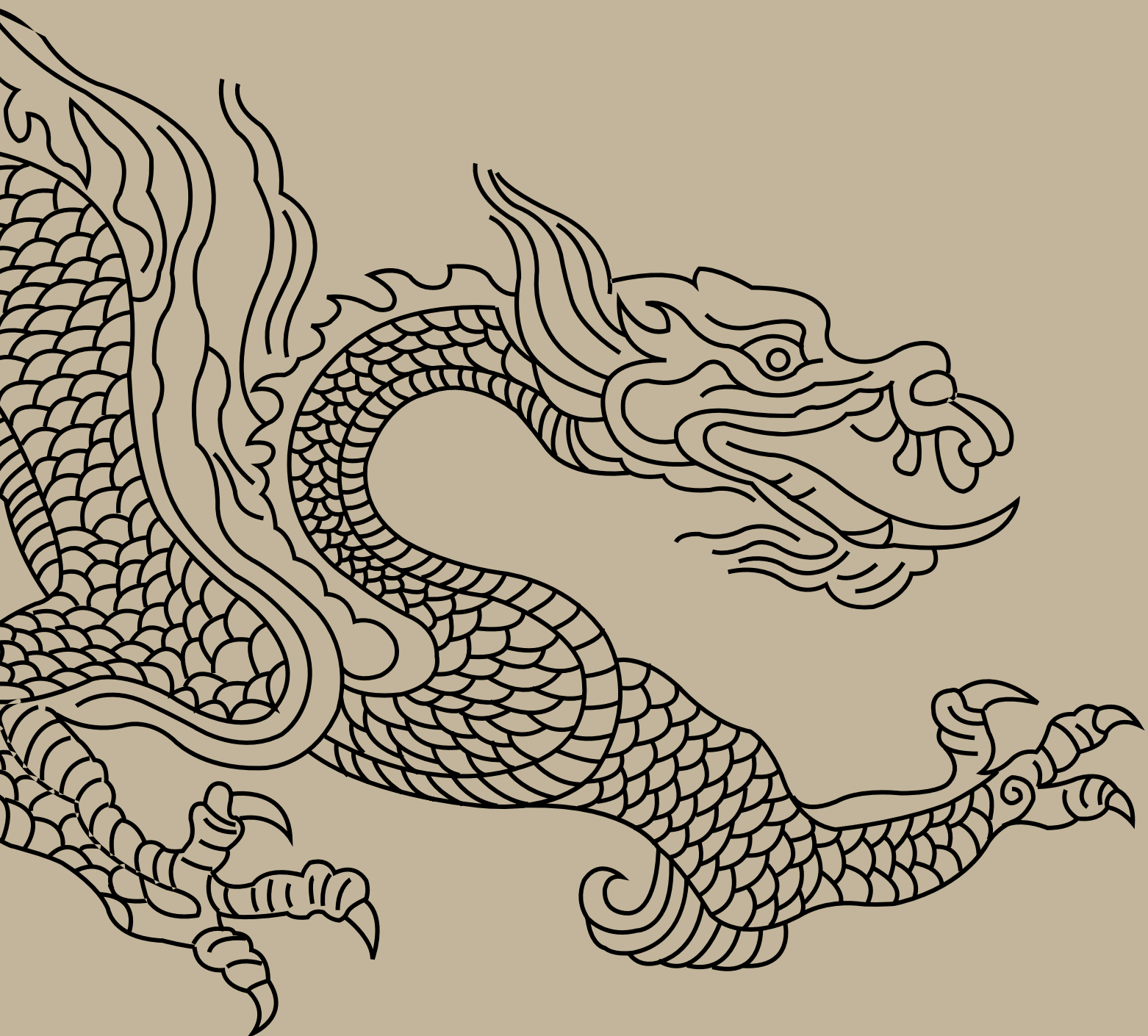


The methodology utilized is based upon the typical scenario making process and is described in detail in ANNEX 1. It should be also noted that a crowd sourcing platform, Co:tunity, was utilized to gather relevant information from a broader stakeholder's community, while the final draft of this report was validated by 3 independent experts, that provided comments and corrections on the suggested scenarios and trends:

- Ass. Prof Anthony Howell, *School of Economics at Peking University, Beijing, China*
- Mr Rikard Wallin, *Managing Director at NCAB Group Sweden AB, Stockholm, Sweden*
- Prof. Daoliang Lee, *China Agricultural University, Beijing, China*

The research was performed by the Phemonoe Lab (Emetris Consulting) and PRAXI/FORTH, while KAIROS Future provided special data and the Co:tunity platform. The work was performed in the context of the Dragon-Star project which has funded by the European Commission (INCO/FP7).

中国



China

What are the main factors that will affect the Research Environment in China the next 10 years?

The post-war era has witnessed the economic miracles of Japan and South Korea that managed to become substantial actors in the global high-technology market. However, both countries didn't have the dynamism and size to transform the global economy and to control the rules of the game. Today, in the beginning of the 21st century, two new countries, China and India, both have the prospects or the potential to shift the balance of global economy.

Today China is the second biggest economy after USA, and is expected to become the largest economy by mid-century. In addition, China became the world's largest trading nation in 2013, overtaking the US in what Beijing described as "a landmark milestone" for the country.

What is however more interesting, especially in China, is the an on-going structural change of the national economy, based on a shifting from low-labor manufacturing, to services, internal consumption and production of high tech products. This transformation of the Chinese economy is on-going and stills remain to be seen whether China will manage to become a global actor in added-value high tech products.

Will China lead? Or will it follow? During a large part of human history, China led the world in science and technology. However, western stereotypes of a backward and unchanging China produced a rather unattractive image of the country.

Yet during and after the industrial revolution China slipped far behind. It is only in the last few decades that it has once again caught up. Today, change is happening very fast and according to just announced data by OECD, China is ahead of the EU for the 1st time in % of GDP spending on Research and Development. Nonetheless, the picture is complex.

It's true that China has primarily excelled at adopting technologies from elsewhere, as a 'fast follower'. However, in some fields it is on the frontier of technological knowledge, and the growth of published research is extraordinary. As regards the commercialization of high tech innovative products, China with its large growth and excess liquidity is eager to invest in new technologies to upgrade its production systems. China (as other emerging markets) are now completing the innovation cycle by rapidly signing deals with innovative startups to quickly commercialize their new technologies at a rapid tempo and to scale.

Another important initiative, China's Foreign Experts Program, the 1000 talents program administered by the State Administration of Foreign Experts Affairs is and is further expected to play a major role in transforming China into an innovative powerhouse in the future. The plan provides lucrative incentives to Chinese nationals who are living abroad to return to China to carry out research within their respective fields, especially in STEM[1].

Still several questions need answers. Will the Chinese research ever become a competitive world leader? Is the financial growth, the financial resources and the central planning, sufficient factors to ensure growth? Are there any unforeseen risks? Some of these aspects will be covered by the current exercise.

1. Science, Technology, Engineering, Mathematics

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Trend Analysis & Evaluation

After the initial analysis of the research environment, and several brainstorming sessions, it was agreed, during the initial scoping, to focus on 16 drivers that will affect the quality and the characteristics of the research environment in China by 2025. Some of these drivers have a global character, but the majority is related with specific developments within the country.

It should be however noted, that during this scanning process, we have been looking for drivers that either will obviously affect (or are already affecting) the research environment, but more importantly we have tried to scan some weak signals and identify some less obvious factors that could potentially have a significant or even dramatic effect directly or indirectly.

It should be also noted that some of the trends, studied in the context of this work, have a broader importance and affect in several ways the global system. These megatrends (like global communications) are long-term, transformational processes with global reach, broad scope, and a fundamental and dramatic impact.

Trend
(According to the Cambridge dictionary)
is a general development or change in a situation or in the way that people are behaving.

Time	Observable over decades megatrends can be projected with a high degree of probability at least 15 years in the future.
Reach	Megatrends affect all regions, and stakeholders
Impact	Megatrends fundmentally transform policies, society, and the economy

George Vielmeteter & Yvonne Sell, 2014, Leadership 2030: The six megatrends you need to understand.

The methodology for identifying and evaluating the trends is briefly presented in ANNEX 1.

16 **trends** that will shape Chinese Research by 2025

01 Economy. China will enjoy strong GDP growth until 2025.

02 Framework Conditions. The Government will provide sufficient financial support and will implement an efficient regulatory framework for research.

03 Private R&D investment. The private sector in China will invest more on R&D by 2025.

04 Energy & Materials. The need for more energy from other sources beyond coal (e.g. from renewables and nuclear) and the need for resources (e.g. alternative raw materials) will strongly increase in China by 2025.

05 Governance. China will enjoy a stable governance and peaceful society by 2025.

06 Urbanization. The urbanization process in China will continue to grow strongly until 2025.

07 Human Rights. In the years to come, China will see a greater openess and improvement of human rights.

08 Global Economy. The global economy is expected to grow steadily until 2025.

09 Peace & Conflict. A peaceful regional cooperation will support the growth of the Chinese Research by 2025.

10 Space & Defense. The space exploration efforts and the development of defense technologies will substantially increase by 2025.

11 Environment. The intensity of the local environmental problems (e.g. atmospheric pollution, contaminated water) and the global environmental implications (e.g. climate change) will increase by 2025.

12 Population. The Chinese population will continue to increase by 2025.

13 IPR. The IPR regulations will be further modernized and the IPR enforcement will continuously improve in China by 2025.

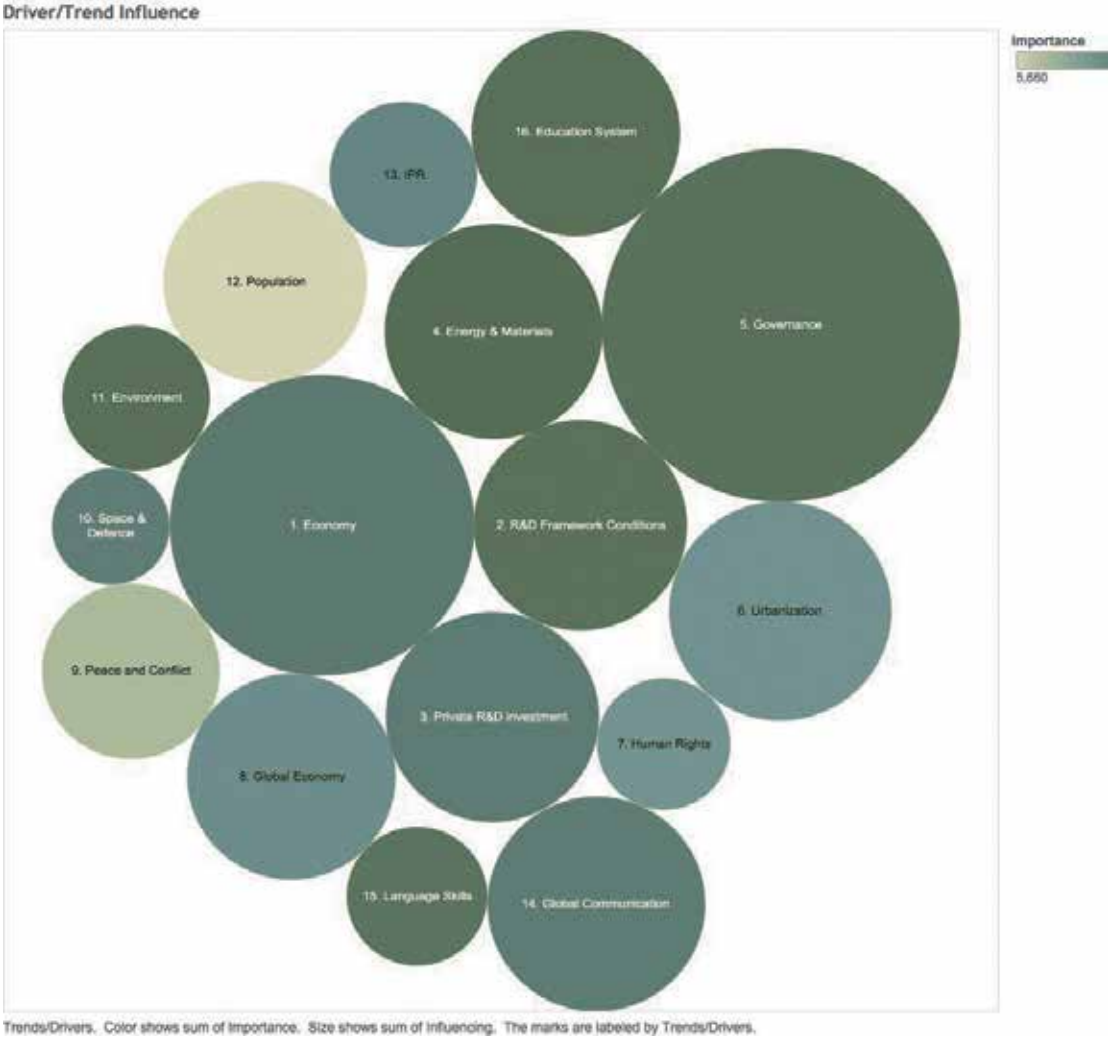
14 Global Communication. The world will become more interconnected and new communication technologies will allow the stronger interaction and cooperation of the Chinese researchers with their global counterparts by 2025.

15 Language Skills. The language skills of the Chinese researchers will substantially improve by 2025.

16 Education System. The Chinese education system (primary/secondary/higher) will be radically modernized and upgraded by 2025.

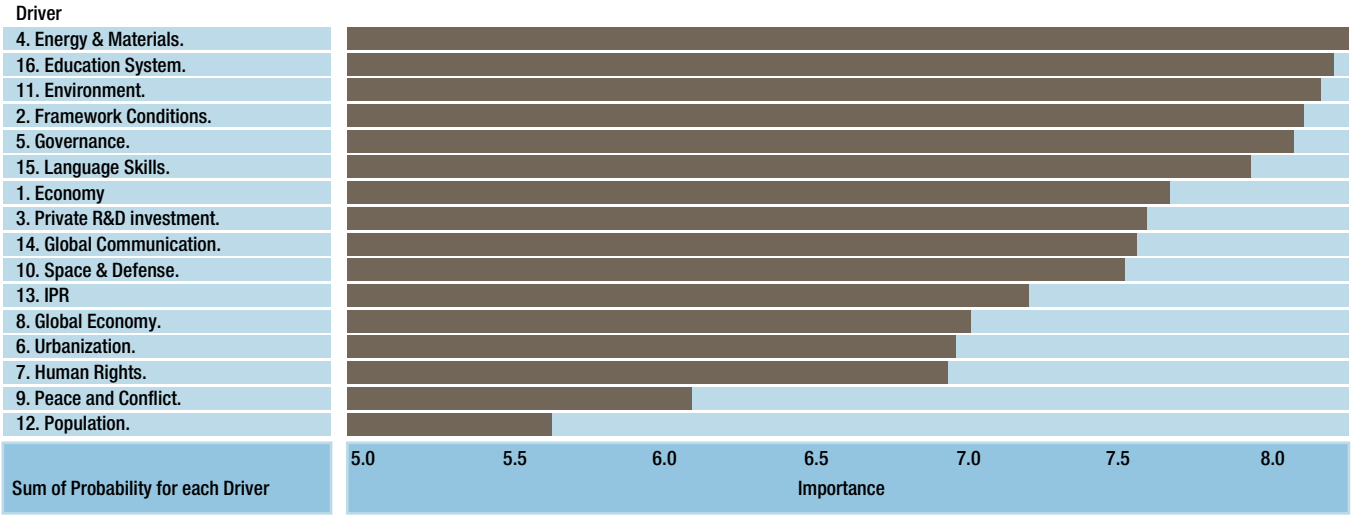
Trend Evaluation

The results of the evaluation results of the 16 drivers are presented in the following graphs. The results are presented on a scale from one to ten in terms of the importance and the probability of a driver to occur.



Although most of the drivers have received a high mark both in terms of their importance and their probability (this is natural as we had preselected drivers of importance), still there are some interesting results that could be extracted by the evaluation process.

In terms of the importance of the drivers, the most influential are considered to be (see following graph):
a) The increasing need of energy and resource efficiency (No.4),
b) The structure and operation of the education system (No.16),
c) The environmental implications (No.11),
d) The framework conditions (the national regulatory framework for research) (No.2),
e) The stability of the government and societal peace (No.5), and
g) The language skills (No.15).



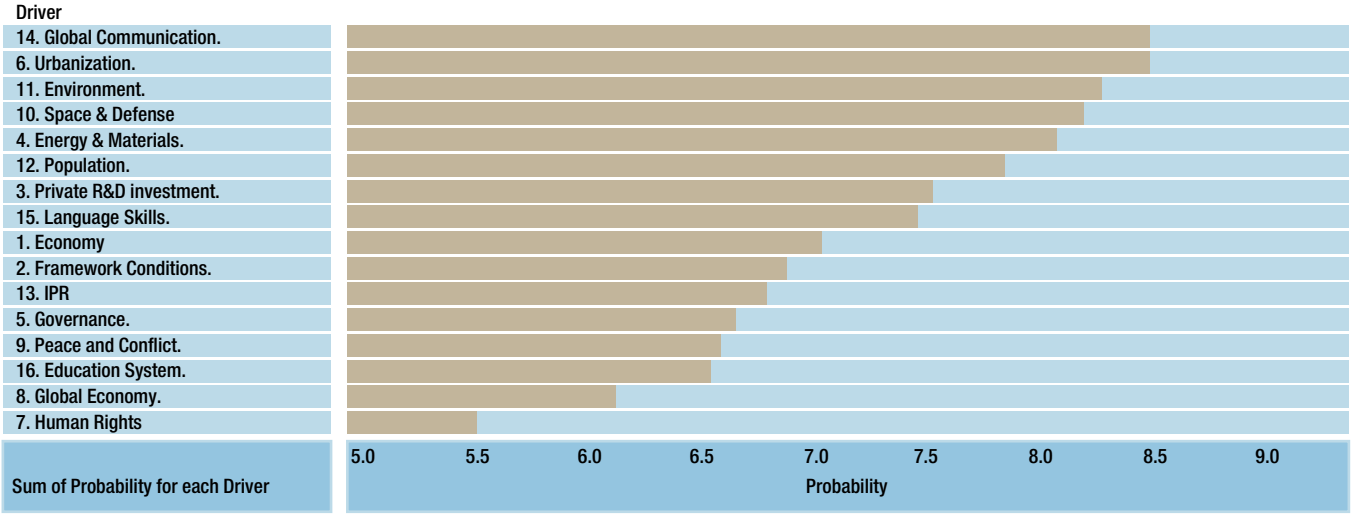
Some other interesting remarks are the following:

• A very low importance rating is given to the population growth and Urbanization, although its major process transforming the Chinese Society. However, it seems that the serious indirect effects, of this process on research, are not that obvious.

• Very little importance is also given on Human Rights and on the possibility of a serious military conflict in the region.

• The Economy and the Private Investment are also relatively low, maybe because they are taken for granted from the experts.

In terms of the probability, the following graph presents schematically the ratings given by the experts (10 is representing the higher probability).

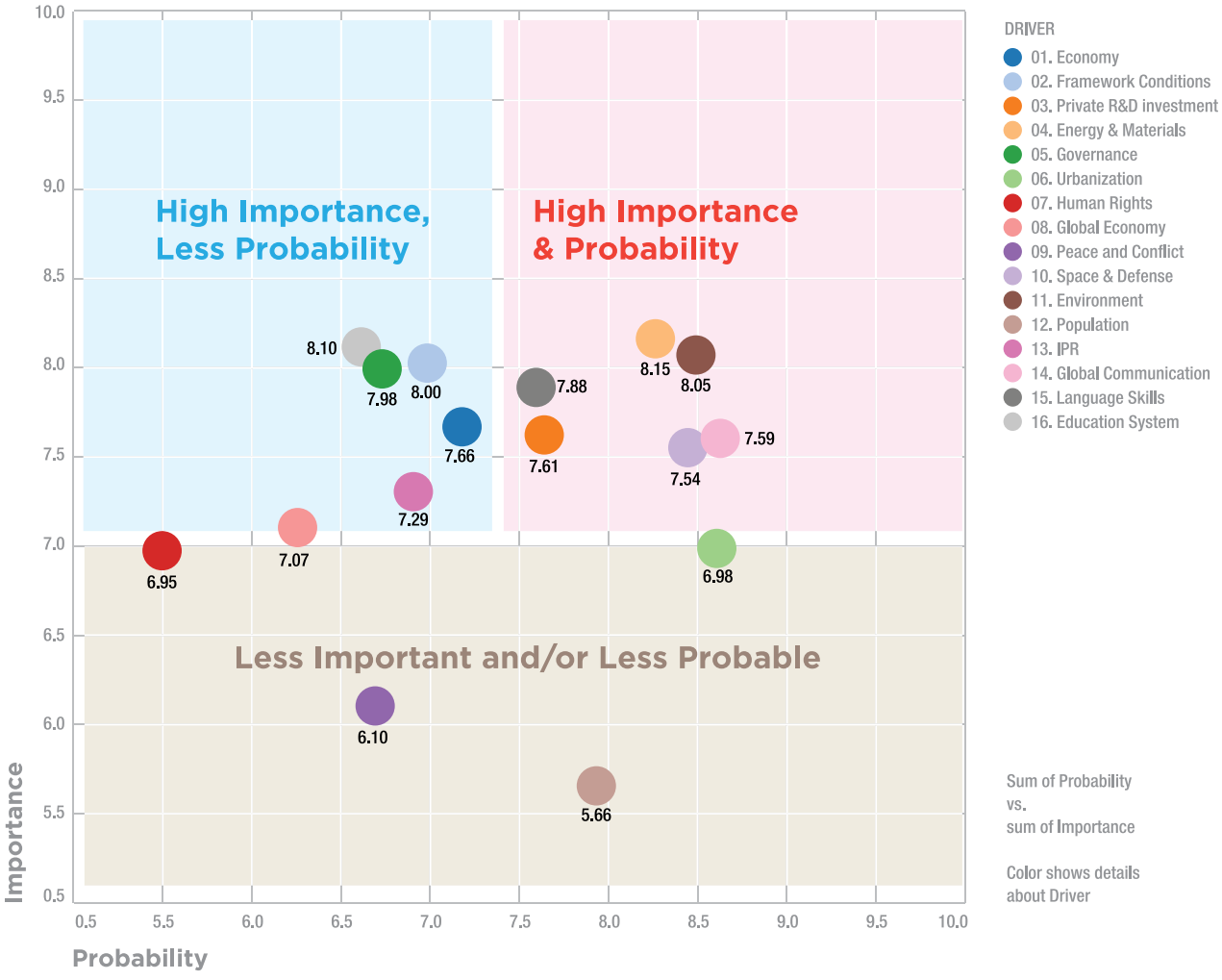


The highest, probability is given naturally on ongoing clear trends like the rise of Global Communication and Connectivity (driver No. 14), and the Chinese Urbanization process (driver No.6). Moreover, it is broadly expected that issues like the environmental degradation (No.11), the space race (No.10), and the need for resources (No. 4) will continue to play an increasing role in the future.

On the other side, it is worth mentioning that there are very low expectations for positive changes on issues like Human Rights, Governance, and the Education System as well as on IPR. Finally, it is also important to underline that risks are expected to affect both the Chinese and the Global Economy.

Summary of Results-Trend Impact Analysis (TIA)

The following graph sums the outcome of the evaluation process, indicating or suggesting specific drivers that are of high importance and high probability to occur. In the following graph the X axis represents the probability (ranking marks from 1 to 10), while the Y axis represents the importance of the same drivers on affecting the research environment (ranking marks from 1 to 10).



• The trends in the upper right corner were evaluated by the experts as certain and important.

• The Trends in the top left corner were evaluated as uncertain (or less certain) but still highly important.

These two sets of trends according to the scenario methodology are deemed of high importance and are studied in more detail, while are playing an important role in the formulation of the scenarios.

The 6 Uncertain and 6 Certain Trends are briefly presented bellow; a detailed description of all trends is available in ANNEX 3.

Uncertain Trends

- Education System (primary, secondary, high)
- Governance and Social Peace
- Research Framework Conditions
- National Economy
- IPR
- Global Economy

Certain Trends

- Need for Energy & Materials (Resources)
- Environmental Problems
- Global Communications
- Language Skills
- Private R&D Investment
- Space and Defence

Uncertain Trends

1. Need for Energy & Materials (Resources)
As the Chinese economy continues to grow, the need for (low carbon and more efficient) energy and the quest for raw and alternative materials is rising. China has quickly risen to the top ranks in global energy demand over the past few years, and as millions of Chinese join the ranks of middle class, energy demands will continue to rise, prioritizing the need for energy diversification. At the same the global growing scarcity of natural resources (oil, water, and scarcity of primary resources) will put additional pressure on securing resources (efficient use) or producing alternative material.

2. Environmental Problems
Local environmental problems as well global environmental implications (e.g. climate change) will grow, having an important effect on China. The trend is closely related to the heavy and rapid industrialization process that started 20 years ago, while it will be fueled with the on-going centrally-driven Urbanization process giving rise to the increased demand for arable and residential land.

3. Global Communications
Internet connectivity, VoIP, file sharing, streaming media, social networking, mobile communications, satellite TV and 24/7 new media will be broadly available reaching the new Chinese middle class. More Chinese will be affected by the global cultural influences and ideas, while the direct communication will be even fewer clicks away!

4. Language skills
The modernization of the Chinese education system, the great interconnection with the global culture, and the greater financial capacity of the rising middle class, will make proficiency in foreign languages a standard skill for young Chinese.

5. Private R&D Investment
China's research intensity has tripled since 1998, whereas Europe's has barely increased. The R&D spending is dominated by business spending, reflecting China's push in the manufacturing and information- and communication-technology industries. Last year business R&D spending in China has grown 35,8%[2] (the highest rate globally). The trend is expected to grow, as Chinese companies are increasingly focusing on efficiency and quality, so as to become technology leaders and not only technology and ideas absorbers.

6. Space and Defense
In the space area, China after successfully deploying the Beidu navigation system and becoming the third country to drive a spacecraft on the moon plans to provide commercial launch services, to build a space station and to further explore the moon and near space. Parallel to space exploration, China is increasingly investing on defense technologies, and modernizing its army. Territorial disputes are expected to further support this trend.

2. Booz's annual Global Innovation 1000 study

Certain Trends

> **Our scientists need to cultivate scientific ethics; most importantly, they need to uphold the truth, seek truth from facts, and be bold in innovation and tolerant of failure. Only science and the spirit of seeking truth from facts can save China**

Chinese Premier Wen Jiabao, Science magazine, 2008

1. Education System (Primary, Secondary, Higher)
The Chinese education system is under continuous reforms and although the system has substantially improved, it is uncertain whether the government will implement the necessary structural changes at all levels (primary, secondary, higher education), in order for China to become a competitive knowledge-based economy.

Possible Outcomes:
• Critical structural changes at all levels will improve the education system. Primary and Secondary schools will encourage creative and innovative thinking and China will become a champion in the OECD PISA test. Universities will become more international and open, able to foster excellence by encouraging new ideas and independent initiatives. A new transparent evaluation system for professors and universities will further boost the modernization of the Chinese public and private universities; or
• Modest reforms will hinder the improvement of the education system. Creativity, Research and Excellence will grow on a slow rate, keeping China away from the top global performers. Or
• The abolishment of the Huku registration system might cause funding issues on education.

2. Governance and social peace
During the last decades, the performance of the Chinese government has been considered successful taken into account the impressive development of the country. There is however great uncertainty with regards the future prospects for greater transparency, fair justice system and better protection of civil rights.

Possible Outcomes:
• The governance practices will remain relatively stable, but cases of social unrest will become more often fueled by the new media and the rising middle class; or
• Increasing cases of state corruption and continuous oppression of various dissident groups (e.g. ethnic minorities) will drive massive demonstrations mainly in rural areas but also in some cities.
• Substantial reforms in governance and in the juridical system combined with substantial improvement in civil rights have transformed governance and radically improvement the life of the people.

3. Research Framework Conditions
Although R&D investment is increasing rapidly in China, the necessary structural changes required for the modernization of the research framework are not implemented in the same pace. Issues of openness (ideas, etc), the strict hierarchical order, the questioned system of incentives, research integrity, the malfunctioning funding system and the limited interconnection with the businesses are issues to be addressed

Possible Outcomes:
• The research integrity will be improved through a novel evaluation and auditing system promoting ethics and focusing on quality, rather on quantity. At the same time, greater openness will play a key role in collaboration, publication, peer review, criticism, replication, the evaluation of government projects and industry activities; or
• Due to conflicts of interest, only moderate changes have been implemented in the research system, limiting Chinese performance in Research and Innovation.

Certain Trends

4. National Economy
In recent decades, growth has exceeded expectations in China, with an average growth rate of 9%. Besides this successful track record, it is uncertain whether China will be able to maintain a similar growth in the beginning of the new decade and whether it will successfully transform itself from a "made in China" to a "designed in China" market!
Possible Outcomes:
• China will continue making the necessary reforms and will have an impressive average GDP growth rate of 9% until 2025; or
• Although China is implementing substantial reforms, the global climate and the rise of new global actors, limit the GDP average growth rate to 5,7% until 2025; or
• China will not be able to cope with external pressures and internal obstacles, and the average GDP growth is a disappointing 3,6%.

5. IPR
China became the world's top patent filer in 2011, surpassing the United States and Japan as the country steps up innovation to improve its IPR track record. IPR is an important issue for China to be able to become a technology world leader, but the final outcome of the process is still uncertain.

Possible Outcomes:
• As increasingly more Chinese companies become patent holders, they will then have a vested interest in protecting their technology, similar to their international counterparts. More than any other factor, this trend will drive to an effective IPR protection framework in China; or
•China will fail to make all the necessary changes to effectively support IPR protection, partly due to slow judicial enforcement, leading to an innovation gap and causing the relocation of several foreign enterprises.

6. Global Economy
The global economy is slowly recovering from the recent economic crisis (2008-2013) that started in the US and quickly moved to the other side of the Atlantic. The greater interconnection of the global economy creates greater prospects for growth, but also increases the risk for more domino effects in the years to come.

Possible Outcomes:
• New cases of malfunction of the global financial system will produce another global crisis in 2020 causing a collapse of the European Banking system and heavily restraining industrial production and consumption; or
Reforms in the European Banking System and new supervision mechanism of the global banking system will create a global business environment that will foster global prosperity.

WILD CARDS

Wild cards are events that could cause a sudden and rapid radical change. These wild cards are very improbable, because if they occur will change the world as we knew it. Such wild card events can substantially change the evolution of the future and should be taken into account in strategic planning. Wild cards are partly included in some of the current scenarios, and some of them are briefly mentioned here:

• A brief military conflict in the South–East Chinese Sea will stop foreign investment, will shift research funding and focus on defense technologies and will stop bilateral cooperation.

• A nuclear accident might change the current governmental planning for several new nuclear plants in the years to come.

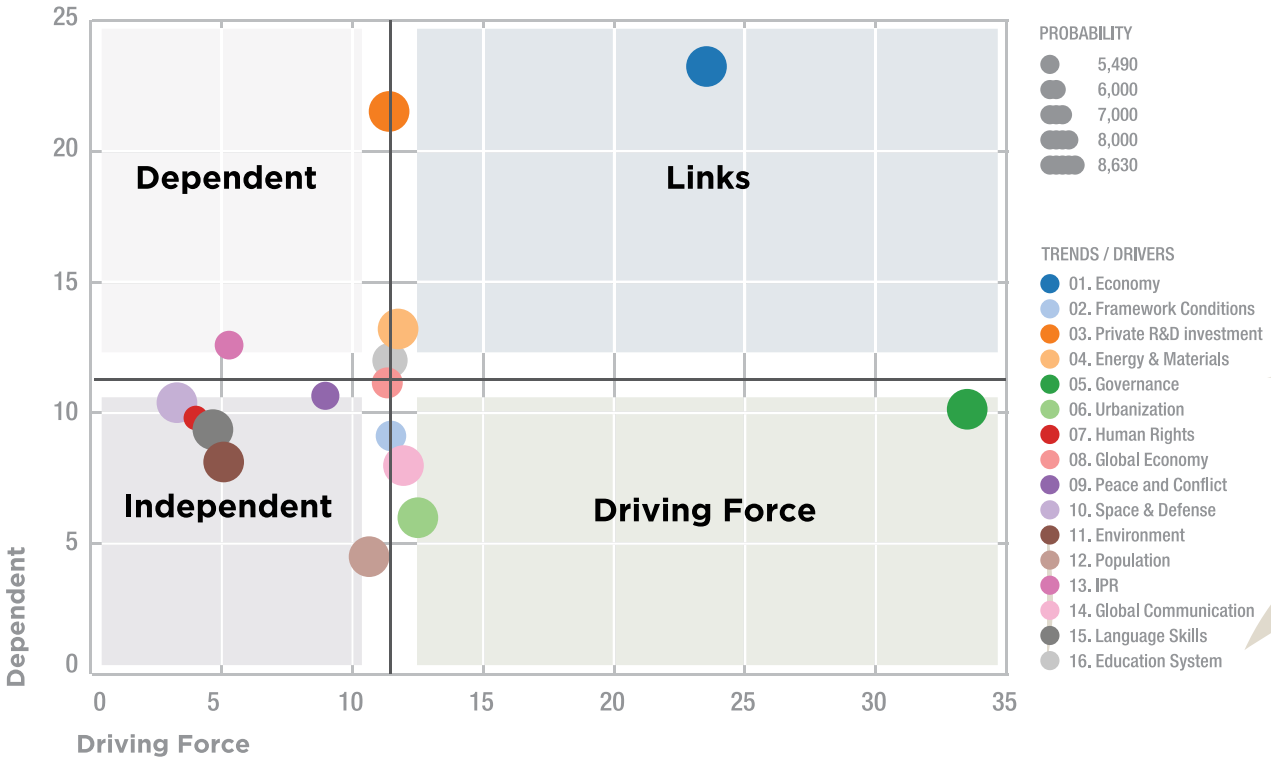
• A massive domino social unrest in the country fueled by poor economic performance, and poor civil rights will radically change the governance model.

• A collapse of the booming property market will cause financial crisis and anger between middle class.

Cross Impact Analysis (CIA)

The Cross-Impact Analysis is an essential part of the scenario methodology that reveals how different trends affect each other, and help analyze the interrelationships between them.

In the first step of the CIA analysis, the influence of every factor/trend upon the other factors was evaluated, highlighting several important findings like the strong role of the National Economy and of the Private R&D investment in transforming the R&D environment, as will the overall strong role of Governance. The graphical visualization of the cross impact analysis (see below), sheds light on a several other issues, such as the seriously interdependent role of IPR.



Sum of Influencing vs. sum of Dependant. Color shows details about Trends/Drivers. Size shows sum of Probability.
The data is filtered on Importance wich ranges from 5,66 to 8,15

The main outcomes of the CIA analysis (graphically presented above), are the following:

- The Governance is the major clear driving force and quite independent by other drivers. Urbanization, Global Communications and the R&D Framework Conditions are other important and quite independent driving forces.
- The National Economy is naturally a major driving as well, and has the strongest interconnections with other drivers. Energy and Resources is also an important driver high several interconnections (e.g. with the Economy and the Environment)
- The Private R&D investment and IPR are both highly dependent by other drivers.
- Several factors with a strong effect on our focal question are strongly dependent by the Governance: Human Rights, IPR issues, Education, Peace & Conflict
- The Environment issues, the Education system, the Language skills, Peace & Conflict, and Human Rights are strongly dependent by other factors (Governance in most of the cases).

And the Future is

This Trend scoping process, was important to identify and study a first set of factors, but also through the online questionnaire and the crowd sourcing tools has initiated a discussion with a broader group of experts, who have already suggested some more issues to consider.

Some initial outcomes could be kept by this first analysis, as are fundamental assumptions for the Future of Research in China by 2025:

• A strong Government Policy and Investment will continue to guide the research, but will also limit it, unless important framework changes are going to take place. In the case of social unrest, the research will also be affected. Moreover, the governmental policies in areas like Foreign Relations and the Space race, is expected to put some focus on defense/space related research.

• The expected Growth of National and Global economy will also support the research, however more financial risks are expected to affect and slow down the development of the research environment.

• The quest for resources and the environmental problems (local and global) will continue to be an important driver, and we could safely expect new technologies on alternative materials, new-generation nuclear plants, as well as on renewable energy.

Moreover, the Cross Impact Analysis and Causal Loop Analysis of the 16 identified trends have revealed that the Governance and the National Economy are the 2 key uncertain strategic trends that affect the development of the research environment. These two strategic trends will become the basis for building our China's scenarios.

Governance and Societal Peace

During the last decades, the performance of the Chinese government has been considered successful taken into account the impressive development of the country. There is however great uncertainty with regards the future prospects for greater transparency, fair justice and better protection of civil rights.

In the recent years, there are several cases of small scale social uprisings in the rural areas mainly due to pressure on ethnic minorities or due to cases of corrupted local governance. However, the main catalyst of change is expected to be the rising Chinese urban middle class.

In China the relationship between the middle class and the state corruption is underpinned by an implicit social contract based on prosperity and social stability. During the last decades, the CCP has supported, in the context of the broader urbanization process, the development of a middle class to drive consumption and serve as a buffer it and relatively deprived groups.[3] Nevertheless, at the same time middle class citizens have higher rate of participation in "rights-upholding" activities and are more likely to pursue legal action to resolve disputes. Given also their superior resources, including personal connections, internet access and financial stability, the rising middle class is expected to become the catalyst of change in governing practices.

For the years to come the Chinese governance under president, Xi Jinping, will have to take decisions towards greater transparency and justice or will move backwards towards a more despotic state.

3. Tom Johnson, Reimaging China's cities, China Dialogues, 2013

Despotic	Governance and Social Peace	Transparent

Each direction will affect dramatically the development of the Chinese society, economy, and education, and thus will shape the Chinese research in 2025.

National Economy

Both Global and National economy are considered important factors on shaping the Chinese Research by 2025. However, it was decided to choose the national economy as the second strategic trend to build upon the scenarios, because:

- There are many ongoing structural changes in the national system, and their success or failure will have dramatic effects in the growth of the Chinese economy and on research.
- During the last years, the Chinese economy has appeared to be quite durable managing to deal successfully with the side effects of the global economic crisis.

The Chinese economy is undergoing a heavy transformation process in order to sustain growth, and to address worsening environmental and social problems. The transformation includes:

- The creation of knowledge based economy, moving from "made in China" to "Designed in China";
- Move from an investment based economy to a consumption based, though supporting the creation of an urban middle class;
- Supporting the development of the services sector
- Changes in the banking system and in the interest rates
- Changes in the ownership rights of agricultural land.

In 2012, the General Secretary of the CCP's Central Committee Hu Jintao stated in his report to the 18th National Congress, that by 2020, on the basis of making China's development more balanced , coordinated and sustainable, the GDP income should be double that of 2010 (that means an annual GDP growth of 7,2%).

By encouraging cleaner industries and the service sector, the government hopes to generate relatively more jobs, as well as clearer skies and waterways. But this transition will require more bank loans, opportunities and policy support to SMEs, and less cheap loans to the State Owned Enterprises (SOEs). It will also need the creation of an innovative Chinese technologies, the successful implementation of the urbanization process and smooth cooperation with the international business partners.

Slow Growth	National Economy	Double GDP

It should be also underlined that the expected emergence of the Chinese consumer could be the greatest global growth engine of this century, benefiting European manufacturing and service enterprises alike.

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FOUR SCENARIOS FOR THE CHINESE RESEARCH IN 2025

The scenarios are not predictions; it is simply not possible to predict the future with certainty. Scenarios are a powerful learning tool that helps us to perceive futures today. The scenarios challenge our mindsets and oblige us to consider a set of potentially uncomfortable futures. The four scenarios will help us suspend the disbelief in all the futures: to allow us to think that any of them might take place – and prepare for them.

Based on the strategic uncertainties described in the previous section, four different scenarios for the future of the Chinese research have been constructed. They are all set in 2025:

Yin & Yang – strong successful central governance combined with greater openness and a flourishing economy determines a cutting edge research community in 2025.

Blue Jasmine– strong and open governance fights to revive the national economy that is hit by a global crisis and the relocation of foreign manufacturing industries, characterizes the situation in 2025.

Dungeons & Dragons – Less open governance, and an insufficient court system support a SOEs based development which seems to still to be successful in 2025.

The Breathless Queen – A broke toxic China, characterized by a collapsed national economy and a dismantled society, seems to be the greatest global disappointment in 2025.

> Prediction is very difficult,
> especially for the Future
>
> Mark Twain, *Author and Humorist*

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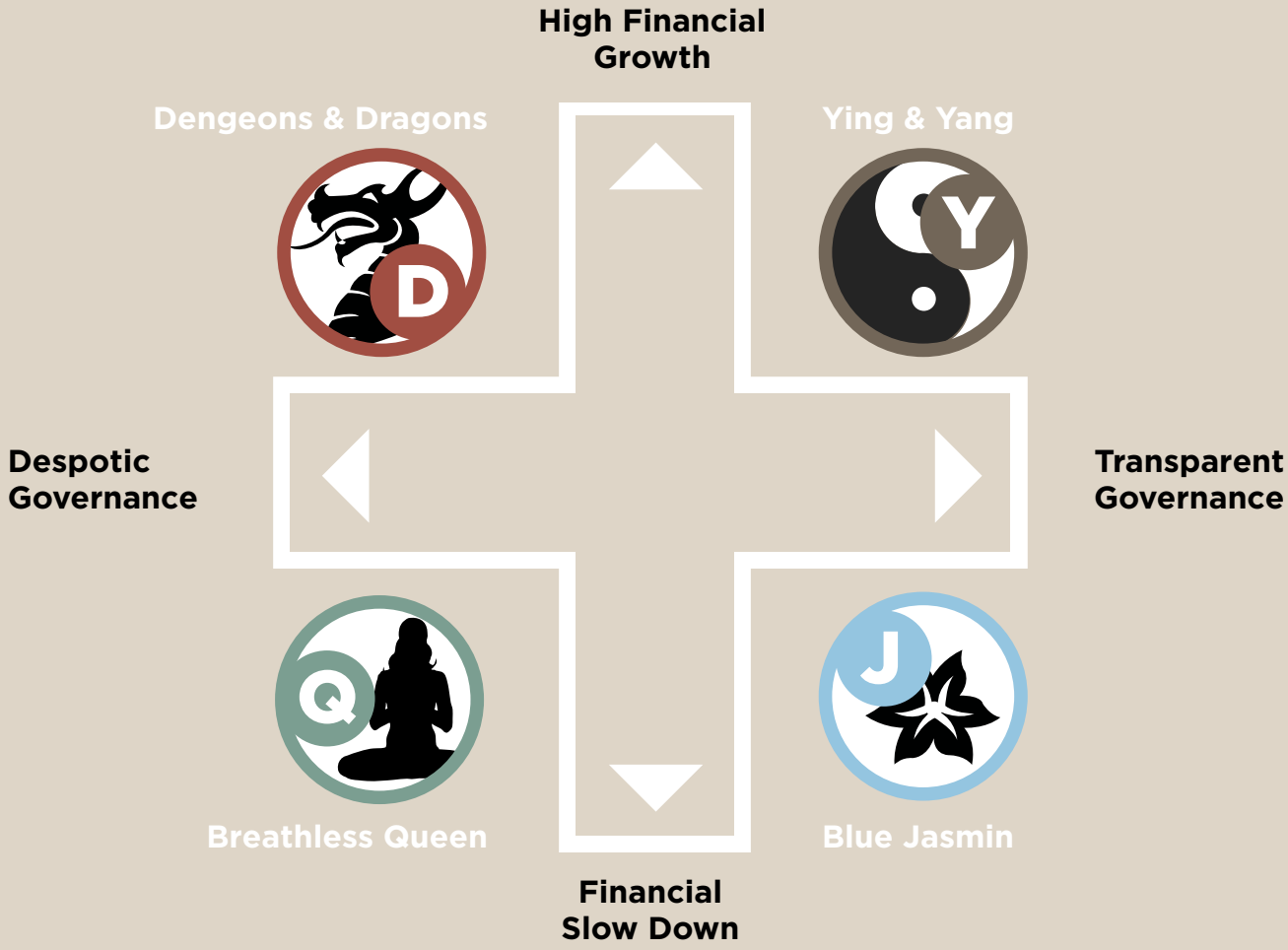

Scenario at a Glance: *The Chinese government under president, Xi Jinping enacted in 2015 substantial reforms to promote transparency ingovernance and the judicial system, inviting, greater participation of the public in local governance. The economy is flourishing and it is now based more on internal consumption, services and high tech exports. Coinciding with moves towards greater transparency, China has emerged as global leader in its investments for R&D. It now boasts the largest amount of public and private R&D investment as a percentage of GDP, and hosts two Nobel Prize winners in Chemistry and Medicine.*

Yin & Yang

Consider the best case scenario of Yin & Yang China. A traveler to China in 2025 will witness a prosperous white-collar middle class interested in civil rights, and environmental conditions and spending their free time playing tennis, driving expensive European and Chinese cars and enjoying high tech products. Although, the one child policy has been loosened, most of the young couples are still having only one child, who, is well educated and speaks fluently in at least, one foreign language. This new urban middle class is paying substantial taxes and in practice became a powerful political force that induced several government policies.

At 2016, a large government driven process has initiated an education and research reform, to prepare well-rounded students with creative and innovative thinking skills, and more self-motivated energetic researchers. The transformation of the education system has also changed the society and the economy, making China a true knowledge economy by 2025.

In 2018 Huawei has managed to reach the 1st place in global smart phone sales, due to novel energy efficiency and an ultra-light phone, while Lenovo is also within the top 5. At the other side, Chinese automakers have improved quality but due to intense market completion, have not managed to gain a substantial share in the European market.

The complete abolishment of the Hukou registration system in 2020, has radically improved the quality of life of migrant workers who are now slowly integrating in the urban communities and increase consumption. To serve the needs of the increased population, Chinese megacities heavily invested in novel health technologies and services, bringing Chinese companies to the forefront of the sector.

In 2020, China's internal market became so important, that the country's prosperity is no longer dependent on exports and foreign investments. Thus, the country managed to deal successfully the new global economic crisis that busted in 2022.

In 2025, the CCP is still the only party but the increased transparency, the easy access to public information and the successfully reformed judicial system, has changed the relationship between the party and the people. The State, during the last decade has showed and increasing positive reaction to addressing people's needs for a cleaner environment, transparent land management and easier access to global information.

A major driver for growth was also the transformation of the research framework in the country. Research integrity has been improved through a novel evaluation and auditing system promotes ethics and focuses on quality, rather on quantity. At the same time greater openness is now playing a key role in collaboration, publication, peer review, criticism, replication, and evaluation of government projects and industry activities. As

a result China has enjoyed two Nobel Prize winners in Medicine and Chemistry.

Private R&D investment has steadily increased after the global financial crisis of 2008, who has been initially driven by the SOEs and big private corporations, coinciding with the creation of several High Tech Funds to SMEs gain greater access to risk capital. The rise of global Chinese High tech brands was also fueled by the modernization of the IPR system that initiated in 2015, and allowed secure investments in technology sectors by local and foreign players.

In 2025, China is already a high-income country rivaling with the EU and USA for access to natural resources, and has emerged as a global super power projecting confidence and prosperity to the rest of the world, and especially with bordering countries. China has started already in 2024 the construction of the Chinese space station and plans the first lunar base by 2040, whereas the «one belt one road" initiative (Asian economic integration with the rest of the world) it's moving towards its completion almost at the same time.

Moreover, China became the global leader of low-carbon economic change, engendering a viable alternative development strategy for less developed economies to follow as opposed to the traditional industrialization transitioning phase.

The main topics of research interest are green energy; novel nuclear plants (Pebble bed reactors); alternative raw materials; IT (especially data processing and transmission); energy storage & distribution; seminconductor devices and electric solid state devices; sensors; micro organsims and enzymes; health (e-health, regenerative medicine, preventive care, oncology, lung and gastric cancer etc) bioeconomy; treatment of water/waster water/ sewage; defense and space technologies.

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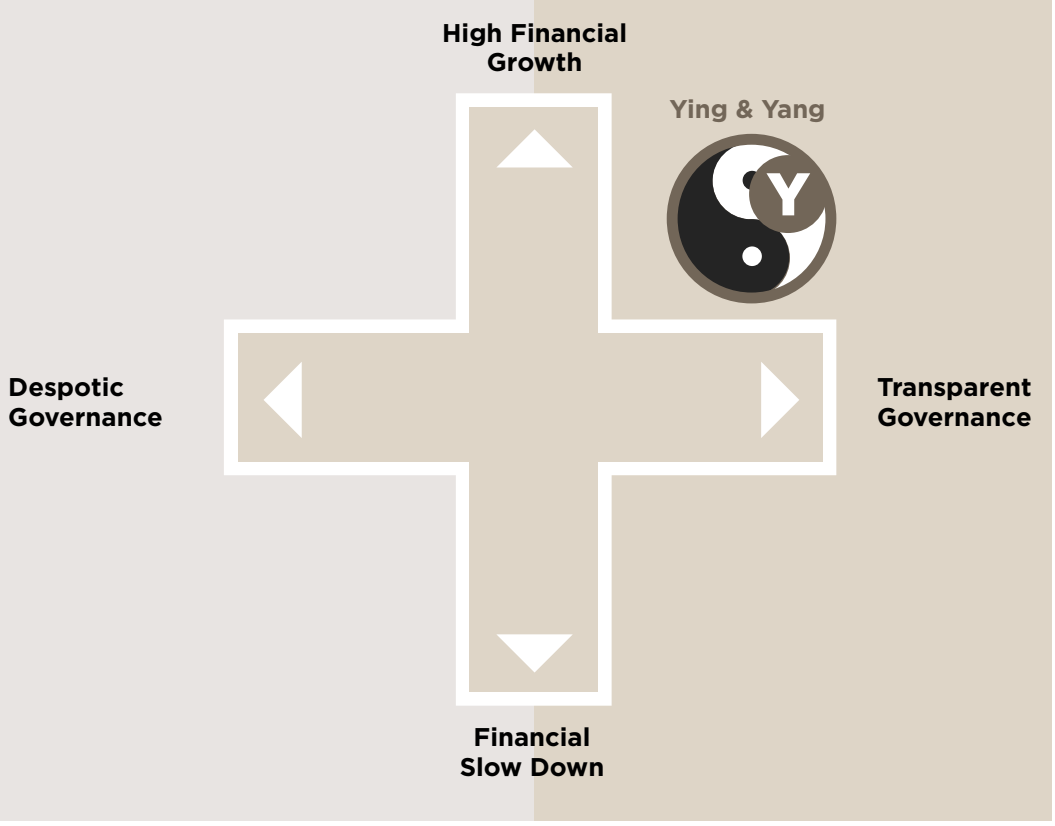

Scenario at a Glance: *The Chinese government under president, Xi Jinping has started in 2015 substantial reforms towards greater transparency and social balance. However it was proved impossible to circumvent the barriers erected by conservative elements within the CCP. A new president was elected in 2018, driving the country in the opposite direction. The new authoritarian governance has managed to maintain high growth rates due to, as well as cost innovations, innovations in ICT, defense, space, and transport technologies.*

Dungeons and Dragons

In contrast to the previous scenario, China regresses in terms of transparency and openness, however the economy manages to maintain substantial growth rates. Travelling to China in 2025, will require passing through a strict visa issuing process reflecting a strong policy to control the movement of people and ideas. All the western social media, including BOB (the successor of Facebook), are banned in the country, thus only the Chinese social platforms are available. WE (the successor of WeChat) is the main communication platform which is now widely spread globally.

The shift towards a more authoritarian governance and stricter censorship were initiated after a series of social and ethnic uprisings in Hong-Kong and other areas, and the failure of Xi Jinping to convince - key Communist Party officials-, for the need to continue reforms. In 2018, besides the successful financial strategies of the previous president, Dr. Le Tsedung was elected as the new president of the PRC. Dr Tsedung has successfully created a dynamic Chinese economy based both on cost innovations, and more efficient management of the SOEs allowing them to gain competitive advantage in specific technological areas (ICT, defense, space, nuclear energy, transport, materials, etc). China has started already in 2023 to produce and sell competitive long-range passenger airplanes, while Chinese fast trains hold a big stake of the global market.

Besides the financial success for many years, the short term military conflicts in 2021 and 2022 with Japan and the financial embargo imposed by the EU and USA, have slowed the growth rates during the last 3 years and obliged China to strengthen the commercial and research relations with non-western emerging economies and with several African and South and Central Asian countries.

In 2024, an agreement has been finally concluded between the entire East and the South-East Asian countries, regarding the exclusive economic zones (EEZ) in the East and South-East Chinese Sea, flagging a new era of regional cooperation and peace.

Reforms in the Education system are modest but ultimately hinder the development of a true knowledge economy. At the same time, Research Framework conditions have been restructured towards global models, however authorities still favor specific groups and interests. Communication hurdles and cronyism have further hampered

collaboration with international R&D partners, and decreased national outputs of disruptive technologies. Openness, innovative culture and creativity can be found in isolated "islands" with the state blessing, good financing and only on topics that are on the state's top priority like, defense.

In order to keep up with its main role as a global growth engine and to maintain a steady growth in GDP, the country implements short term policies like easing credit controls, decreasing interest rates, and easing consumer credit. As growth and job creation is the priority, in many cases production overrides any concerns about the environment and working conditions, resulting in serious industrial chemical accident in 2019 in Donguan.

The main topics of research interest are military technologies; Gen IV nuclear power plants; alternative raw materials; hydrocarbon fuel from bacteria, IT; transport and space; security; sensors; health technologies; water/sewage cleaning; GMOs.

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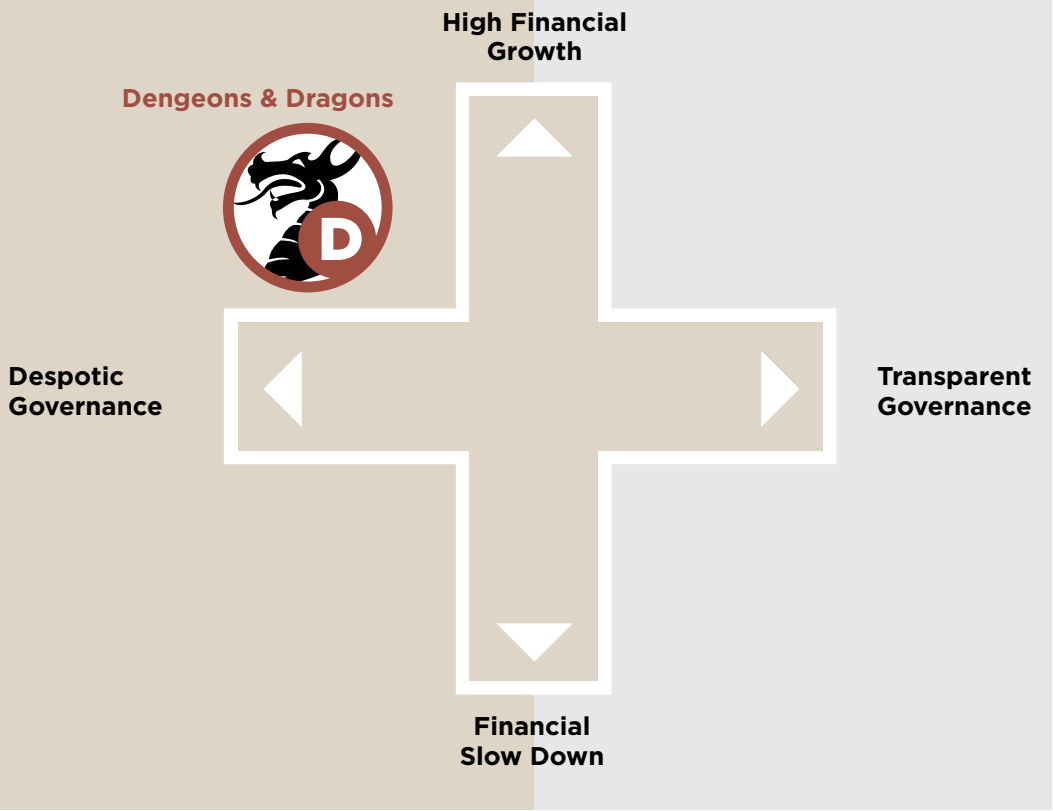


Scenario at a Glance: *The Chinese government under president, Xi Jinping has started in 2015 substantial reforms in the transparency of governance and the judicial system, that were further enforced with the support of a dynamic urban middle class. Mr. Jinping has received a popular support by the CCP and the public and was re-elected in 2018, however the huge amount of public debt (of central and regional governments) and the global "Rare Earth Metals crisis" of 2022, have stagnated the Chinese economy. Nevertheless, Chinese research is thriving driven by the substantial reforms in the National research system that initiated in 2017 and by many international research cooperations, especially in the fields of alternative materials, biotechnology and health.*

Blue Jasmine

In 2025, Xi Jinping's dream for a Strong China (economically, politically, diplomatically, scientifically, militarily), Civilized China (equity and fairness, rich culture, high morals), Harmonious China (amity among social classes),Beautiful China (healthy environment, low pollution), is partly realized, while the country has seen the building of several 'green' cities fueled completely by solar, wind and other forms of low-cabin intensive sources. During the last 10 years, there has been a steady decrease in air and water emissions, coinciding with increased efforts to enact local government environmental policies and a growing Urban Middle Class, have considerably improved environmental conditions. However still the problems of clean air and water scarcity remains top in the political and research agenda.

The Chinese education system has been radically modernized and upgraded, in terms of creativity and meritocracy, providing momentum for an innovative knowledge economy. A number of critical structural changes at all levels have improved the education system, and boosted open innovation and strengthened China's position in the global R&D arena. In 2018, the second term in power of president Xi Jinping, has started with strong reforms towards greater openness, transparency and more rights to ethnic and religious minorities.

At the same time the research reform that had been announced in 2014, and began implementation in 2016, has rapidly transformed the Chinese research environment towards, greater transparency in the management of funds, greater flexibility, better strategic focus and stronger international links.

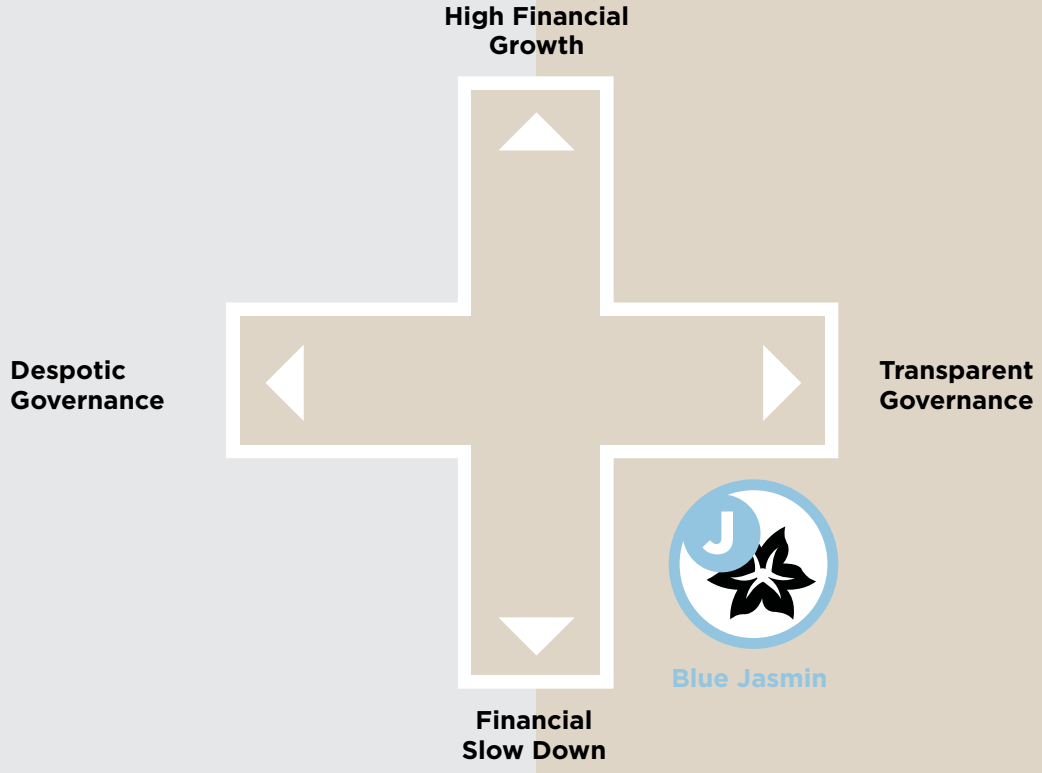
The Implementation of the Medium and Long Term S&T Development Plan (2006-2020) and the Five-Year-Plans for Science and Technology Development have led to an increase in SME's funding, and to a more transparent and efficient IPR law enforcement (seeing increasing numbers of foreigner filling patents in China). At the same time, private investments guide research both on high tech technologies and copy innovations, as state funding is now limited due to the economic slowdown.

Besides, the technological, and societal advances the country was hardly hit by the global "Rare Earth Metal Crisis" that boosted the prices of many rare earth metals, creating a

domino effect in the global economy and seriously affecting the Chinese economy, that was also already bearing a great debt due the reforms in the Hukou system.

The main topics of research interest are alternative raw materials; energy storage and distribution; IT (5G, data management, internet of things, etc.); preventive care; sustainable land use; environmental technologies (soil & water cleaning, emission control, etc.); renewable energy (solar plants, biomass, etc.); and biotechnology and less effort and resources will be heading to natural sciences

3



Scenario at a Glance: *China emerges as a 'fragile' superpower, which can be likened to the Soviet Union of the 80s. The shortsighted and insufficient financial reforms have curtailed the growth rate to below 3%, fuelling several social side effects. Social unrests led by the middle-class and ethnic minorities are creating a great deal of unrest in the Chinese society. The old-fashioned research system has limited funds and cannot follow the advances in space race, energy or biotechnology.*

The Breathless Queen

The first years of president Xi Jinping were quite successful, however criticisms from within the CCP objected to President Xi's massive reforms and the improper management of the student uprisings in Hong Kong (2014) and Xinjiang (2017) by Uyghurs. As a result, President Xi was replaced in 2018 by the more hard liner Dr. Le Under the new president, ACFTU[4] continues to hinder the operation of independent trade unions, and violent trade disputes are common.

Throughout Breathless Queen the operation of court system has regressed, and is again heavily influenced by local party officials, making it impossible for the people to seek justice, and giving rise to more social unrest. In an attempt to control the situation, the new presidency has established a more authoritarian style of governance, applying stricter censorship, and transferring impressive powers to the cyber police and to the secret police.

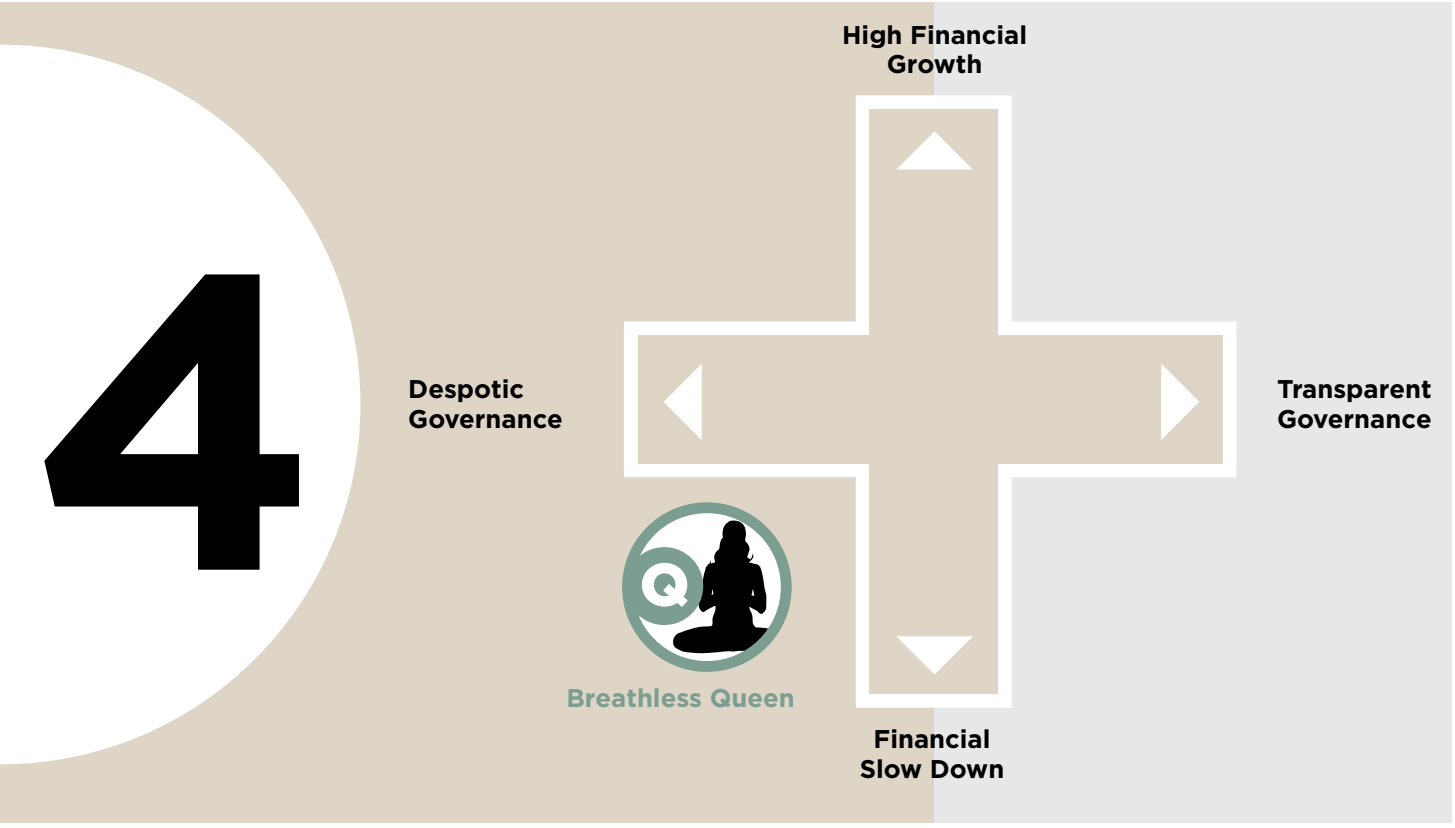
Under this scenario, China has completely failed to transform from an export driven economy to one based on internal consumption. Gradually, foreign companies have lost interest investing and manufacturing products in China and moved to other areas in South Asia, Latin America and Africa.
At the same time, the shortsightedness of the financial reforms imposed by the new government have limited the annual growth rate below 3%, fuelling a domino of several side effects (unemployment, unrest, terrorism, rising public debt, etc).
However, the financial embargos imposed in 2023 by the global community, due to severe civil rights violations, seem to initiate a policy shift but still the final direction remains to be seen.

The Chinese education system is underfunded for several years and the important modernization reforms introduced in 2017 have now stopped, due to funding limitations and lack of political will. Naturally, the research environment was equally affected by the crisis, due to the reduced public and private R&D funding, the old-fashioned research framework, global isolation, and the absence of a realistic long-term strategy. Instead of openness and meritocracy, we see the return of bureaucracy and nepotism. The main

4. All China Federations of Trade Unions

outcomes are less creativity, low innovation rates and many young minds moving to innovation hubs in S. Asia, the EU and the USA.

In this context, research is focused in specific priority areas (like defense, security, and telecommunications) where China remains competitive. Other topics of interest are nuclear energy, chemistry & materials, transport and space; security; GMOs, and less effort and resources will be heading to natural sciences

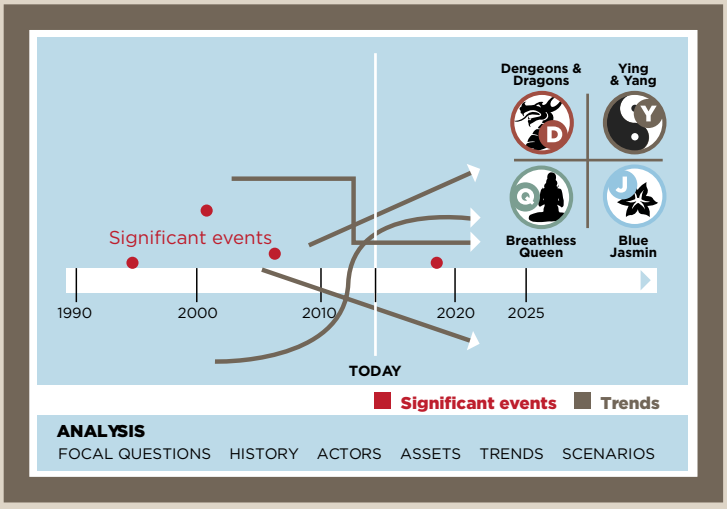


ANNEX

DRAGON | STAR

Annex 1: **Methodology**

The foresight work in the context of the DRAGON-STAR project has utilized both traditional and modern foresight tools for understanding the rapidly changing and complex (research) environment in China, in order to produce plausible scenarios for the Future of Research in China in 2025.
A scenario however is not a forecast! It is a method for imagining possible futures that will assist an organization to take the right strategic decisions. It provides the tools to identify and understand strong trends, as well as weak signals that will shape the future environment.



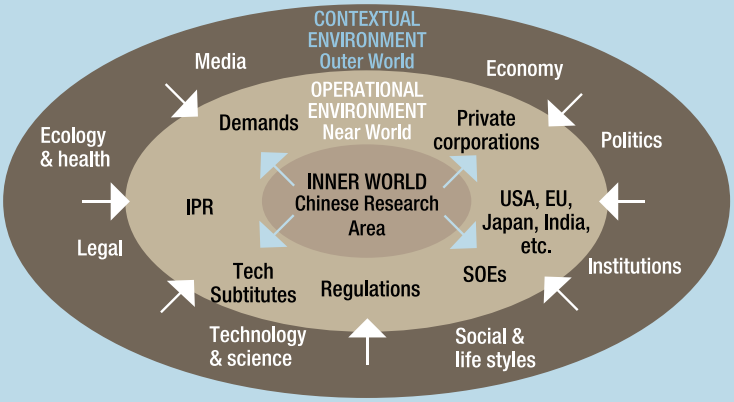
The current work is structured upon the following steps:

1. Definition of the Focal Question

The main task was to produce plausible scenarios about the Future of Research in China in 2025.
Having that in mind, the trends scanning was limited to identify the main factors that will shape the research environment in China during the next 15 years.
The client of this study is the European Commission, thus, the main interest is to provide some scenarios and visualize some plausible futures, which will assist the better formulation of the strategic decisions today.

2. Definition of the System

Definition of the Inner World, of the Near World and of the contextual Environment. The main actors of the system (internal and external) was identified and analyzed.



3. History

The historical development of the System (see step 2) affecting the research in China was studied in order to better understand the current and future trends, and identify unexpected developments.

4. Trend spotting

A relatively large list of "strong" trends affecting (directly or indirectly) the research in China has been composed.

The trends have been identified through different tools:

- Media scanning desk-study,
- Media Watch
- Guruing (interviews with experts)
- on-line questionnaires

Finally, a crowd sourcing platform, Co:tunity, was also utilized. Co:tunity is a multi-functional Smartphone and web application for collaborative trends potting and innovation developed by Kairos Future and provided for use to the DRAGON-STAR team. Co:tunity was utilized to easily gather, share, develop and analyze trends and ideas.

Co:tunity

Read more about Co:tunity: http://www.cotunity.com

5. Evaluation of Trends

The importance of the identified trends and the possibility of these trends to occur have been discussed internally by the task team, but in addition further input was requested by a broader group of experts around the world (China, Europe and Globally). The feedback from the 41 experts was collected by an online questionnaire (Delphi Study). The 41 experts were evenly distributed around the globe, and coming from different backgrounds (research, business, consultancy, etc).

After taking into account the feedback of the experts, the task team has selected 16 major trends for further analysis.

6. Trends Analysis

Find driving forces and specify consequences of the main selected trends.

In addition, specific information on the current technological and innovation trends was provided by KAIROS Future (Check Annex 2). This information was essential for identifying specific technological areas of high importance and for composing the final scenarios.

7. Trend Progress

An analysis of the main trends and especially with regards to their development pattern, saturation level, speeds, etc.

8. Trend Impact Analysis (TIA)

An in-depth analysis of the impact of the main selected trends on the FQ.

9. Cross Impact Analysis (CIA)

A further analysis of the influence of the different trends.

10. Consequence trees

The construction of tree-structures for the main trends that will reveal their driving forces and their consequences.
The outcome of this analysis will feed the scenario-making process in order to identify some plausible futures for the Research in China in 2025.

Finally, the final draft of this report was validated by three (3) independent experts that provided comments and corrections on the suggested scenarios and trends:

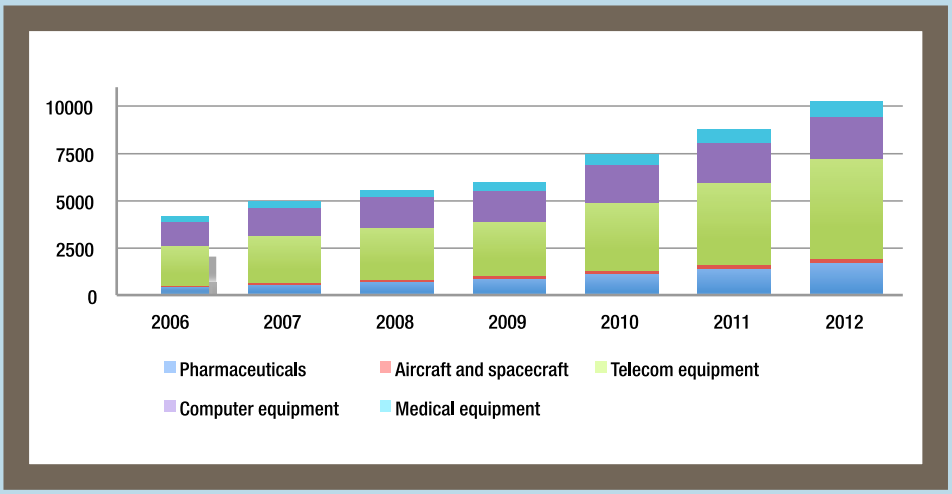
- Ass. Prof Anthony Howell,
School of Economics at Peking University, Beijing, China
- Mr Rikard Wallin,
Managing Director at NCAB Group Sweden AB, Stockholm, Sweden
- Prof. Daoliang Lee,
China Agricultural University, Beijing, china

Annex 2: **Technological and Innovation Trends and Indicators**

Growing high-tech exports from China

The diagram below shows China's revenue from high-tech export from 2006 to 2012 (in bn RMB). Telecom equipment has the largest share, followed by computer equipment and pharmaceutical products.

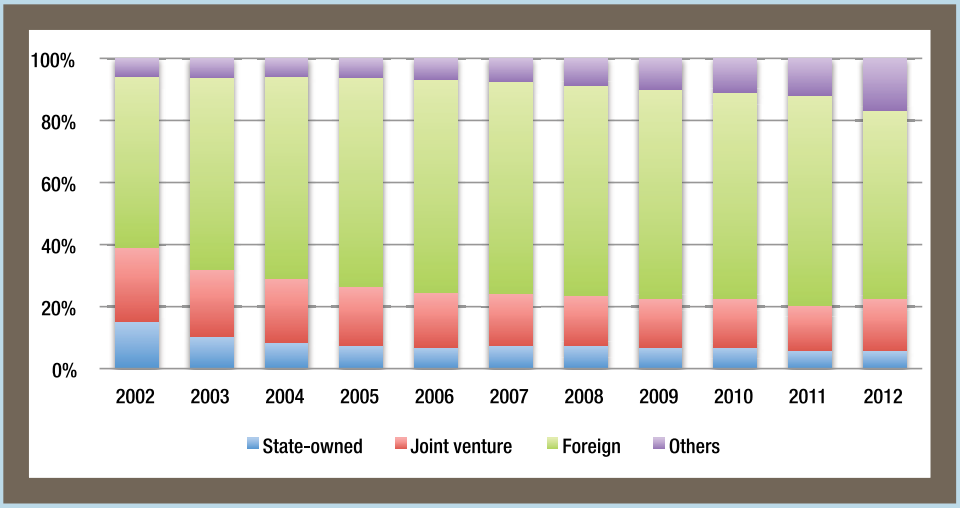
Source: Ministry of Science and Technology of China



Foreign companies are less dominant

The diagram below shows the share of high-tech export by ownership. Even though private, domestic (Chinese) companies are increasing their share, that still remains low as percentage in the total high – tech exports.

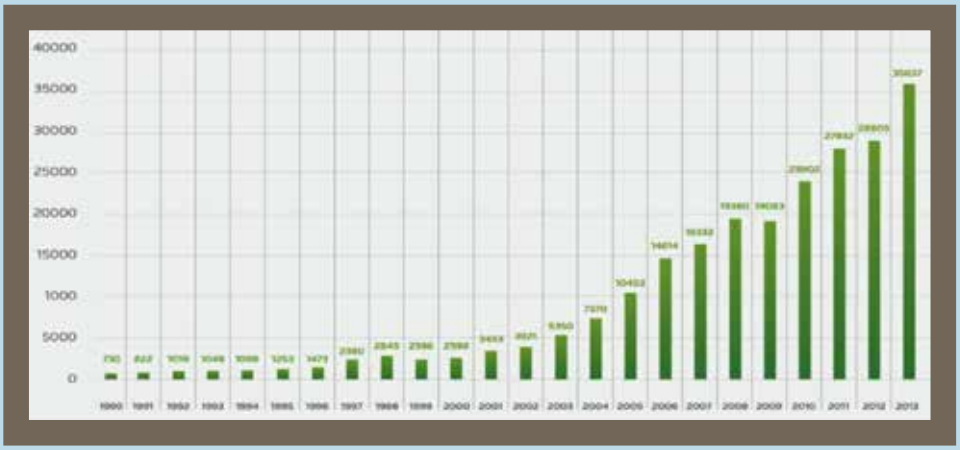
Source: Ministry of Science and Technology of China



Source: Annual report on the development of Chinese returnees 2013,Analysis: Kairos Future

Chinese companies building their brands

International trademark filings by Chinese companies (chart below) have grown rapidly, reflecting an ambition to build international brands.

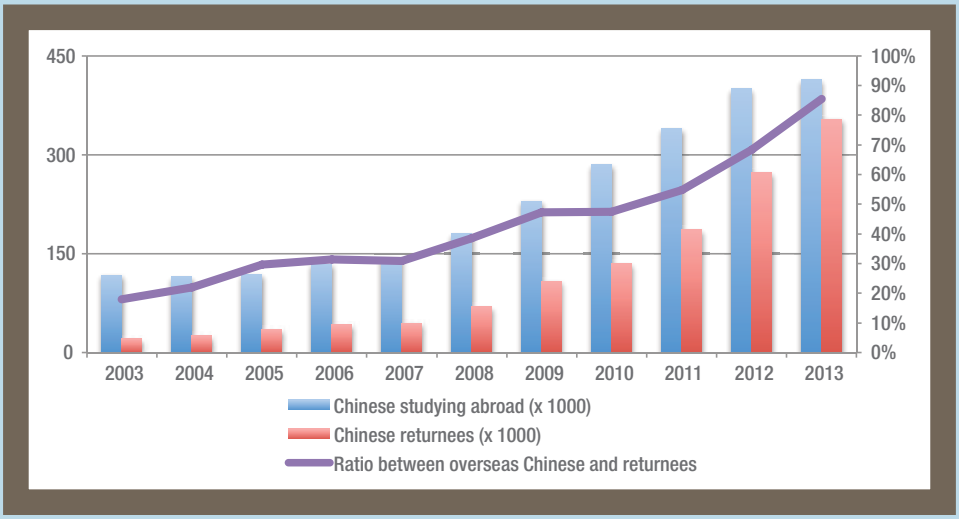


Source: Thomson CompuMark SAEGIS on SERION

Source: KAIROS Future

Overseas Chinese are returning

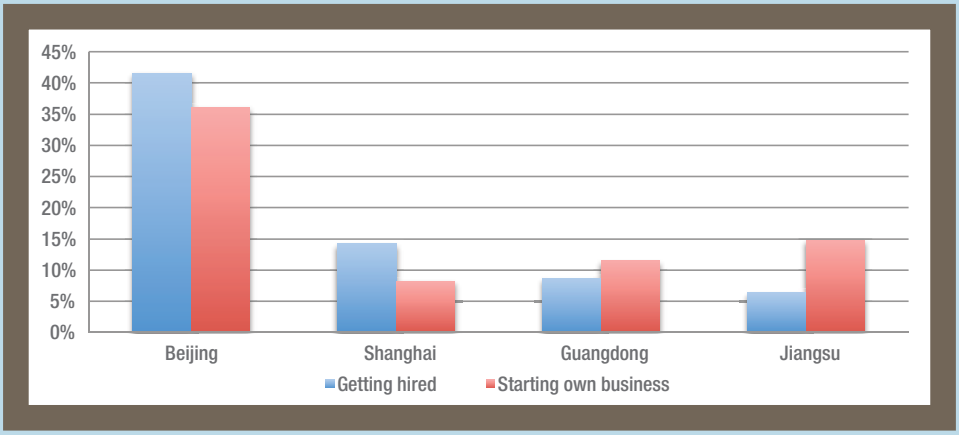
While an increasing number of Chinese are opting to study abroad, more and more Chinese are also returning home. The ratio between the two groups is approaching 0.9.



Source: Innofund, Analysis: Kairos Future

Entrepreneurial returnees go to Beijing

Beijing is the area that attracts the highest number of returnees, followed by Shanghai. Almost half of the returnees opt to start their own business.



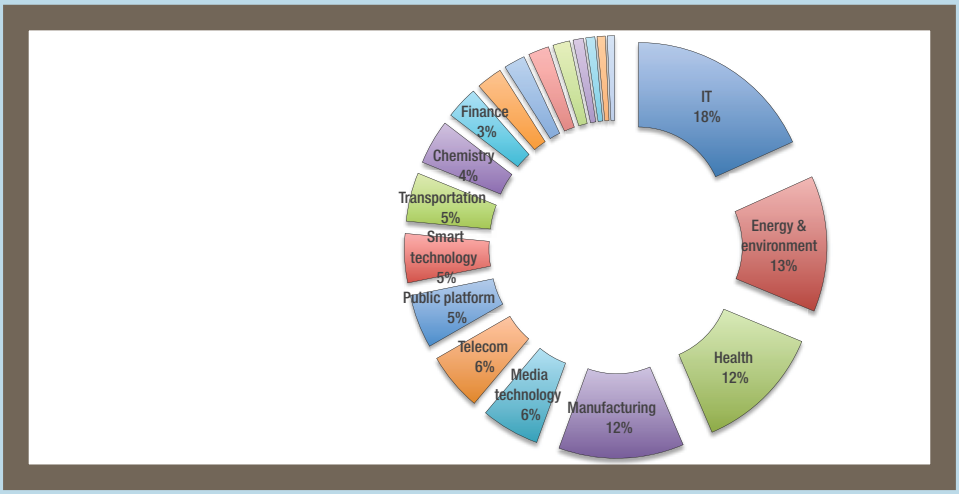
Source: Annual report on the development of Chinese returnees 2013, Analysis: Kairos Future

SMEs innovate in IT, energy and health

Distribution of funding from Innofund, a Chinese government funding program for innovative SME projects, shows activity in IT, energy, health & manufacturing.

Not displayed in the chart:

Security 2%, Education 2%, Mobile internet 2%, E-commerce 2%, Space 1%, Food 1%, Creative work 1%, Urbanization1%

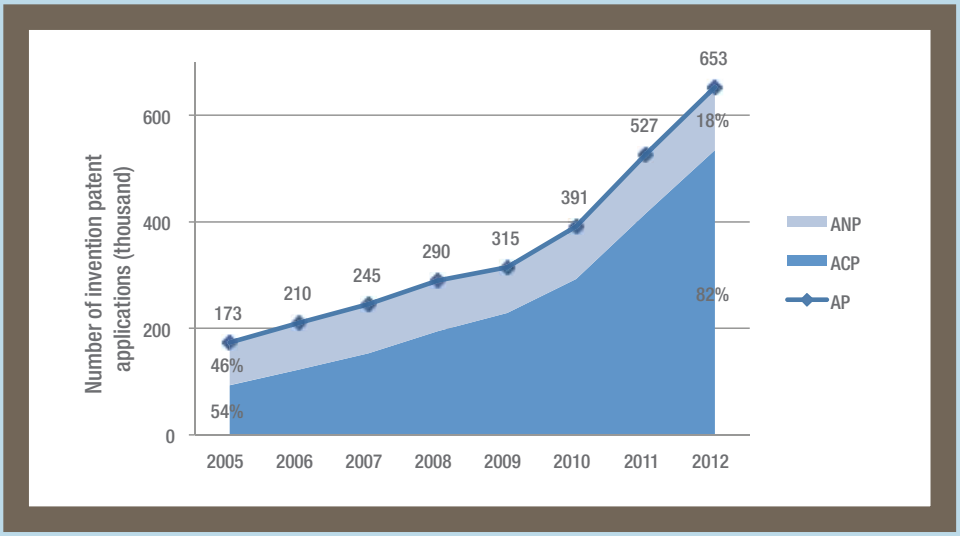


Annex 2: **Technological and Innovation Trends and Indicators**

Chinese companies file more patents

Invention patent applications are growing (see chart below); Chinese entities occupy a larger share. Incentives have pushed them to codify more of their intellectual property.

ANP: Non-Chinesepriority patent applications;
ACP: Chinesepriority patent applications;
AP: applicationssum.

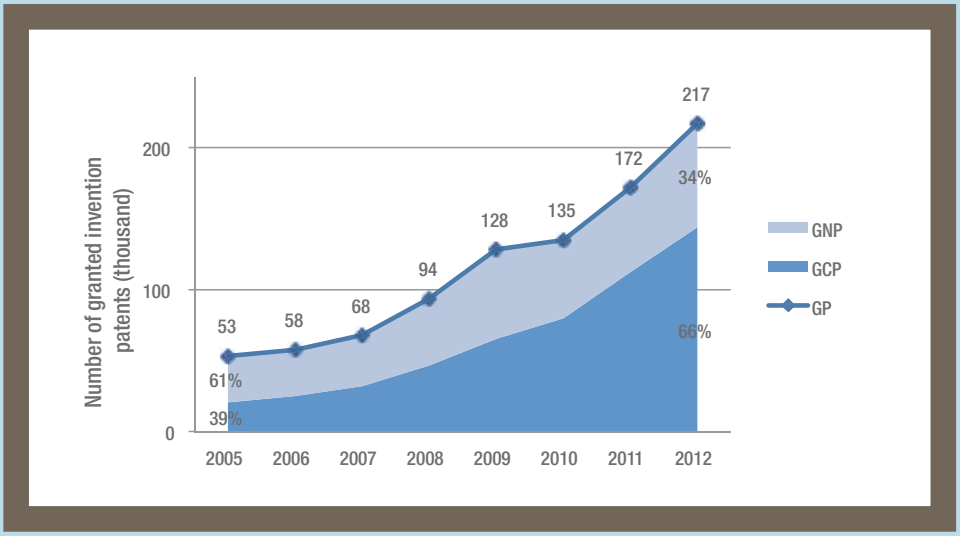


Source: SIPO; Analysis: Kairos Future

Chinese companies are granted more patents

The number of granted patents is rising quickly (see chart below). This happens despite the fact that Chinese authorities raising the bar to bring requirements in line with international practices.

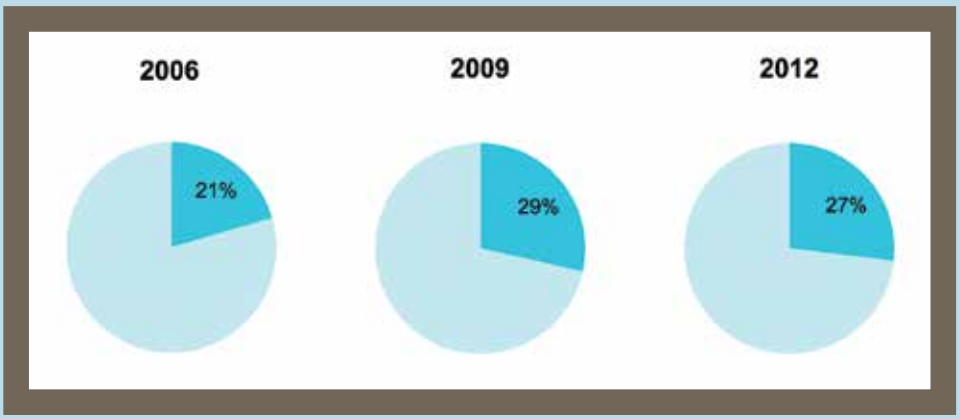
GNP: Non-Chinesepriority patents granted;
GCP: Chinesepriority patents granted;
GP: grantedsum.



Source: SIPO; Analysis: Kairos Future

The quality of patents has not declined

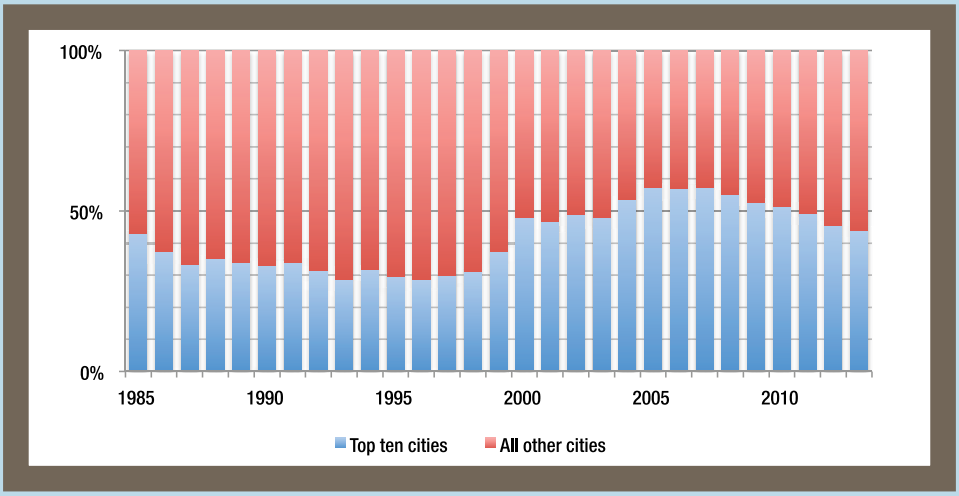
Measured as granted patents' share of applications (see charts below), the quality of Chinese invention patent applications have not declined despite a rapid growth in patenting.



Source: SIPO, Analysis: Kairos Future

Innovation is spreading geographically

Share of patent applications by top 10 cities vs. all other cities (chart) has declined since 2007; R&D is increasingly happening away from the major centers.



Source: SIPO, Analysis: Kairos Future

Cities on the rise

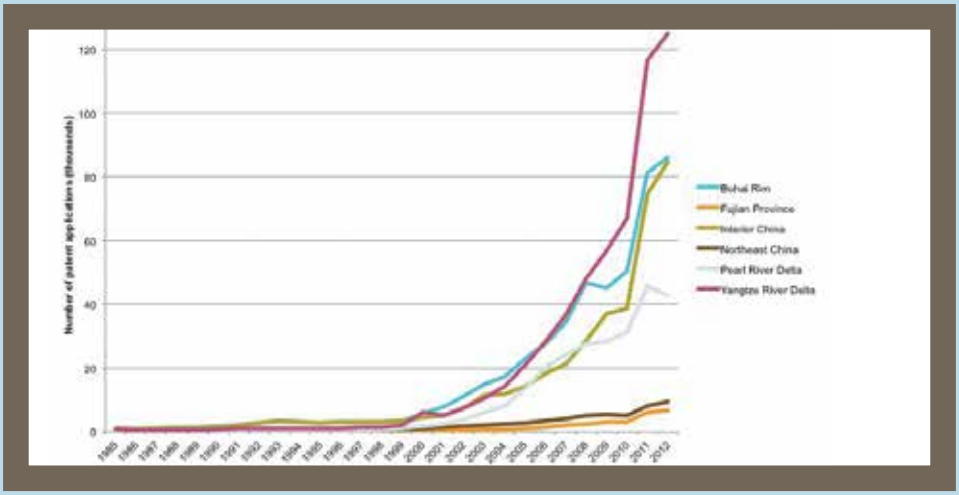
While Beijing, Shanghai, and Shenzhen maintain high R&D activity; other cities (Suzhou, Wuxi, Qingdao, Changzhou, Hefei) are rapidly stepping up their efforts.

Source: SIPO, Analysis: Kairos Future

The Yangtze River Delta is rising

Patenting over time by region (diagram below) shows us, that the Yangtze River delta is taking the lead in patenting activity, followed by the Bohai Rim and Interior China.

Source: SIPO; Analysis: Kairos Future



Source: SIPO, Analysis: Kairos Future

Annex 2: **Technological and Innovation Trends and Indicators**

The backbone of China's R&D

The largest areas of patenting among Chinese entities (table) are telecom, IT, pharmaceuticals, materials, chemistry, and semiconductor technology.

Area of Technology	Number of applications*	Rate of change**
Electrical digital data processing	40,851	87%
Transmission of digital information	26,613	24%
Analysis of materials	25.085	80%
Preparations for medical, dental or toilet purposes	23,231	33%
Semiconductor devices and electric solid state devices	17,200	70%
Wireless communication networks	15,334	-9%
Compositions of macromolecular compounds	12,972	113%
Measuring electric or magnetic variables	12,938	146%
Micro-organisms or enzymes	11,086	62%
Treatment of water, waste-water, sewage, or sludge	10,684	62%
Foods, foodstuffs, or non-alcoholic beverages	10,639	92%
Heterocyclic compounds	10,384	56%
Treatment of natural stone	10,358	83%
Pictorial communication, e.g. TV	10,250	18%
Chemical or physical processes	10,095	52%
Acyclic or carbocyclic compounds	9,903	22%
Systems for electric power supply or distribution	8,986	175%
Separation	8,919	90%
Conversion of chemical into electric energy, e.g. batteries	7,880	90%
Control or regulation of systems	7,106	106%
Heat or laser cutting, soldering, welding	7,019	105%
Coating compositions	6,841	96%
Alloys	6,775	76%
Shaping or joining of plastics	6,585	126%

* Refers to the number of invention patent applications in a given area 2011-2013
** Refers to the growth in the number of invention patent applications between '08-'10 and '11-'13

Fastest growing areas of patenting

The fastest-growing areas of patenting among Chinese entities (table) are mostly low-tech: manufacturing, construction, and agricultural equipment and apparatus.

Area of technology	Numb. Of applications*	Rate of change***
Workshop equipment	538	368%
Cooling and freezing apparatus	2,335	354%
Transport and storage devices	5,562	264%
Layered products	4,005	250%
Handling thin or filamentary material	2,371	246%
Tools or bench devices	2,047	242%
Dredging and soil-shifting	917	241%
Servicing vehicles	511	241%
Hoisting, lifting, and pushing	1,082	234%
Machines for packaging	2,317	233%
Catching of animals	671	231%
Chairs, sofas, and beds	846	222%
Coffee and tea	2,028	221%
Outerwear, protective garments	1,178	210%
Details/components of machine tools	4,000	208%
Soil working in agriculture	682	204%
Electric power boards/substations/switches	1,724	204%
Working of metal sheets/tubes/rods	5,123	203%
Household or table equipment	1,861	202%
Cleaning in general	2,078	200%
Tables, desks, and office furniture	993	198%
Working of wire	519	197%
Fluid systems	1,945	195%
Printing machines and presses	1,094	193%

* Refers to the number of invention patent applications in a given area 2011-2013
** Refers to the growth in the number of invention patent applications between '08-'10 and '11-'13

Specific R&D topics over time

Based on words used in Chinese invention patent abstracts, the focus of Chinese R&D has shifted toward environmental protection, automation, and cloud computing.

1990-1999	• TCM, plants metals, construction, microcomputers, nutrition, vitamins, foods, digital input of Chinese characters
2000-2004	• Nucleotides, DNA, sequencing, tumors, embryonic development, refrigerator, composite materials, civil engineering, SAARS, washing machines
2005-2009	• Immunity, telecom, pharmaceutical
2010-2013	• Environmental protection, solar energy, energy saving, temperature control, motors, cost of production, efficiency, automation, internet, cloud computing

Evolution of the R&D actors' landscape

Key patenting entities now include private companies in electronics, appliances, communications, and IT, as well as SOEs in key sectors and major universities

1990s	• Reemergence of key state-owned companies (Sinopec, State Grid) • Among private companies, domination of electronics, appliances, and communications (Foxconn, ZTE, Huawei, Datang Communications) • Emergence of private companies in IT (Tencent, Qihoo), photoelectronics (Ocean's Lighting, Huaxing Photoelectronic, BOE), and heavy machinery (Zoomlion)
2000-2005	• Reemergence of key state-owned companies (Sinopec, State Grid) • Among private companies, domination of electronics, appliances, and communications (Foxconn, ZTE, Huawei, Datang Communications) • Emergence of private companies in IT (Tencent, Qihoo), photoelectronics (Ocean's Lighting, Huaxing Photoelectronic, BOE), and heavy machinery (Zoomlion)
2006-2010	• Reemergence of key state-owned companies (Sinopec, State Grid) • Among private companies, domination of electronics, appliances, and communications (Foxconn, ZTE, Huawei, Datang Communications) • Emergence of private companies in IT (Tencent, Qihoo), photoelectronics (Ocean's Lighting, Huaxing Photoelectronic, BOE), and heavy machinery (Zoomlion)
2011-2013	• Reemergence of key state-owned companies (Sinopec, State Grid) • Among private companies, domination of electronics, appliances, and communications (Foxconn, ZTE, Huawei, Datang Communications) • Emergence of private companies in IT (Tencent, Qihoo), photoelectronics (Ocean's Lighting, Huaxing Photoelectronic, BOE), and heavy machinery (Zoomlion)

Annex 2: **Technological and Innovation Trends and Indicators**

Main Conclusions

*China's **innovation scene** has seen several changes since the financial crisis and global economic downturn:*

• Domestic companies taking an increasing share of high-tech exports

• A growing focus among domestic companies to build their own international brands, accompanies by a steady growth in the number of trademarks registered overseas.

• An uptick in the number of returnees from overseas, last year almost equaling the number of Chinese leaving the country to study abroad. With over one million returnees since 2009 and almost half of them starting their own business, Chinese with overseas experiences and networks is a growing force in China's innovation ecosystem.

***Geographical patterns** of innovation are changing:*

• While the top ten cities still make up almost half of all invention patent applications in China, their share has been declining since 2007, indicating a shift from the largest innovation centers toward the long tail of smaller cities.

• Cities in interior China – notably Chengdu, Xi'an and Wuhan – are rising rapidly, but the highest momentum are in coastal second and third tier cities, especially Suzhou, Wuxi, Qingdao, Changzhou, Nanjing, and Hangzhou.

• Most of these rising stars are in the Yangtze River Delta which, through a combination of government policy and driven entrepreneurs, is emerging as the major region for R&D in China.

• It is followed by the Bohai Economic Rim, where Qingdao, Jinan, and Dalian are emerging centers of innovation, alongside the incumbent hubs Beijing and Tianjin.

• The Pearl River Delta has lost some of its earlier momentum due to a slowing Shenzhen, where patenting has been dominated by a few large actors (ZTE, Huawei, Foxconn, and Ocean's King). However, Guangzhou as well as the manufacturing hubs of Dongguan, Foshan, and Jiangmenare quickly climbing the value chain.

Innovation in China is driven by a new set of actors:

• The center of gravity of R&D in China has undergone a shift from state research institutes toward universities, from state-owned companies toward private companies, and from the largest R&D actors toward the long tail of smaller actors

• R&D in China is now dominated by major universities, state-owned enterprises in key sectors (notably State Grid and SINOPEC), as well as private companies in areas spanning IT (Tencent, Qihoo, Qizhi), electronics/photoelectronics/microelectronics (Foxconn, Ocean's Lighting, BOE, SMIC), telecom (Huawei. ZTE, Yulong), and heavy machinery (Zoomlion).

The content of the Chinese innovation effort is changing shape:

• While telecom, IT, electronics, and pharmaceuticals remain the backbone of China's R&D effort, the fastest growing areas of patenting are considerably low-tech, relating to the key sectors of manufacturing, construction, and agriculture. This indicates that actors that have traditionally been far down the supply-chain are now moving toward higher value-added. One scenario is that China will see the emergence of its own "Mittelstand" of innovative manufacturers, benefitting from hands-on knowledge of the manufacturing processes that have been outsourced to China throughout the last decades.

• In recent years, Chinese R&D has become increasingly concerned with environmental protection, energy saving, and efficiency.

Annex 3: **Trend Descriptions**

TREND 1

NATIONAL ECONOMY

Description: *The performance of the national economy is directly connected with private and public investment in R&D, and it is an important driver that will define Chinese research performance in the years to come.*

Today, China is the second biggest economy after USA and it is expected to become the largest by midcentury. In addition, China became the world's largest trading nation in 2013, overtaking the US in what Beijing described as "landmark milestone" for the country. China's fast development over the past 30 years has been propelled by cheap labor, huge savings and large scale investments, which has resulted in a widening income gap and low consumption level.

The Chinese economy is currently undergoing a structural change characterized by a Shifting priority from rapid GDP growth to sustainable and inclusive growth and from an export – oriented (cheap labor manufacturing) economy fueled by foreign investments to one in which China's domestic market (increased consumption) is the major engine deriving growth and is based on capital-intensive high-tech and service industries.

China will probably continue its economic growth in the next decade and beyond, due to a combination of factors such as China's solid industrial foundation, newly-built world-class infrastructure, huge savings, high rates of investment (mainly foreign direct investment), large domestic market, human resource advantage, investment in education and finally, the country's commitment to making the transition towards a domestic demand-driven and environmentally-friendly mode of economic growth.

On the other hand, It will be difficult for China to maintain the same high growth rates if rapid structural changes are not implemented in order to create a more sophisticated economy, such as: tax incentives for entrepreneurial innovation, a more decisive role of the market forces in allocating resources, a further opening of the country by widening investment access, a tradable national currency (renminbi), addressing public sector debt, democratizing the domestic market, protecting IPR, etc.

Example 1: The General Secretary of the Communist Party of China's Central Committee, Hu Jintao, stated in his report to the 18th National Congress, that by 2020, on the basis of making China's development more balanced, coordinated and sustainable, the GDP and per capita income should be doubled in comparison to 2010, and for this, China needs to maintain an annual growth of 7.2%.

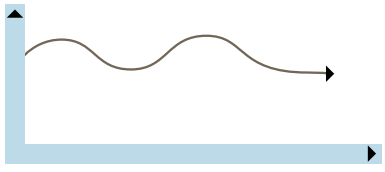
Example 2: Luggage sales in China can be a predictor of economic growth. Samsonite expects a growth in Chinese sales despite cooling of the economy. The company has more than doubled its sales in China in recent years, from $91.8 million in 2010 to $192.2 million in 2013.

Counter Trends: In the 21st century, China will need to address the social and environmental costs of three decades of rapid economic growth: depletion of resources, social peace, polarization of income, shadow banking, and the increased gap between rich and poor.

Driving Forces: Bilateral Economic Relations, FDI[5], technological development, cheap labor, urbanization, domestic consumption, shift in growth pattern, R&D investment, domestic capital, currency policies, etc.

Actors: Chinese Government, enterprises and institutions, foreign banks and domestic investors, etc.

Future: The economy will continue its growth but at a slower pace, overcoming some minor crises.



FUTURE

Consequences: In order to implement the required changes, China will need to invest more in developing domestic high-tech innovations, to secure technological exports, and maintain a competitive advantage. Further research will be required on urbanization, alternative materials and energy. China's moving towards an open economy could create cyclical effects and economic bubbles that would affect R&D investments.

5. Foreign Direct Investment

TREND 2

FRAMEWORK CONDITIONS
(FOR RESEARCH)

Description: *The current main guiding policies for Science, Technology and Innovation include the Medium and Long Term S&T Development Plan (2006-2020) and the Five-Year-Plans for Science and Technology Development (current plan 2011-2015). These plans aim to transform China into an innovative society by 2020. Critical challenges in environment, energy, agriculture, employment and indigenous innovation capabilities have being ranked as of highest importance. In this direction, focus will be on breakthroughs that are required in biotechnologies, ICT, new materials, advanced manufacturing, renewable energy, marine science, laser technology, and aerospace technologies.*

However, the R&D framework is characterized by weaknesses identified also by MoST, such as government micro-management in entrepreneurial activities, the lack of policy transparency and the ineffective intellectual property law enforcement, among others. While R&D investment is increasing rapidly in China, the necessary structural changes required for the modernization of the research framework are not implemented at the same pace. Issues of openness (thoughts, ideas, etc.), the strict hierarchical order, the questioned system of incentives, research integrity, the malfunctioning funding system, and the limited interconnection with business world, are issues which need to be addressed.

Both technology catch-up through technological absorption and innovation at the technological frontiers will rest on several factors, including the success of policies focused on effective competition; the composition of the business sector and its strategic orientation; agile policy making and robust regulation that minimize the risk of crises and prepare the economy to seize evolving opportunities; skill development; research and development (R&D); national and international networking to promote innovation; and the nurturing of innovation especially in the areas of green technologies, health and

Annex 3: **Trend Descriptions**

medical services, and urbanization modes, and in major urban centers.

The importance of clusters, particularly hi-tech clusters in Zhongguancun and Suzhou; manufacturing clusters in Guangdong province and Tianjin; and financial clusters in Shanghai are another critical aspect of Chinese growth and future innovation performance. New clusters such as the Laser cluster which will be built in Wenzhou, may help to catapult China to the forefront of lasers.

Beijing is planning and slowly implementing regulatory and structural reforms for improving the efficiency of the current system, however the success of the current plans and the pace of the reforms are under question.

Example 1: The Minister of Science and Technology, Wan Gang, at the 18th National Congress of the Communist Party, declared that the top priority is the building of a transparent system for the management of research funds.

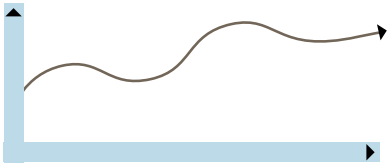
Example 2: Change[6] is coming to the institute that has been at the heart of China's scientific development since the communist State began. The Chinese Academy of Sciences (CAS) is making unprecedented structural reforms to foster collaboration and turbo-charge research.

Counter Trends:
1. Openness[7]: Openness in a broad sense, including thought, expression, social acceptance, attraction and retention of the brightest foreign minds.
2. Confucian legacy: In "western" society, the values of independent thinking and dialectic discourse are deeply ingrained, while the Confucian legacy in China demonstrates a strong respect for the hierarchical order.
3. Publication incentives: The current scientific publication incentives system that besides others, rewards publications with bonuses that excess $30,000, leads to cases of academic corruption and abuse of funds.
4. Technology Transfer bureaucracy: Lengthy procedures for State-owned institutions to commercialize research results.

Driving Forces: Policy changes, cultural changes, global communications, CAS reforms, R&D funding, large enterprises & SMEs, international collaborative research.

Actors: Ministries, research institutes, academies, regional & local government, private sector etc.

Future: Strong government policy and investments will continue to guide research, but will also limit it, unless important framework changes take place. In the case of social unrest, research will also be affected. China's large market size will allow rapid scaling up of successful technologies to achieve economies of scale and reduce unit costs.



Consequences: China can become a high-income country by 2030 through a strategy which combines high levels of investment with rapid advances in disruptive technologies. China's spending on R&D is on a steep upward trend. This spending will increase the generation of ideas and foster innovation.

The commercialization of ideas will flourish and drive productivity only when enterprises make innovation a central axis of their business strategies. Capacity building of Chinese workforce will be enriched, the potential gains in reputation for Chinese cities will come to be seen as science hubs and research can greatly contribute to industrial upgrading. An increase in R&D is being complemented by investments in the physical infrastructure supporting technological upgrading.

6. David Cyranoski, Chinese science gets mass transformation, NATURE, Volume 513, Issue 7519, September 2014, http://www.nature.com/news/chinese-science-gets-mass-transformation-1.15984
7. Kostas Kostarelos, http://www.theguardian.com/science/small-world/2014/jan/24/chinese-science-research-development

Annex 3: **Trend Descriptions**

TREND 3

PRIVATE R&D INVESTMENT

Description: *China is still an absorptive state[8], attracting and profiting from global knowledge. However, in order to maintain a substantial growth rate, China is obliged to become an industrial leader, investing in novel technologies and ideas.*

During 2012, business R&D spending in China grew by 35,8%[9] (the highest rate globally). Overall China's research intensity has tripled since 1998, whereas at the same time Europe's barely increased. R&D spending in China is dominated by the business sector (responsible for almost 75% of the R&D investment in 2012). As a result: 1.High-tech exports of private Chinese companies (non SOE & foreign) have increased (although there is space for further increase), 2. New international technology-based brands have been flourished, and 3. A steady growth in the number of trademarks registered overseas has been witnessed.

The private sector in China will invest more on R&D by 2025, as Chinese companies are increasingly focusing on efficiency and quality, so as to become technology leaders and not only technology and ideas absorbers. SOEs in China have currently edged EU 28 in terms of R&D intensity, falling behind Korea, USA, Japan and other OECD countries, but heavily spending to catch up with an annual growth rate of 18% since 2000. Enterprises have become the main players as regards R&D output, reflecting China's push in terms of IT, electronics, photo electronics, microelectronics, telecommunications (e.g. 5G) , health, automotive, railways, aerospace, defense, energy (including nuclear), and manufacturing industries.

Example: In 1995, 63.4% of the total transactions on the technology market were realized by enterprises. By 2009 that percentage had risen to 77.3%. In 2009, 86.6% of all contracted technology was exported by enterprises (both joint ventures and domestic).

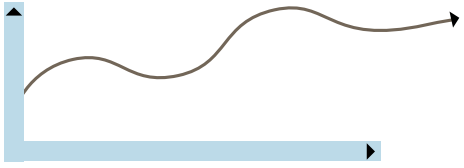
Counter Trends:

Slowing economic growth, accompanied by the stressed financial situation of companies (especially private), who already have steadily falling returns on investment. In addition a foggy IPR system could make them reluctant to invest in R&D and other long-term projects, preferring short-term activities away from basic research and start-ups.

Driving Forces: Property and IPR rights' system and laws, financial system and capital availability even for high-risk innovative projects, education and research framework, China's position in global value-added chains by developing and producing high-tech products.

Actors: SMEs, State-owned enterprises, large and medium-size enterprises, regional and Government funding, Venture Capital and other funds, foreign investors, Foreign Multinational Enterprises

Future: Private R&D investments will continue to increase addressing technological needs and future challenges. China will transform into a competitive producer of high-tech products and services.



FUTURE

Consequences:

- More competitive companies
- National Economy improvement
- Increase in venture Capital companies and funds
- Increase of the stock market alternatives for high-tech and high-risk investments,
- Competition with the rest of the world for highly-skilled manpower will remain intense,
- More Chinese brands will compete in the global market,
- R&D activities will be added to corporate innovation strategies, especially for firms active in ICT, Agro, Biotech, Energy, Materials, Environment, Aerospace, etc.

8. China's Absorptive State, NESTA, 2013
9. Booz's annual Global Innovation 1000 study

TREND 4

ENERGY & MATERIALS

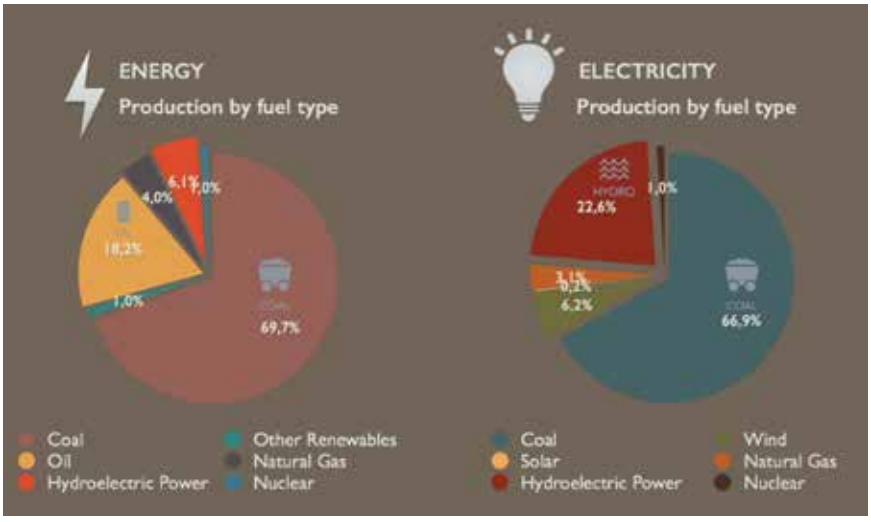
Description: *As the Chinese economy continues to grow, the need for (cleaner and more efficient) energy and the quest for raw and alternative materials are rising. At the same time, the globally growing scarcity of natural resources (petrol, water, and rare earth materials) will add additional pressure on efficient use of resources or producing alternative materials.*

China is the world's most populous country and the largest energy consumer in the world. Rapidly increasing energy demand has made China extremely influential in world energy markets. Coal is a highly important energy source for China, and China is the largest producer and consumer of coal in the world, accounting for almost half of the world's coal consumption. Naturally, China's electricity generation is dominated by fossil fuel sources, and especially coal.

China is the world's second-largest consumer of oil behind the United States, and the second-largest net importer of oil as of 2009. At the same time, China's largest oil fields are mature and production has peaked, leading companies to focus on developing largely untapped reserves in the western interior provinces and offshore fields. The Chinese government has made the expansion of natural gas-fired and renewable power plants as well as electricity transmission a priority. China possesses the world's largest capacity for renewable energy generation. It is a world leader in small hydroelectricity generation. It has been doubling its wind-driven turbine capacity every year since 2005. In addition, it has become the world's largest manufacturer of solar panels. However, renewable energy sources might prove to be incapable of dealing with the increasing energy needs. It should also be noted that China is currently a moderate nuclear energy producer; while government plans to nuclear capacity to reach 70 GW by 2020.

China exports of rare earth minerals meets 97% of world demand. However, the complex production process, combined with environmental risks, results in low revenue. Further innovations may increase China's global position

Annex 3: **Trend Descriptions**



and ability to profit. As there is currently an increasing desire for rare earth metals, fueled by the increasing demand from local industries. China has reduced or even banned the export of some scarce raw minerals and is investing in land mines in Africa and other continents.

In addition, climate change, resource depletion and biodiversity risks will increase investment in key areas of low–carbon and sustainable innovation, that will enable China to lead globally in these sectors as they grow.

Concerned that past and current economic growth patterns are environmentally unsustainable and that the environmental base needed to sustain economic prosperity may be irreversibly altered, the Chinese authorities proposed a new approach toward green development in the 12th Five-Year Plan. The plan emphasizes continued rapid growth, together with ambitious targets for energy efficiency, natural resource management, and environmental sustainability.

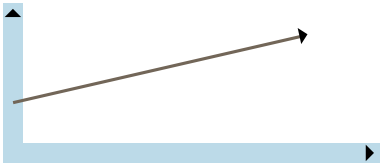
Example 1: The Three Gorges Dam hydroelectric facility, the largest hydroelectric project in the world, started operations in 2003 and completed construction in 2012.
Example 2: In 2012, China invested US $65.1 billion in renewable, a 20 % increase from the previous year.

Counter Trends:
• Excessive dependence on administrative mechanisms to deal with environmental and natural resource management issues.
• While a green development strategy will be of considerable benefit in the long run, in the short term it will conflict with other economic objectives (for example, meeting employment and industrial targets for the five-year plan).
• A slower financial growth or a financial meltdown will delay the developments.

Driving Forces: Scarcity of resources, uneven geographical distribution of water resources; rapid economic development and urbanization with a large and growing population; poor water resource management, climate change and other environmental problems, energy demand, new technological breakthroughs.

Actors: Government, Chinese industries, society, regulatory bodies, International Organizations

Future: This trend seems quite certain to continue ata similar pace as the demand for energy and resources will steadily increase until 2025.



Consequences:

Technological breakthroughs, unpredictable as they may be, are more likely in some areas, (such as clean water, energy storage, and biotechnologies), than in other less critical areas.

• New business opportunities will be created in the areas of alternative materials and energy production and storage, but much will depend on how effectively government policies will motivate firms to innovate and seek technological breakthroughs.
• NOCs (National Oil Companies) are going to invest more in Enhanced Oil Recovery (EOR) techniques. In

order to secure and diversify energy supply, and to develop technical expertise in unconventional resources, Chinese NOCs are expected to invest in international projects and form strategic commercial partnerships with IOCs (International Oil Companies). It is particularly expected to increase investments in Middle East, Africa, Latin America, North America and Asia.

• China is building 40% of the world's new nuclear plants, and plans to increase its nuclear power by 20 times over the next two decades and lessen its dependence on coal. A relatively new technology "is expected to become more important by 2025" (Schwartz, 2015)[10]. A technology like pebble bed reactors or Gen IV nuclear power plants that can burn nuclear fuel without producing plutonium. China has already been investing in this technology and is likely to invest more in the future.

• The hunger for oil will be the cause for conflict and for increasing territorial disputes in the East China Sea (China-Japan) and in the South China Sea (especially China-Vietnam). Refer to the recent developments between Japan and China.

• Of highest importance will be the research on alternative materials. It is already recognized as a priority area by the CAS. New super-strong biological materials could take the place of steel and ceramics, while fairly complex products could be produced with the use of biotechnology-based processes.

• Nanotechnology – using nanofiltration technology, nanomaterials and nanoparticles in the areas of desalination, water purification and wastewater, treatment and using nanosensors to monitor – shows particular promise for water resources management.

• To meet its seemingly limitless electricity needs, China is turning to its solar industry, which already leads the world in panel production, and is gearing up to produce gigantic solar plants.

• Efforts for the production of hydrocarbon fuels from bacteria will be reinforced, and production could be expected to start around 2030.

As regards rare metals, efforts are focusing on (i) increasing the rare earth concentrate grade and (ii) rare earth extraction (REE) separation efficiency to help increase production efficiency.

10. Peter Schwartz, Learnings from the long view, 2011

TREND 5

GOVERNANCE

Description: *Chinese officials aim for the country to be able to enjoy stable governance and peaceful society by 2025. Authorities have defined the meaning of the Chinese dream: national prosperity and a better life for the people, by doubling the GDP and per capita income so that by 2020/2025 China will be become the world's biggest economy, and a more harmonious nation, with socialist modernization, and with Its military and economic strength playing an even more important role on the global stage.*

A strong government (national and regional) policy and Investment will continue to guide research, but will also limit it, unless important changes take place, acting on or reacting to several challenges, addressing difficult political reforms, like avoiding the "middle income trap", balance between the official centralized planning methodology and a decentralized one, and the move from an economy based on export-oriented labor intensive industry to one based on capital-intensive high-tech industry

During the last few decades, the performance of the Chinese government has been considered successful if one takes into account the impressive development of the country. There is however great uncertainty with regards to future prospects for greater transparency, fair justice and better protection of civil rights. Chinese civilization has a long and influential history and still the Chinese government and people are committed to continuing and expanding China's influence on the progress of humanity. In 1978, China gradually stepped onto the road towards establishing a socialist market economy system. Entering the 21st century, it embarked on a new development stage, starting the full-scale construction of a modern and harmonious society by pursuing its policy of reform, opening up its market and rebuilding the nation.

On November 8th 2012 China began the once-a-decade process of changing its leaders, with the launch of the 18th

Annex 3: **Trend Descriptions**

National Congress of the Chinese Communist Party (CCP). Mr. Xi inherited an economy that is likely to have recorded its slowest rate of annual economic growth since the late 1990s. He believes that it is time for China to become a "moderately well-off" society with "economic opportunity for all" and focus also on "social harmony", dreaming of the rejuvenation of the Chinese nation as a strong and prosperous party-state that has global influence. The new leaders of China are young, ambitious, experienced and result-driven. Government efforts will continue to promote reforms designed to build an innovative and corruption-free government under the rule of law.

China's political system is complex. The country is essentially run by two parallel systems of government that interlock at every level: the CCP hierarchy and the State one. The Chinese system-unlike that of the Soviet Union-is mixed and flexible and, despite imperfections is designed to serve the nation and its people. The CCP could be described as a deeply meritocratic institution, a characteristic that is rooted in the Confucian political tradition. According to this tradition, CCP practices-not always successfully – meritocracy at all levels of governance and thoroughly and constantly tests its people's skills and talents to ensure successful management.[11] The main modern guiding socio-economic principles that set the governance principles in China are described in the Scientific Outlook on Development. The Scientific Outlook on Development[12] shifts the focus of the official agenda from «economic growth» to «social harmony» and describes the way forward.

The government employed a mix of fiscal, administrative, and employment policies to maintain social stability during a period of rapid economic and structural change. Changing the development model is an urgent issue because the economy has exhausted the potential for acquiring and applying technology from abroad, the role of the government needs to change fundamentally. As enterprises take a leading role, the government needs to adopt a more supportive and facilitating role.

A better innovation policy in China will begin with a redefinition of government's role in the national innovation system, moving towards institutional development and an enabling environment that supports economy-wide innovation efforts within a competitive market system. The Chinese government should take urgent measures to ensure that every Chinese enjoys economic opportunity.

Example 1: The "Great Firewall" is China's nexus of surveillance and censorship that checks for anti-government activity and allows or blocks access to specific sites. Currently in China, Facebook, Twitter and Instagram are blocked, while access to Gmail is problematic. In this context, it seems to be a trend, especially between domestic social networks (E.g. SinaWeibo) to apply self-censorship.[13]

Example 2: At the 12th National People's Congress on 10 March 2014, Zhou Qiang, president of the Supreme People's Court warned that corrupt judges damage litigants and the credibility of the court. With the backing of the President Xi Jinping, Mr Zhou called for the establishment of "an impartial and authoritative socialist judicial system".[14]

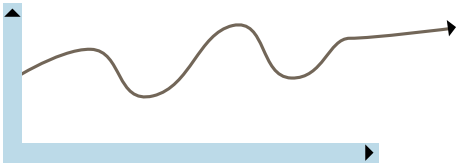
Counter Trend: It's well known that implementing reforms in China is a complex matter and most likely a dominant one over the coming decades. In this context it is only wise to keep peoples' expectations modest. Although the new leadership team has already clearly demonstrated that it is very different from the previous administration and could find a way to buck history and surprise us on the upside., some signs that this is going to be extremely difficult exist. One such pursuing reform is the interested implementation of the Shanghai Free Trade Zone (SHFTZ), which was envisioned by the state as a good practice to be followed in the future, but ended up not only generating much speculation that the leadership was following the timeworn practice of confining economic experimentation up to the limits of a pilot project but also arose vast dissatisfaction among investors unable to participate in the zone. Chinese history has shown that many times produced unplanned consequences, which required far more extreme measures to contain the chaos.

Driving Forces: Co-operation inside CCP party; transparent state and regional structures; public participation in decisions; middle class reactions;

income gaps and other disparities; external international environment.

Actors: Government and local authorities regions and big cities, party officials, public sector enterprises, actors of innovation, cultural institutions, intellectuals, middle class

Future: This is a very uncertain trend. The State will try to push and continue in the same direction due to substantial reforms in governance and in the juridical system, combined with substantial improvement in civil rights. But when, how and what would be the results will certainly be different from what will happen in real life. The question arises whether China is able to maintain a socialist rule while at the same time boost open innovative environment; given that it is a goal that its leaders want to accomplish soon.



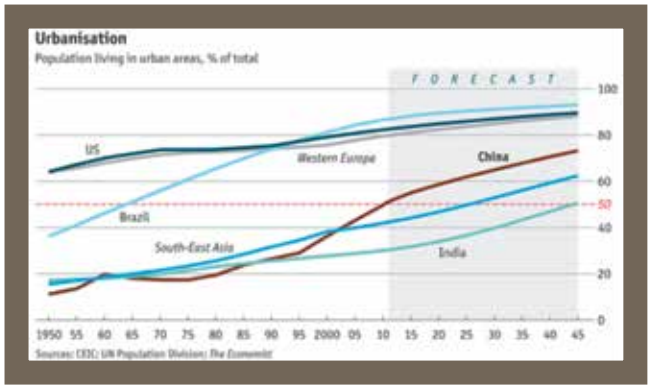
Consequences: More transparent policy making and judicial system, open innovative environment, increase in high- tech patents, consuming innovative products will rise exponentially, global cooperation will increase.

11. CHINA CHANGES LEADERS, Meritocracy Versus Democracy, ZHANG WEIWEI
12. Together with Marxism-Leninism, Mao Zedong's Thought, Deng Xiaoping 's Theory, and the Three Represents.
13. China's Cyberpolice Enlist Foreign Firms ; Companies Faced Fines If They Didn't Help Spying Effort Ahead of Congress, Ansfield, Jonathan, International Herald Tribune , November 15, 2012
14. China Rethinks Its Judicial System,http://www.nytimes.com/2014/03/18/opinion/china-rethinks-its-judicial-system.html?_r=0

Annex 3: **Trend Descriptions**

TREND 6

URBANIZATION



Description: *China's urbanization over the past three decades is a massive phenomenon of scale and speed. In the 1980' s, in a very much "different" China, there were fewer than 200 million inhabitants in "urban» areas (a fifth of the total population). However, by 2011, 700 million inhabitants (half of the total population) were living in urban areas, while the figure is expected to further grow in the future, as 250 million migrant workers are expected to move to the cities by 2030. The main driver behind this massive population move is the urgent need to transform the economy and society from a rural, agricultural society to an urban, industrial one, and from a command economy to a market-based one.*

At the same time, total sub-national government debt has reached 26% of GDP, according to the National Audit Office. Such indirect borrowing played a key role in financing important infrastructure investments and thus supporting industrialization and urbanization. Debt financing will remain important for China's urbanization drive, which demands continuing large infrastructure investments.

In addition, the urbanization process has caused many serious side effects (e.g. environmental and social implications) and urged the need for changes in the household registration system (hukou), in land ownership regulations, and in land transfer mechanisms.

Example 1: Urban residents spend nearly four times than rural residents. In 2010, rural residents spent US$600 per year.

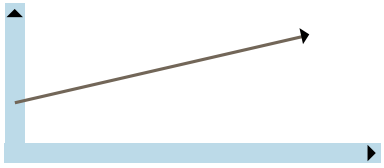
Example 2: 52% of the Chinese population lived in cities in 2012, but only 27% of them had an urban "hukou", or household registration. This means that large numbers of people do not have equal access to services reserved for the urban population, such as education and health care.

Counter trend: Environmental degradation; unbearable economic burden for cities budget; Slow modernization of the regulatory framework; Slowdown of the economy; insufficient restructuring of social security systems.

Driving Forces: A centrally-managed process to boost domestic consumption and reduce costs. The need to improve the quality of human capital. Better paid urban jobs.

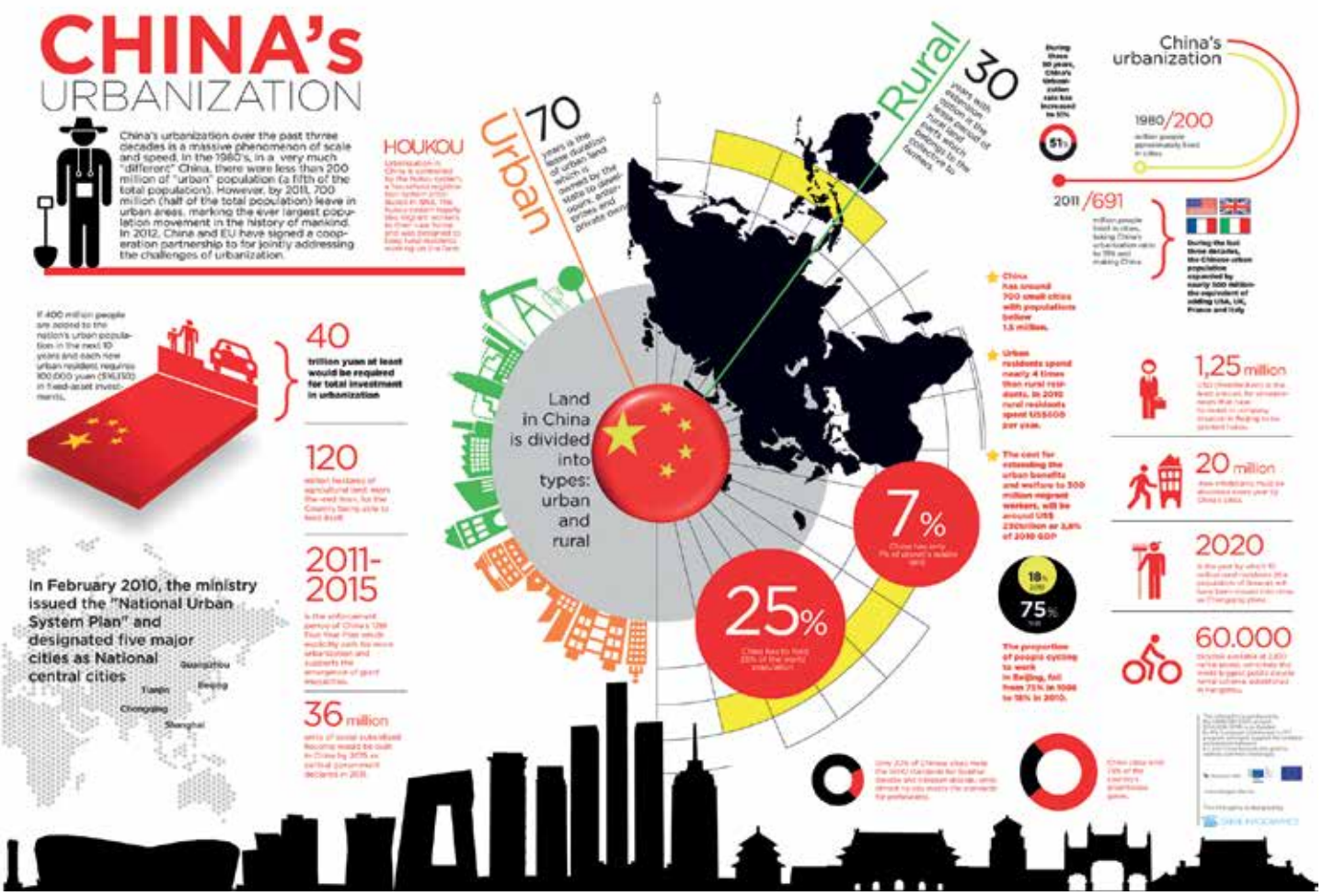
Actors: Government, Migrant workers, Urban Middle Class

Future: By 2025, China is forecasted to have 200 cities with populations of over one million (while America has 9), and about 60% of China's people will live in cities (UN estimations). Moreover, the urban middle class (and middle income) is expected to double from the current 23% to about 45% of the population.



Consequences: During the 12th Five-Year Plan period (2011–2015), the country is expected to invest US$ 300 billion in basic infrastructure. But this strong urbanization trend will also require further research on new urban technologies and applications (e.g. transportation systems, environment, efficient energy, housing, water sustainability, urban agriculture, ICT tools). So far Europe is a leading provider of urban technologies, but China is moving fast, utilizing its vast research capacity and the availability of a huge test bed.

Finally, a growing urban middle class will further increase domestic consumption and expand the request for life-style products and services.


CHINA's
URBANIZATION
China's urbanization over the past three decades is a massive phenomenon of scale and speed. In the 1980's, in a very much "different" China, there were less than 200 million of "urban" population (a fifth of the total population). However, by 2011, 700 million (half of the total population) leave in urban areas, marking the ever largest population movement in the history of mankind. In 2012, China and EU have signed a cooperation partnership to for jointly addressing the challenges of urbanization.
HOUKOU
Urban
70
Rural
30
Land in China is divided into types: urban and rural
7%
25%
China's urbanization
1980/200
2011/691
40
trillion yuan at least would be required for total investment in urbanization
120
2011-2015
36 million
In February 2010, the ministry issued the "National Urban System Plan" and designated five major cities as National central cities
Guangzhou
Tianjin
Beijing
Chongqing
Shanghai
1,25 million
20 million
2020
60.000

Annex 3: **Trend Descriptions**

TREND 7

HUMAN RIGHTS

Description: *The last few years have witnessed a mixed picture of progress in human rights conditions in China. On the one hand, several human rights reports have stated that China's record has remained rather poor. None of the groups suffering the greatest persecution have experienced notable improvement in overall treatment, according to these reports. On the other hand, the Chinese government has established laws aimed at reducing some of the most serious human rights abuses, protecting property rights, and promoting government transparency, and continued to develop mechanisms for consulting with non-State policy experts. In addition, the Chinese Communist Party (CCP) and local governments have considered or have already taken minor steps towards abolishing the re-education through labor system or laojiao[15], making elections more transparent, and enabling rural migrants to gain official residency status in some large cities.*

Freedom of speech and human rights are affecting research and innovation performance in different ways. China will not be able to become a global technology leader until it moves towards freedom of expression and encouragement of critical thought: 1) free society encourages people to be skeptical and ask critical questions, 2) innovation is mostly the product of individual thinkers through a bottom-up process, 3) free society attracts foreign talent.

Different driving forces are pressing towards improvements, however to break the current status quo will not be an easy task. In the last five years, China's urban middle class have become vocal in defense of their property interest, the environment and their overall wellbeing, urging for changes.

In the same direction, the Chinese leadership is displaying a will to improve the country's old-fashioned legal system, aiming to establish a system that will safeguard people's rights and interests. Furthermore, the State has invested tens of billions of dollars to build a fast, cutting-edge national internet infrastructure, aiming to bring China into the information age.

Nevertheless, it should be underlined that any changes are not necessarily towards a western-style democracy. China follows a different political model based on meritocracy and not on popular election. Meritocratic governance is deeply rooted in China's Confucian political tradition, and the future will probably see improvements of the current system including opinion surveys, internal evaluations, and small-scale elections.

Example 1: At the 12th National People's Congress (10/3/2014), Zhou Qiang, President of the Supreme People's Court, warned that corrupt judges damage the credibility of the court and, having the backing of President Xi Jinping, proposed specific reforms that will transfer power from provincial authorities to the central government.

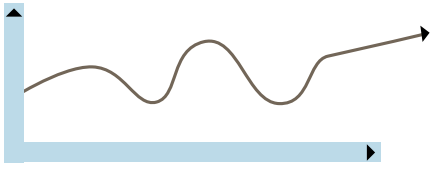
Example 2: On-line discussions have occasionally led to systemic political change. In March 2003, Sun Zhigang, a migrant worker, was beaten to death by the Guangzhou police. The case has received widespread publicity in chat rooms and microblogs that eventually brought six police officers and officials to justice.

Counter Trends: Censorship, corrupt judicial system, Resistance from CCP members or other political groups

Driving Forces: Internet, rising urban middle class, globalization

Actors: Chinese Government, Chinese Middle Class, Civic institutions, NGOs (e.g. Amnesty International), International Organizations.

Future: Besides some positive signs, the future of civil rights in China remains highly uncertain. A slow process of moderate improvements is expected, but drawbacks cannot be excluded.



FUTURE

Consequences: The quality of the performed research and the capability of China to innovate are directly connected to human rights conditions in the country, and the freedom of communication, and of travelling

15. Re-education through labor (RTL), laojiao, is a system of administrative detentions which is generally used to detain persons for minor crimes such as petty theft, prostitution, and trafficking illegal drugs, as well as religious or political dissidents such as unregistered Christians or Falun Gong adherents.

TREND 8

GLOBAL ECONOMY

Description: *Global growth by 2025 will accelerate thanks to the contribution from the emerging economies. On average, annual growth is projected to be accelerating towards 3%, while China and India will be two of the largest economies in the world. Considering growth driving factors such as the size of the Chinese work force, the ongoing convergence in the productivity levels with the U.S. and the strengthening of the country's currency exchange rate, , China along with India and other emerging economies are very likely to dominate future growth. Even if China's population will reduce and be aged, its productivity would still remain ahead of the US. Other growth inducing factors such as Yuan evaluation, high savings rates and investments could boost development higher, around 5-6% for the next 15 years according to many scholars.*

Globalization used to be everyone's favorite word. Technology breakthroughs, cost reduction, liberalization of policies and asset investment around the globe were some of the signs and basic parameters that boosted global economy. Although this was not the first time in the world's history that international trade of products and services was so open and free, some incidents like the internet bubble, the terrorist attacks on 9/11 and the recent financial crisis that hit severely mainly the western countries, hindered the increase of international transactions.

As the global value-added chains for products and services became more sophisticated, complicated and fragmented, the recent change in the rate and scope of globalization, has brought some negative consequences, mainly in the countries hit by the crisis. Enterprises and countries today are more interconnected, and countries that are open, (having improved their policies and legal systems), would most probably continue business as usual – just as before the 2008-2009 crisis. The world would most probably continue the same way, but more cautiously, since this is a major trend in the global arena.

Example: China, India, Malaysia, Thailand and Indonesia

Annex 3: **Trend Descriptions**

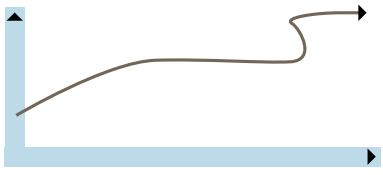
all demonstrate rapid rates of growth and as their education and policy systems develop, these are likely to be sustained over our forecast horizon.

Counter Trends:
• Capital and money markets have already forgotten the recent crisis, and are all experiencing increases in asset prices, as high risk offerings are looking for better yields, due to increased liquidity in the financial system.
• Increased income gaps at a global level could create protectionism.
• High insecurity increases costs and time for processing trade and other free services around the world, diminishing the benefits of globalization.

Driving Forces: Financial liquidity, demographic changes, local conflicts, resource scarcity, climate change, large income gaps, a seismic shift in the global attitude: 'me' versus 'us' mentality.

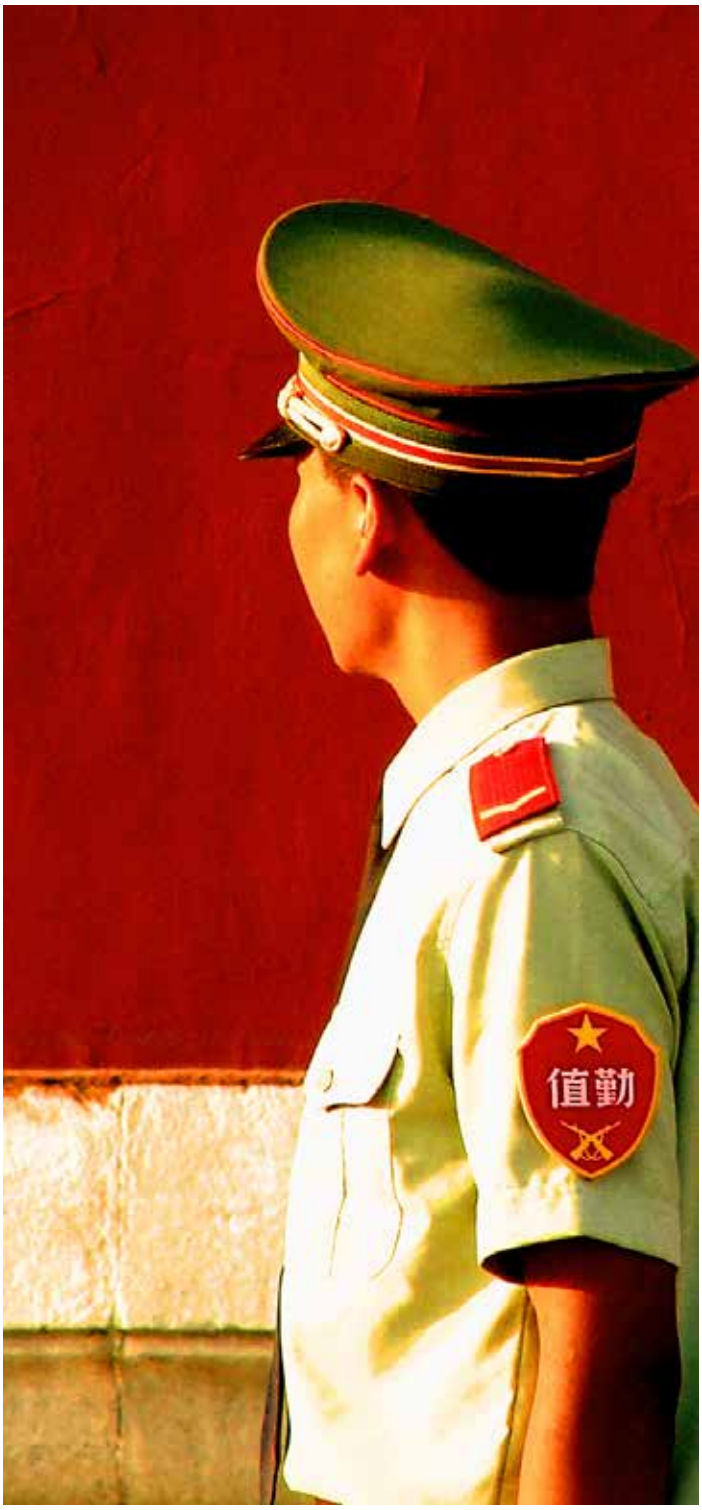
Actors: Global Institutions, Markets, countries, social movements,

Future: The world economy could grow and emerging economies like the BRICS might be underpinning such growth. Global institutions could create safety nets mainly in the financial products sector for the benefit of global balance. The recently reduced globalization pace could on the one hand reduce the growth rate, but on the other, could impose some ethical rules to avoid future intense incidents. In this respect, China will be the main engine due to the considerable increase of the middle class, savings and investments in addition to being a trusted member in the global value-added chains.



FUTURE

Consequences: More income for the middle class could create a huge market for new high-end tech products; copying western values could increase start-ups and entrepreneurship, but could also decrease the 'us' value.



TREND 9

PEACE AND CONFLICT

Description: *This trend refers to the cases of regional tensions, verbal confrontations, and small-scale armed conflicts that have been tending to increase during the last decade.*

Most analysts believe that, as China continues to grow economically, it will attempt to dominate Asia the way the US dominates the Western hemisphere, driven by the need to secure more resources. An immediate effect of this situation is growing defense spending in the region, following the growing wealth of the South East and East Asian countries. In 2013, Asia spent $232bn on military budgets, up from $262bn in 2010, with China growing more dominant (military spending in China grew 43.2% from 2008 to 2013).

It should be noted that the biggest risk for the future a possible accidental killing that could escalate a small- scale incident into a minor armed conflict.

Example 1: In 2010, China held the biggest ever naval exercises in the South China Sea. For the first time since the fifteen century, China has a predominant naval presence in the southern seas.

Example 2: An on-going dispute between six countries that claim the oil-rich Spratly islands in the South East China Sea has been a catalyst for military investments, especially for ships and submarines.

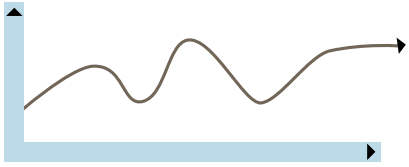
Example 3: The recent (2013) tension between Japan and China has seriously hurt Sony mobile phone sales in China, which fell dramatically according to data from IDC researchers. Sony had to increase its marketing budget by 50% to address this issue.

Counter Trends: US-Japan-EU coalition.

Driving Forces: Need for (energy) resources, Rising power of China

Actors: China, USA, EU, Japan, Russia, South Korea, North Korea, Vietnam, Malaysia, Singapore, Philippines, UN, ASEAN, NATO.

Future: A more powerful China can be expected to try to push the USA out of the Asia-Pacific region. Beijing's neighbors (India, Japan, Vietnam, Singapore, South Korea and even Russia) will eventually join with the US to address Chinese power. This will increase regional tension, insecurity and the risk of war.



Consequences: The escalation of conflicts (even without any serious incidents) will affect the regional economics (especially imports and exports of consumer products). The situation will drive an arms race and will focus research on defense applications, aerospace, vehicles, communication, but also on alternative energy sources and materials. It is also expected that there will be a request for co-development of defense technologies. This will also mean that the defense industry has to adapt to the needs of the Asian countries and this might prove to be either an opportunity (defense sales) or a serious risk for Europe.

Another possible consequence from the escalation of regional tensions, especial for multinational companies based in China, is the imposition of embargos from the international Community or various penalties from Beijing.

Annex 3: **Trend Descriptions**

TREND 10

SPACE & DEFENSE

Description: *The space exploration and the further development of defense technologies are going to be important drivers for the Chinese research by 2025. China, recently, became the third country to guide a spacecraft onto the moon, while has even more ambitious plans for a manned mission to moon.*

Space exploration, for China, will be a key driver for enhancing technological expertise, military strength and country status.

Peter Schwartz suggests that it is plausible to see, in the near future, a new space race, with China playing the role of the Soviet Union during the 60′ s. We also might see a race to Mars or to stake claims to mineral rich Asteroids.

At the same time, the strategic upgrade of the operational capacity of the People's Liberation Army (PLA), will boost defense related research. We have seen during the last years the deployment of the first Chinese aircraft carrier, and the tests of intercontinental missiles, as well as new war airplanes. The military power it is a necessary tool for China, as re-entering in the global politics arena.

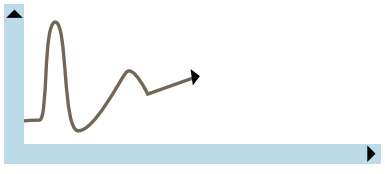
Example: The Chinese Navigation System, called Beidou, came from a technology partnership between Beijing and the European Union. The Chinese essentially supported the European satellite-navigation initiative, called Galileo.

Counter Trends:
• An agreement with other space agencies (US, EU, Russia) for common missions might reduce pressure.
• In the event that Japan, China, Vietnam and South Korea reach an agreement for the exploitation of the East and South Chinese seas, then the most important regional tension will relax. The same stands for the situation with Taiwan.

Driving Forces: National pride, exploitation of mineral rich asteroids exploitation of the fossil fuels in the South East Chinese seas, emphasizing power, supports the national foreign policy, support China's Vision.

Actors: PLA, Chinese Government, South Korea, Japan, Vietnam, Taiwan, Global community.

Future: Very likely continuation in the same direction. Serious risk of small scale regional conflicts that could be potentially escalated.



FUTURE

Consequences: Increased need for technologies on telecommunications, navigation, military, space, aircrafts, shipping, etc.

A conflict will affect the national economy, foreign investments, reduce investment on research and transfer focus on defense industry and related research topics.

TREND 11

ENVIRONMENT

Description: *Local environmental problems (e.g. atmospheric pollution, contaminated water) and global environmental implications (e.g. climate change) will affect research in China by 2025. Moreover, China is expected to become a test bed for new environmental technologies.*

The trend is closely related to the heavy and rapid industrialization process that took place in China during the last 20 years, while it is also fueled by the on-going centrally-driven Urbanization process. New sprawling cities are rapidly emerging, meaning land competition for residential use, longer commuting times, climbing carbon emissions, and choking pollution.

It should be also underlined that environmental activism is a growing trend in the Chinese society (assisted by the rise of microblogs), and it's further feeding the need for radical solutions in the environmental problems. At the same direction is the pressure put by the rising of the urban middle Class in China that requires a clean and secure environment.

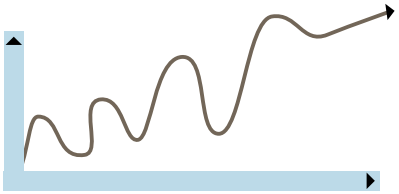
Finally, we shall expect greater global pressure on issues related to climate change, which could require serious changes in the production processes and on the mitigation of the climate change effects. The pressure could come by global organizations (e.g. UN) or in the form of regulations e.g. from the EU.

Example: The regular smog events in Beijing have raised awareness and have great pressure on the government to deal with the air pollution issue. The Institute of Public and Environmental Affairs (IPE) is a non-profit organization that has developed two pollution databases (water & air) to monitor corporate environmental performance and to facilitate public participation in environmental governance (www.ipe.org.cn).

Counter Trend: If the government addresses seriously the environmental problems, this might reduce future pressure.
Driving Forces: Safer and better environment, government plan for "Beautiful China"

Actors: Urban Middle Class, Public Awareness, Activism, NGOs, Microblogs, UN, EU, Government, 77 environmental protection courts nationwide, International Organizations

Future: Very likely continuation in the same direction



FUTURE

Consequences: Increased need for technologies to deal with air pollution, contaminated land & water, low carbon alternative energy sources (not coal), smart and greener transportation, etc.

Annex 3: **Trend Descriptions**

TREND 12

POPULATION

Description: *In the years to come, China is expected, by most analysts, to face a huge demographic shift. It will be acute and rapid and will raise future challenges, not only to social policies, but also to the economy. With rising life expectancy and with total fertility rate very low, China is "growing old before growing rich".*

As the population ages, the growth rate of the labor force will slow down, and in some cases it will even decline, leading to higher dependency ratios and lower growth. The old-age dependency ratio will double over the next 20 years , reaching that of Scandinavia's level today. Both the 11th and 12th Five-Year Plans recognize the limitations of the current growth model and place emphasis on addressing inequality and enhancing the basic safety needs of the population.

The population demographics are uneven, overstated by rapid ageing, as a result of the single child policy, and by the large number of highly-mobile workers within the country, while health infrastructure is inconsistent, with excellent medical centers in the east of the country, whereas more rural areas lack basic sanitation. Some of these inequalities are consequences of market reforms and past failures to deal appropriately with the provision of public goods. Others, however, are consequences of policies that institutionalize inequality of opportunity (i.e. hukou system). The inequalities across the population are reflected by large gaps between the richest and poorest citizens, and between urban and rural areas. Part of the rising income and consumption inequality is based on structural changes as labor moves from rural areas to the urban centers where they could find employment in the capital-intensive manufacturing sector which represents a major part of China's export industry oriented economy.

The rapidly aging population will also need a range of elderly care and long-term care services, which are currently underdeveloped in China. Historically, aged care in China has been primarily the responsibility of the family, but the State has provided some help for the

poorest elderly people (known in rural areas as wubao people and in urban areas as the "three no's). Developing health restructuring is one of China's major challenges in the years to come, a complex and politically-challenging reform, a challenge intensified in China by population aging and the rise of non-communicable diseases.

Example:

• China has experienced the kind of fertility transition over the past 40 years that typically took more than 100 years in developed countries.

Counter Trends:

• Chinese and international experience demonstrates that health sector reforms are complex and politically

challenging and especially that holds more than true in China due to country's rapid pace of population aging.
• Analysts and scholars believe that economic growth will be slower due to population aging and increase in services as well, unless general levels of productivity growth would increase.

Driving Forces: Demographic policies; Middle class values; Pace of structural changes and investments in safety nets and infrastructure; Technological implementations mainly in health care.

Future: It seems that this trend will inevitably happen that is population will be older. With a more complex economy at least in some parts of the country (cities) that will require the government to take measures that enhance safety nets for old age people and support workers to better manage risks inherent in a more flexible labor market, reform pension and unemployment insurance systems, expanding long-term care, and strengthening labor market institutions to enable wage bargaining and dispute settlement mechanisms that balance the interests of workers and employers.

Consequences:
• Slower growth, lower savings rates, and investments, and a better educated human capital to increase labor productivity.
• A shift in health-care strategy from curative to preventive care, The fiscal costs of health and pension programs will need to be limited through greater emphasis on primary care rather than hospitals, structural reforms, and efficiency improvements in service delivery through information and communications technology (ICT),
• Innovation will be an important mechanism for controlling costs while raising quality and expanding access to health care.
• Urbanization and aging will accelerate a rapid increase in the prevalence of non-communicable disease over the coming decades, implying a major increase in demand for both curative and preventive health care.

16. Ratio of those aged 65 and over, to those between the ages of 15 and 64
17. UN 2010; UN 2009
18. People who have no working ability, or no stable income, or no dependable providers
19. Uhlenberg 2009

TREND 13

INTELLECTUAL PROPERTY RIGHTS
(IPR APPLICATIONS AND REGULATORY FRAMEWORK)

Description: *Prior to the industrial revolution in Europe, China led the world in technology. Over the last few decades, the country has been focusing mainly on manufacturing capabilities and cost innovation – imitating products, but also integrating innovation for lowering product prices -[20] in major product categories. During the last few years, China has been spending heavily on R&D in an effort to take the lead in technological and novel products by 2025 to 2030. With that vision in mind, the protection of IP rights is crucial. The country has started a local patent office just at the beginning of the 1980s. However, different levels of IPR infringement are occurring every day, mainly due to poor law enforcement. Chinese companies, and especially SOEs, have been very aggressive in terms of technology-used competition. In recent years though, the increased interaction and co-operation with counterparts from all over the world (especially from the West) has made them more conscious about IPR issues. Also the country has made extensive progress in IPR protection in order to promote its dream of becoming a technology-edge country, by implementing reforms in 2008 to support the creation and operation of a modern and sophisticated IPR system, (regulations, trademarks, copyrights and patent laws), which largely meets WTO requirements.*

Despite regulatory reforms, enforcement hasn't kept pace with improvements in the legal framework. The problem of law enforcement is sharper in West China and other locations far away from Shanghai and Beijing, but as more and more Chinese firms file court cases against violation of IP rights by other Chinese firms, the awareness of IPR protection will be further raised and protection rendered more effective. While past improvements in the Chinese IPR protection system were largely driven by pressure from abroad, in the future, change will be increasingly driven by domestic pressure.

The recent data regarding patents are impressive. International trademark filings by Chinese companies

Annex 3: **Trend Descriptions**

have grown rapidly (from 2.598 in 2000, to 35.637 in 2012), reflecting an ambition to build international brands. Invention patent applications are also growing. For example, Chinese priority patents inside China occupy a rising share against foreigners from 173.000 in 2005 with 54% of the total, to 653.000 in 2012 with 82% of the total). A number of incentives granted by local and central governments have pushed them to codify more of their intellectual property. Despite that huge increase, the number of granted patents (as a percentage of the total filings in the country) increased, showing a relative increase in patents quality. This is partly due to the efforts of the Chinese authorities to reach international standards.

As China wishes to boost technology-based innovation in the future, it is expected that the country's IP regime will eventually provide a reliable, transparent, and fair system that encourages and protects innovation, regardless of the nationality or location of the creator / innovator.

Example 1: American Superconductor Corporation (AMSC) supplied power systems and software to the Chinese wind turbine manufacturer Sinovel and is now suing it for $1 billion after it paid an AMSC engineer to steal its source code.

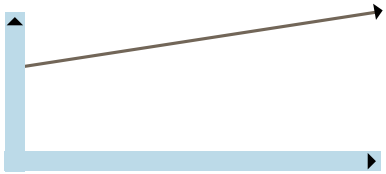
Example 2: Nearly 2.38 million patent applications were accepted and over 1.31 million authorized in 2013. At the same time, 37,660 patent disputes were resolved from 2009 to 2013 nationwide.

Counter Trends:
- Poor implementation of IPR laws
- Insufficient effort and resources on dealing with IPR

Driving Forces: China's ambition to become the world leader in innovation; spillover effects of R&D investments; competition and law enforcement.

Actors: Chinese authorities (national, regional and local), domestic enterprises, SOEs, foreign enterprises, Chinese innovators, Chinese courts, IPR regulators, Patent Agents, Investors, MNCs, WTO, EU, USA.

Future: As the number of Chinese innovators grows, PRC officials have recognized that China's aspirations for indigenous innovation are unlikely to be met without a far more credible intellectual property (IP) protection regime that protects the creators of new technologies. In addition, as Chinese enterprises become more and more innovative, they would be affected by the lack of efficient IPR protection and will push for changes. An efficient patenting system that reflects the experience of the West will accelerate the growth of China's innovation capabilities, and will encourage MNCs[21] to establish R&D centers in China. Proper IPR policies will support the transfer of research-and-development results from public organizations to the Chinese economy. IPR infringements are happening every day, and this will continue in the future but at a lower level.



Consequences: The creation of a dynamic and open innovation system.

20. Dragons at Your Door: How Chinese Cost Innovation Is Disrupting Global Competition.
21. Multi National Companies

TREND 14

GLOBAL COMMUNICATIONS

Description: *Information and communications technologies (ICT) are rapidly shaping a new R&D landscape. For example they facilitate co-resourcing, networking, cloud computing, simulation, and virtual environments. ICT has changed the way research and innovation move forward, by allowing with a click of a button, unprecedented networking, creativity sharing as well as infrastructure, (such as computing power), as well as utilizing new ways of disseminating information and acquiring funding.*

The increasing availability of information and the growth of communication capabilities have been major factors in the globalization of the 20th century. Internet enables creativity, innovation and has created new governance structures, increased openness, and participation. Latest developments in ICT are the Creative Commons (universal access to research and education), the Internet of Things, 5G, Broadband developments and Cloud Computing.
In that context, communication between Europe and China is increasing at a rapid rate. R&D collaboration has been developing radically over the last few years. Europe and China share a strategic interest in further increasing combined efforts that will enhance the quantity and quality of research results and technological innovation in both Europe and China, particularly in tackling global challenges. EU and China have signed many official agreements, and some of them are related to R&D activities, pointing out that access to information and a satisfactory / minimum communication flow between the two sides are key requirements for international collaboration, mainly in the R&D&I global value chains.
Internet connectivity, VoIP, file sharing, streaming media, social networking, mobile communications, satellite TV and 24/7 new media will be broadly available, reaching not only the new Chinese middle class and the R&D communities, but the majority of Chinese citizens. Advanced communication and access devices will continue the evolution of the Chinese society, by allowing individuals to not only communicate irrespective of their location, but also to access a wealth of information, and also enable e-governance in all aspects.
Example: The Europe-China Standards Information Platform, (CESIP), is a one-stop-shop for market access information to help businesses internationalize and ultimately strengthen trade between European and Chinese small and medium-sized enterprises. The new CESIP platform provides detailed information about European and Chinese standards and market access requirements.

Counter Trend: Globalization and ICT have created a new open world. However, in recent years, there have been a number of risks and threats, like hacking, unclear IPR context, and break-out of local disputes and terrorism. These factors have created various concerns in the field of networking and co-operation arising from the use of ICT and other new technologies, in the context of R&D global value chains.

Driving Forces: Global governance, ICT and other Technology developments, Globalization

Actors: Chinese Government, EU, International Institutions, Multinational Companies, Education Institutes, Research & Innovation Institutes, etc.

Future: In the next ten to fifteen years, wireless communication, (including both wide-area networks and satellite connectivity), new software and applications will likely enable further collaboration between researchers from around the globe in order to access data, information and R&D infrastructures and outputs. Intelligent sharing, access and processing of information activities will be improved, as well as increase of security and use of encrypted technologies.

Consequences: Competition will foster the restructuring of industries. Institutions will be stimulated, with major impact on innovation and growth. ICT will account for a significant share of total R&D spending, patent applications and firm start-ups. The global nature of the Internet will further spur the pace and scope of research and innovation and encourage new kinds of entrepreneurial activity. The costs of transmitting information will be significantly reduced, boosting the diffusion of information and ideas. Economic development will be affected through productivity improvements and continued economic expansion from global Internet commerce.

Annex 3: **Trend Descriptions**

TREND 15

LANGUAGE SKILLS

Description: *The slogan "Education needs modernization and modernization needs education"[22] reflects the dilemma facing China as it undergoes a rapid transition from a largely agrarian society to a modern globalized economy.*

The modernization of the Chinese education system, the great interconnection with the global culture, and the greater financial capacity of the rising middle class, rapidly makes proficiency in foreign languages a standard skill for young Chinese.

Although education has always been held in high regard in China, the force of globalization and the emergence of a new era of technology, driven by internationalization, have accelerated the process. In order for China to develop an economy that focuses on the production of goods for foreign trade, and to respond effectively to the forces of globalization, the education system must develop students' knowledge and skills to international standards[23].

China has made learning English part of its economic strengthening strategy with its introduction into primary, secondary and tertiary education. In 2010, there were estimated to be over 100,000 native English-speaking teachers in China, workers in a market worth three billion dollars annually. Increasing numbers of teachers, teacher educators and researchers are now beginning to devote themselves to the study of language teaching with young learners. Research into primary school English teaching and teacher training are urgently needed to ensure a better understanding so as to better inform and improve practice.

To protect other foreign languages taught in schools, special support will be given to keep the present number of schools teaching Russian and Japanese or other foreign languages within the same areas. As indicated from the World Language Map, Chinese is spoken by the majority of people in the world. But with the rapid economic development in recent years, Chinese people are enthusiastic about learning foreign languages. A list of the top foreign languages learnt in China is: 1) English, 2) Japanese and Korean, and 3) French and German. Lately the Russian language has been gaining popularity in China.

Example: The Confucius-Institute at the University of Vienna, was founded in September 2006 as a cooperation between the Office of Chinese Language Council International (Hanban), the Beijing Foreign Studies University and the University of Vienna. The Institute is devoted to introducing the Chinese language and culture and promoting the dialogue and exchange between different societies and cultures. With its expertise and activities it has become a meeting place and platform for many joint projects.

Example: Foreign language schools are shifting their mission from cultivating language expertise to preparing well-rounded students, versed in foreign languages and culture. Tianjin Foreign Languages School, launched in 1964 as one of the first batch of foreign language schools under the supervision of then premier Zhou Enlai, is focusing more on the comprehensive skills of students than the mastery of languages alone, in an attempt to foster greater expertise and the development of open and tolerant mindsets. Forty-nine of the school's students were accepted by overseas universities and colleges in 2012 and 35 in 2013.

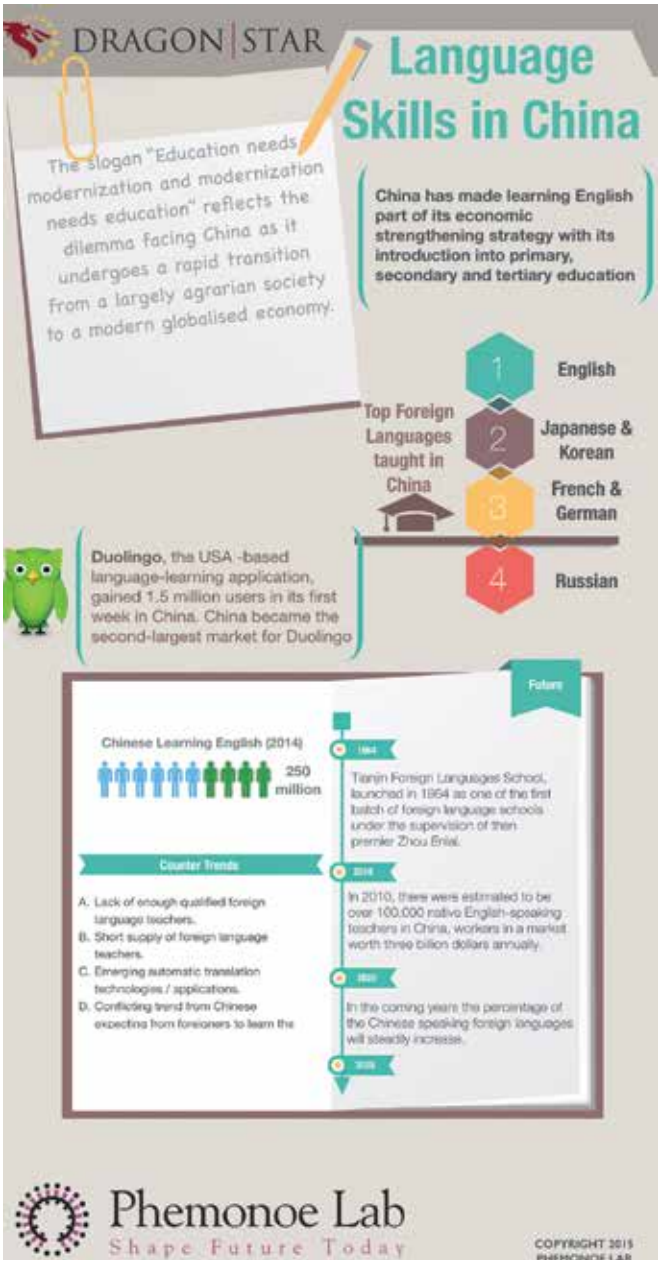
Counter Trends:
1. Lack of enough qualified foreign language teachers.
2. Short supply of foreign language teachers.
3. Emerging automatic translation technologies / applications.
4. Conflicting trend from Chinese expecting from foreigners to learn the Chinese Language

Driving Forces: Globalization, modernization of the Chinese education system, the great interconnection with the global culture, need for foreign trade, emerging urban middle class, etc.

Actors: Domestic and international universities, government, schools, teachers and professors, middle class.

Future: In the coming years the percentage of the Chinese speaking foreign languages will steadily increase.

Consequences: Improving labor skills, increase in international co-operation in research field, international students mobility.



22. Ross, 1991, p. 67
23. Ross, 1992

TREND 16

EDUCATION SYSTEM
(MODUS OPERANDI)

Description: *China's social development over the past three decades has been impressive. Since the founding of the PRC in 1949, China has shifted from a major power with low literacy rates or with large part of population at low literacy level to an equally major power with universal primary education (1949-77), and subsequently from a major power with universal primary education to a human resources powerhouse (1978-2000). Throughout this process, the PRC has turned its huge population from a burden into a significant advantage. This achievement marked the transition of higher education in China from a system of elite education to a system of mass education. Fast forward 30 years to 2013, and the country is almost unrecognizable. The country has universalized compulsory primary education and expanded participation in higher levels of education. Since this expansion, educational enrollments have increased rapidly, with large increases in high school attainment and above. It produces almost 13 % of the world's scientific papers and has 25 % of the R&D workforce worldwide, while over six million of its students will graduate this year from higher education. China has also opened up its system of higher education to the outside world, becoming the Asian country with the largest number of foreign students.*

The modernization of the Chinese education system, tHowever, according to the latest OECD data, the level of upper secondary attainment among adults between 25 to 64 years of age is one of the lowest (22.3 %, ranking 42/42), while one of the lowest is also the percentage of today's young people expected to graduate from upper secondary programs (76.4 %, ranking 24/29). Similarly, in China, the total compulsory instruction time for primary students and for lower secondary students, is one of the shortest among OECD and partner countries. On the other hand, the ratio of students to teaching staff at the upper secondary level is especially high. (16 students per teacher, ranking 7/35), while Chinas one of the most attractive destinations for foreign students compared to other OECD and partner countries (2 %, ranking 10/40).

Annex 3: **Trend Descriptions**

Developing education, especially higher education, in an open manner is important as China seeks to secure its position in the world. In pursuit of this goal, the government is attempting to raise the gross enrollment rate at senior secondary institutions to 90 percent by 2020, putting the number of students in these schools at 47 million. By then the gross enrollment rate of higher education is also expected to reach 40 percent. At 2008 the number of college-age individuals began to decrease, a trend that will continue for at least few years.

China still lags behind from the rest OECD and partners countries in most of the indicators. However the figures are gradually improving, indicating a strong potential for further growth that will, in the future, fuel R&D performance and economic growth. The Chinese education system is undergoing continuous reforms and although the system has substantially improved, it is uncertain whether the government will make the necessary structural changes at all levels (primary, secondary, higher education), in order for China to become a competitive knowledge-based economy.

By 2025, China will be the world's largest power in terms of population that has received higher education. Already by 2020, nearly 200 million Chinese citizens will have college degrees. Without a doubt, education has been one of the most important factors in the Chinese economy's rapid growth. Wang Xiaolu expects this to continue, forecasting an economic growth rate of 9.34 % by 2020, with the net contribution of education to GDP expansion reaching 2.4 % points.

Example: The quality of university training is improving rapidly: China now has 22 universities in the top-ranked 200 universities of the world, compared with 12 just eight years ago.

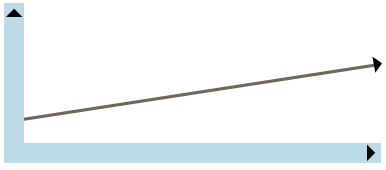
Example: Inequality in China's education system seems to be on the rise. The percentage of students at Peking University of rural origin has fallen to 10 % in the past decade, in comparison to 30 % in the 1990s.

Counter Trends:
• Hukou system reforms are necessary to provide suitable education to urban immigrants' children.
• The rising inequality in compulsory education for children of different demographic status, namely, residential areas, social categories and income groups.
• Around one-third of citizens mistrust the educational system.
• The education system does not encourage creativity.
• Scarcity of public education resources.

Driving Forces:
• Decisiveness to become a leading innovative nation and therefore to catch up with and, ultimately, to overtake the West, by shifting production from labor-intensive to skill-intensive activities.
• Rising urban middle class
• Globalization
• Education Reforms.

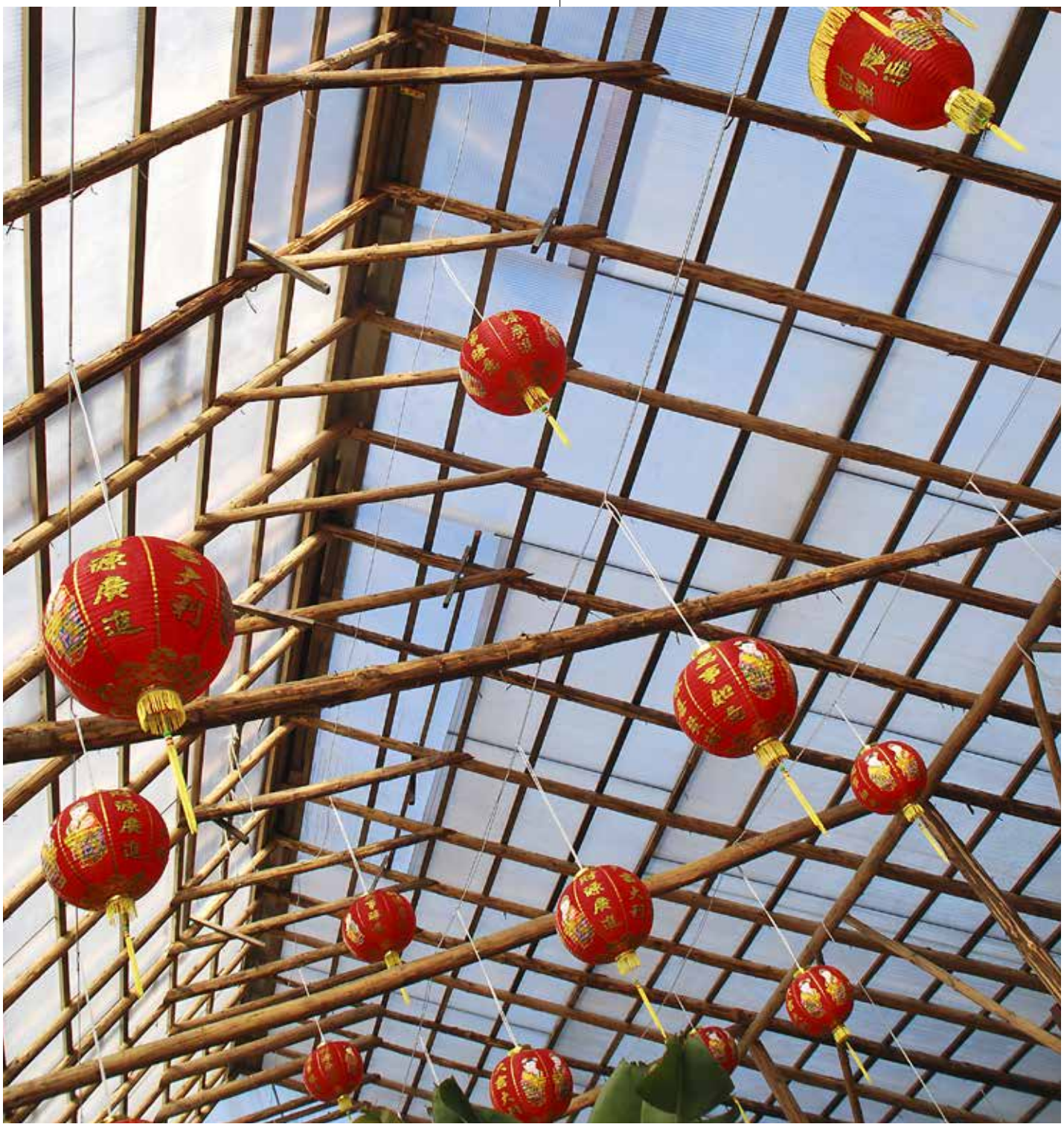
Actors: Ministry of Education, Chinese Government, educational institutions, research institutions, domestic and foreign universities, urban middle class, etc.

Future: Possibly, China will become an innovative knowledge economy only if government makes the necessary structural changes



Consequences: China a world power in terms of human capital, harmonious society, equal access to education for all, technological progress, human capital accumulation.

24. Wang Xiaolu, Fan Gang and Liu Peng, "China's Economic Growth Model Changeover and Sustainability", Economic Studies, no. 1 (2009): 4-16



Annex 4: **Sources**

• Scottish Executive, Edinburgh 2006, Scotland's strategy for stronger engagement with China. See: http://www.scotland.gov.uk

• Fraunhofer Institute for Systems and Innovation Research ISI (2014), Project for the European Commission, DG Research & Innovation, A6-Science policy, foresight and data, Research and Innovation cooperation between the EU and china.

• Cheng Fan (project leader), Stephanie Christmann - Budian and Sarah Seus, Fraunhofer Institute for Systems and Innovation Research ISI (2013), Research and Innovation cooperation between the EU and China.

• The World Bank and the Development Research Center of the State Council of the People's Republic of China (2012), China 2030Building a Modern, Harmonious, and Creative High-Income Society. See: www.worldbank.org

• JariMakkonen , Tony Yao (2014),TekesTeam Finland Future Watch China Growth Paths - Understanding Future Business Trends in China, Future Watch Reports

• Kirsten Bound, Tom Saunders, James Wilsdon and Jonathan Adams, Nesta (October 2013), , China's absorptive state Research, innovation and the prospects for China-UK collaboration

• Eduardo Herrmann and Emilie Bertrand (2012), Steinbeis-Europa-Zentrum, Strategy Paper for enhancing reciprocity in EU-China S&T Cooperation, ChinaAccess4EU: Supporting the EU access to Chinese research & innovation programmes

• Micah Springut, Stephen Schlaikjer, and David Chen (011) , China's Program for Science and Technology Modernization: Implications for American Competitiveness, Prepared for THE US –CHINA economic and security review commission centra technology

• Junying Fu, Rainer Frietsch, Ulrike Tagscherer) (2013), Fraunhofer Institute for Systems and Innovation Research ISI, Publication activity in the Science Citation Index Expanded (SCIE) database in the context of Chinese science and technology policy from 1977 to 2012

• EU SME Centre, EURAXESS, (2013) How to establish a Europe-China Joint Research Structure? CHINA IPR SME HELPDEX, Handbook

• Charles Wolf, Jr., Siddhartha Dalal, Julie DaVanzo, Eric V. Larson, Alisher Akhmedjonov, HarunDogo, Meilinda Huang, Silvia Montoya (2011) China and India, 2025 A Comparative Assessment, Rand National Defense Research Institute

• Jerome Glenn, Theodore Gordon & Elisabeth Florescu, 2013-2014 STATE OF THE FUTURE, The Millennium Project

• Peter Schwartz, 2011, Learnings from the long view

• George Vielmeteter& Yvonne Sell, 2014, Leadership 2030: The six megatrends you need to understand

• Twelfth Five Year Plan for Science and Technology Development 2011-2015 Summary, ERAWATCH (in English).

• NESTA ,2013, China's Absorptive State

• Joint Declaration on European Union-China, Innovation Cooperation Dialogue, Brussels 20 September, 15th EU-China Summit

• Mats Lingren, 2013, , Global Youth, Kairos Future CEO

• The ASPIRE study team (2012) ASPIRE - A Study on the Prospects of the Internet for Research and Education: The Adoption of Cloud Services

• The ASPIRE study team (2012) ASPIRE - A Study on the Prospects of the Internet for Research and Education: Middleware and Managing Data and Knowledge in a Data-rich World

• The ASPIRE study team (2012) ASPIRE - A Study on the Prospects of the Internet for Research and Education: The Adoption of Mobile Services

• Karen Ward (HSBC GLOBAL Researcher) ,January 2011), The world in 2050 Quantifying the shift in the global economy, Global Economics

• Soumitra Dutta, 2012, The Global Innovation Index 2012 Stronger Innovation Linkages for Global Growth, WIPO,INSEAD The Business School for the World

• Daniel Franklin with John Andrews, (2012) Megachange-The world in 2050, The Economist

• PwC Economics, 2013, World in 2050 The BRICs and beyond: prospects, challenges and opportunities

• Economist Intelligence Unit, 2012, China's leadership handover: The changing of the guard, The Economist

• Christopher k. Johnson, October 2013, Thoughts from the Chairman, About the Freeman Chair, freeman report, ChinA's Third Plenum: Go BiG or Go home?, Centre for Strategic & International Studies, Issue 14

• Michael Santoro, 2009, China 2020, Cornel University Press

• John & Doris Naisbitt, 2010, China Megatrends Pillar 8, HarperCollins Publisher, New York

• Zhang Weiwei, 2012, Meritocracy versus democracy, International Herald Tribune, 10-11/11/2012

• The Scottish Government, Riaghaltasna h-Alba, 2013, Working with China A Five Year Strategy for Engagement between Scotland and the People's Republic of China.

• United Nations University, 2012, International Institute for Software Technology Analyses of Research strengths of SEA countries for SEA- EU-NET under Task 4.9 Bibliometric Analysis of S&T strengths in Southeast Asia

• Dragon Star , Beijing 10-11 October 2013, Fab Seminar Background Document

• Andre Ross Sorkin, 2014, Risks ahead as Japan and China feud, NYT, 29/1/2014

• Sarah Mishkin& Jennifer Thompson, 2013, Sony shapes future as smartphone survivor, Financial times, 29/11/2013

• Jonathan Ansfield, 2012, China's cyber police enlist foreign firms, International Herald Tribune, 15/11/2012

• Compilation by the S&T Section, 2012, Overview of Europe-China Research and Innovation Co-operation, EU Delegation in China

• SFIC recommendations for thematic priorities in cooperation with China

• Tom Miller, China's Urban Million, ZED Books

• STI China project Science, July 2014, Technology and Innovation in China, D6, Final Report,

• William A. Callahan (2013), China Dreams, 20 visions of the future, Oxford University press, New York

• Hu Angang (2011) China 2020, A New Type of Superpower, Bookings Institution Press, Washington D.C.

JOURNAL ARTICLES

• Simon Rabinovitch, 2014, Beijing backs role of shadow banking, Financial Times, 7 January 2014

• RoubinaSpathi, 2013, Emerging economies are cutting speed, Daily News, 7 July 2013

• Zhang Monan , 2012, Turning point for growth, China Daily, 14 November 2012

• Government call for growth driven by innovation, 2013, Global Times, pg.1, October 12-13

• ALL-ROUND REFORM, 15-21 NOVEMBER 2013, Main points of reform and opening up from the communiqué, China Daily, released on November 12

• Luo Jiexin and Xue He, 2013, We have

direction now for the action, China Daily, 15-21 November

• Deng Yuwen, 2012, Amendments reflect CPC's resolve, China Daily, 15 November 2012

• Andre Vltchek , 2012, China dares to evolve differently, China Daily, 15 November 2012

• Hu Yuang, Li Xiaokun and Zhang Chunyan, 2013, Gear Challenge, China Daily, 15-21 November 2013

• Mike Bastin , 2012, For a moderately well-off society, China Daily, 12 November 2012

• Simon Rabinovitch, 2012, Central bank governor set to step down, Financial Times China's, 15 November 2012

• Li Yang, 2013, Urban-rural divide near top of agenda, China Daily-European Weekly, 8-14/11/2013

• Tom Orlik& Bob Davis, Relief on China Growth Delivered with Caveats, The Wall Street Journal, 21/1/2013

• Chi Fulin, 2013, Blueprint and timetable for the future, China Daily, 28/2/2013

• Lu Mai, 2013, The urbanization solution, Global Times, 25/2/2013

• Cheng Yingqi, Xu ,2012, Wei Counties to balance access to education, China Daily, 14 November 2012

• Ian Johnson, Choosing death over eviction, International Herald Tribune, 10/9/2013

• Xu Mingqi, 2013, Social, financial woes loom for China's expanding cities, Global Times, 25/2/2013

• Efficient use of new stimulus plan key to national rejuvenation (editorial), 2013, Global time, 2-3/3/2013

• Chen Yang, 2013, Price controls urged as property market soars, Global Times, 21/2/2013

• Syetarn Hansakul, 2013, Property market so far so good, China Daily, 28/2/2013

• Henry M. Paulson Jr., How cities can save China, 2012, International Herald Tribune, 6/12/2012

• Gideon Rachman, 2014, China's World, Financial Times, 10-11/11/2012

• Philip Stephens, 2013, China has thrown down a gauntlet to America, Financial Times, 29/11/2013

• Carola Hoyos, 2014, Tensions in Asia help keep sales buoyant, Financial Times, 11/2/2014 ELECTRONIC RESOURCES

• PISA 2012 Results, OECD [online] http://www.oecd.org/pisa/

• China Country profile, OECD, [online] http://gpseducation.oecd.org/

• Helen Gao, China's Education Gap, International Herald Tribune, 8 September 2014 [online] http://www.iht.com/2014/09/08/chinas-education-gap/

• China Hungry for Energy, Phemonoe Lab [online], http://phemonoe.eu/el/china-hungry-energy/

• State Council, Twelfth Five-Year Plan for Science and Technology Development 2011-2015, http://www.most.gov.cn/mostinfo/xinxifenlei/gjkjgh/201107/t20110713_88230.htm (in Chinese). Last accessed on May 14th 2014.

• Kostas Kostarelos, 2014, We face being buried under an avalanche of Chinese science, The Guardian, 24 January, http://www.theguardian.com/science/small-world/2014/jan/24/chinese-science-research-development

• David Cyranoski, Chinese science gets mass transformation, NATURE, Volume 513, Issue 7519, September 2014, [online]http://www.nature.com/news/chinese-science-gets-mass-transformation-1.15984

• Peng Gong, 2012, Cultural history holds back Chinese research, NATURE, 26 January | VOL 481 |411, [online], http://www.nature.com/polopoly_fs/1.9901!/import/pdf/481411a.pdf

• European Commission, Notes from EU-China framework for cooperation, Research & Innovation International Cooperation, [online] http://ec.europa.eu/research/iscp/index.cfm?pg=china

• Human Rights in China: Trends and Policy Implications, Thomas Lum , Congressional Research Service, June 12, 2009, [online]http://fpc.state.gov/documents/organization/125955.pdf

• Stephen L Sass, 2014, Can China innovate without dissent?, NYT, 22/1/2014, [online] http://www.nytimes.com/2014/01/22/opinion/can-china-innovate-without-dissent.html

• China Rethinks its judicial system, 2014 , New York Times18/3/2014, [online] http://www.nytimes.com/2014/03/18/opinion/china-rethinks-its-judicial-system.html

• Murong Xuecun ,2014, Beijing's propaganda crisis, New York Times, 18/3/2014,[online] http://www.nytimes.com/2014/03/18/opinion/murong-beijings-propaganda-crisis.html

• Yu Hua, 2013, Censorship's many faces, , New York times, 1/3/2013,[online] http://www.nytimes.com/2013/02/28/opinion/yu-censorships-many-faces.html

• Desperation in Tibet, New York times, 2/12/2013, [online] http://www.nytimes.com/2013/11/30/opinion/desperation-in-tibet.html

• Helen Gao , 2014, Tienanmen, forgotten, New York times, 4/6/2014, [online] http://www.nytimes.com/2014/06/04/opinion/tiananmen-forgotten.html

• Re-education Through Labor in China, Human Rights Watch,[online] http://www.hrw.org/legacy/campaigns/china-98/laojiao.htm

• 5 more universities set up human rights centres, China Daily, [online] http://europe.chinadaily.com.cn/china/2014-07/23/content_17904113.htm

• Report on Patent Enforcement in China, U.S. Patent and Trademark Office, [online] http://www.uspto.gov/ip/global/China_Report_on_Patent_Enforcement_(FullRprt)FINAL.pdf[8/10/2014]

• High quantity, low quality: China's patent boom, China Daily, http://europe.chinadaily.com.cn/business/2014-06/23/content_17609691.html [8/10/2014]

• Lauren Johnston , Battle of the Second Languages [online] , 18/7/2014 http://europe.chinadaily.com.cn/epaper/2014-07/18/content_17831640.htm

• Top Foreign Languages Learned in China [online], 12/9/2009 http://www.lexiophiles.com/english/top-foreign-languages-learnt-in-china

• Joint Declaration on The EU-China Partnership on Urbanisation , (Brussels, 3 May 2012), [online]http://eeas.europa.eu/delegations/china/eu_china/sustainable_urbanisation/sustainable_urbanisation.htm

• Tom Orlik, 2013, China Faces Big Budget For Needed Reforms, WSJ, 1-3/3/2013

• Asian worries about China's rise - The people concerned, Economist, http://www.economist.com/blogs/banyan/2014/07/asian-worries-about-china-s-rise?fsrc=scn/fb/wl/bl/thepeopleconcerned

• Roger Cohen, China's Monroe Doctrine, NYT, 9/5/2014, http://www.nytimes.com/2014/05/09/opinion/cohen-chinas-monroe-doctrine.html?_r=0

• Phemone Lab, China joins the elite club of moonwalkers, 22 December 2013, http://phemonoe.eu/china-joins-elite-club-moon-walkers/

• IPE, Institution of Public and Environmental affairs http://www.ipe.org.cn/En/default.aspx

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www.emetris.gr
www.phemonoe.eu

Tel.: +30 2310 471 721
Fax: +30 2311 999 910
9th Km. Thessaloniki-Thermi Road,
570 01 Thessaloniki
Greece

PRAXI Network

http://help-forward.gr/en/
Tel.: +30 2310 552 791,
Fax: +30 2310 552 790
FING, 1 Morichovou Sq.,
546 25 Thessaloniki
Greece

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DRAGON-STAR is funded by FP7, aiming to support the Chinese participation in Horizon 2020, the reciprocity originating from the signed EU-China Scientific Cooperation Agreement, the bilateral cooperation in scientific, technological and industrial research and innovation fields, and the ongoing EU - China Innovation Cooperation Dialogue.