

White Paper

China's Innovation Ecosystem

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World Economic Forum
91-93 route de la Capite
CH-1223 Cologny/Geneva
Switzerland
Tel.: +41 (0)22 869 1212
Fax: +41 (0)22 786 2744
Email: contact@weforum.org
www.weforum.org

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Preface



David Aikman
Chief
Representative
Officer, Greater
China Member
of the Executive
Committee, World
Economic Forum
Beijing

This end-of-term paper by the Global Agenda Council on China (2014-2016) considers innovation in China. It compares China's entrepreneurial and innovation ecosystem with others in the rest of the world. At the same time, it suggests ways to improve innovation in China with reference to engaging case studies that illustrate specific best practices. Above all, it is a call for knowledge development and further action.

In 2015, China launched a pioneering programme called Mass Entrepreneurship and Innovation. This is in line with the country's goal to shift from labour-intensive manufacturing to growth driven by innovation. The country also has an enormous and valuable internal consumer base which is hungry for new technology.

According to the Chinese National Bureau of Statistics, the country was the number two investor in R&D in the world in 2015. Substantial resources, policy support and energy are being dedicated to upgrading value chains, improving technology and boosting innovation. The number of innovative projects and patents awarded has increased and more science parks and zones are being established.

Online technology – particularly ecommerce, internet banking and social media – is also accelerating the rapid pace of change. Technology has enabled Chinese entrepreneurs to disrupt traditional industries in powerful ways. Start-ups are using crowdfunding, open-source design and innovation incubators to enable even more radical disruption.

The country's innovation drive has led to the number of private-sector companies rising fourfold¹ in the past ten years. These firms are increasingly moving from imitation to innovation. They are also expanding out of the domestic market into the global marketplace. Today, companies like Tencent, Baidu and Alibaba are among the top 10 internet companies in the world. It is clear the country has the drive and vision to become an innovation-driven economy.

On behalf of the World Economic Forum, I would like to express my deep gratitude to the Co-Chairs and Members of the Global Agenda Council on China who contributed to this white paper. The full list of council members is listed in contributors and we are honoured to have worked with such a stellar group of outstanding individuals. I would also like to personally thank our council Co-Chairs, Zhang Xiaoqiang, Vice Chairman, China Center for International Economic Exchanges, and Kevin Rudd, President, Asia Society Policy Institute, for their leadership in steering this council over the past two years to a successful conclusion.

Executive Summary

Today, the world is realizing the remarkable extent of China's capacity to transform its economy by becoming a global leader in science and technology.

China has made huge progress in terms of R&D expenditure, the number of high talent projects and awarded patents, and the establishment of scientific demonstration parks and zones. Technological influences ranging from e-commerce and social media to internet finance are helping China leapfrog its innovation process in all aspects.

China still has major challenges to overcome. But it is clear that the country has an enormous drive to become an innovation-driven economy.

Evaluating innovation in China

In this part of the report we examine China's successes in recent years and look at the challenges that remain.

Together with Tsinghua and Stanford Universities, the World Economic Forum Global Agenda Council on China surveyed over 100 entrepreneurs in Greater China. The aim was to understand how entrepreneurial companies become scalable, high-growth businesses by accelerating access to new markets. Responses came mainly from Beijing, Shanghai, Nanjing and Guangzhou.

For Chinese entrepreneurs, human capital, accessible markets and regulatory issues are key factors for growth. This is in line with the findings of the Forum's 2014 *Entrepreneurial Ecosystems around the Globe and Early-Stage Growth Dynamics* report.

China's innovation policy and regulations

China has launched pioneering programmes and is investing heavily to create a healthier "innovation ecosystem". It is also capitalizing on the potential of its enormous consumer base when it comes to new technology. In its evaluation of China's intensive innovation drive, The Global Agenda Council on China makes four recommendations:

- Consolidate the part the market plays in allocating resources and enhance the role of government to create an environment that makes a dynamic, innovation-driven development strategy possible
- Help make companies the dominant force in innovation
- Enhance the way innovative talent is nurtured and used
- Promote open source innovation.

We then go on to consider ways of protecting intellectual property.

Best practice case studies

China's drive to transform its economy by becoming more innovative is already achieving impressive results in a number of different ways. Cities, industrial sectors, environments that support innovation and companies themselves are all evolving and flourishing. The inspiring examples drawn from across China's newly emerging innovation ecosystem presented in this paper offer practical lessons and signposting for the country's future.

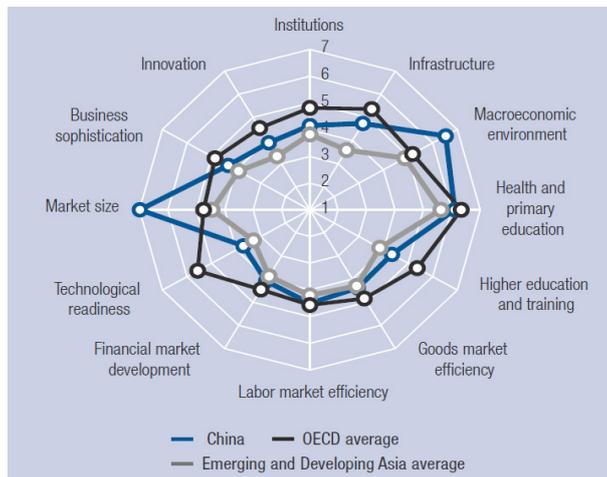
Evaluating innovation in China

The state of innovation in China – strengths

The *World Economic Forum Global Competitiveness Report 2015-2016* indicated that China has a strong economic foundation. The country has achieved near universal primary education and high levels of public health. It has invested massively in its transport and energy infrastructure and the macroeconomic environment is relatively stable.

China's market size also offers significant advantages, as Figure 1 shows.

Figure 1: China in the 12 pillars of the Global Competitiveness Index



Source: *The Global Competitiveness Report 2015-2016*

All of these factors represent assets on which to build. But China also faces rising production costs, an ageing population and diminishing returns on the massive capital investments of the past three decades. The country needs to generate productivity gains through innovation and demand by domestic consumption. This is the context in which China's "innovation ecosystem" is evolving.

The term "innovation ecosystem" refers to the stakeholders and resources necessary to achieve ongoing innovation in a modern economy. According to the *World Economic Forum Global Competitiveness Report 2015-2016*, "The way economists and practitioners think about innovation has evolved considerably in the past decade. From coming up with new ideas, innovation is now seen as an "ecosystem" conducive to the generation of ideas and the "implementation" of these ideas in the form of new products, services, and processes in the marketplace."

In China's case, governance has been transformed from a government-run central management system for R&D projects to a macro-level coordination system of science and technology development.²

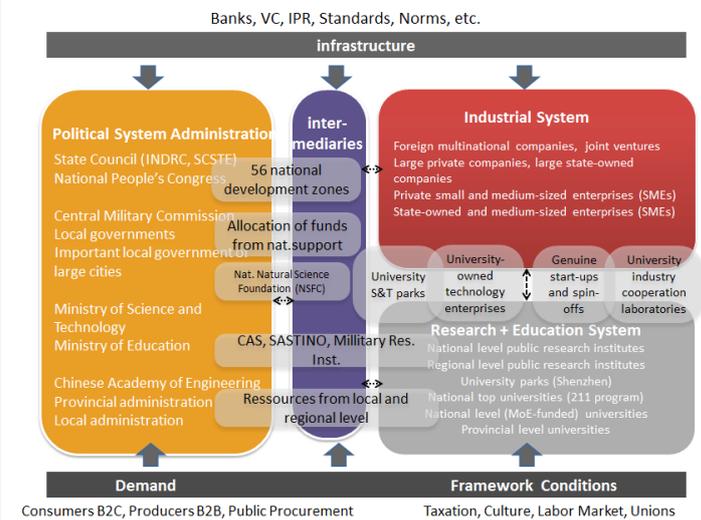
China's innovation ecosystem is characterized by the strong position of local government and official research institutes. The state council has final decision-making authority for structural organization of the research system and guidelines for research policy.

Traditionally, there has been a disconnect between academic and industrial research. Today, however, universities are increasingly pursuing exciting joint projects with enterprises. They are also setting up their own technology enterprises. Technology parks and incubators connect entrepreneurs with local resources.

In vocational and higher education, there are an increasing number of forward-looking programmes focusing on entrepreneurship. Some larger enterprises have incubators for new products and services.

Because of their speed, agility and potential for disruption, SMEs are key players in China's innovation ecosystem. The entrepreneurs behind companies like Tencent, Baidu and Alibaba, working within China's unique ecosystem, also have a vital part to play. Statistics show that SMEs own 65% of invention patents and 80% of the most innovative products in China.³

Figure 2: China's innovation system⁴



Along with significant improvements in innovation capacity, scientific and technological innovation are playing a vital role in improving China's economy.

Scientific and technological progress has helped optimize the structure of sectors such as transportation, energy, manufacturing, information engineering and modern services.

China has completed seven ultra-high voltage (UHV) electricity transmission circuits (1,000 kV AC, 800 kV DC), with four more under construction. The Xiangjiaba-Shanghai 800 kV UHV-DC line is more than 2,000 km.

China is the world's only country that possesses such engineering and technological prowess.

A number of innovative Chinese companies have entered the list of the world's top 10 internet companies. In 2015, China's online retail sales totalled 3,877.3 billion yuan, including 3,242.4 billion in sales of goods. China has become the world's largest e-commerce market.

The role of companies as the dominant innovation driver has been increasingly strengthened in recent years.

R&D spending at Huawei has been maintained over 10% of its revenues in recent years. In 2015, the figure reached 38 billion yuan. High R&D spending has turned Huawei into the world's strongest player in 4G and telecom systems and equipment.

In 2015, Sinopec was awarded 2,844 invention patents, the largest number of patents secured in China. The 4.5 million-ton ethylene project dominated by Sinopec in Saudi Arabia is by far the world's largest and most sophisticated project of its kind.

Hi-tech parks and independent innovation demonstration zones are growing fast.

China is seeing rapid development in more than 130 high-tech parks and independent innovation demonstration zones. These parks and zones, accounting for less than 1% of China's territory, account for nearly 40% of R&D investment by all the country's enterprises, as well as 32.8% of revenue from sales of new products.

The Zhongguancun Science Park (Z-Park) in Beijing recorded 4.07 trillion yuan in revenues in 2015. Covering only 3% of the land, it contributed 37% of Beijing's economic growth. The Z-Park is already at the global forefront in such sectors as Internet+, AI, biomedicine, smart manufacturing and new materials. Strategic emerging industries contributed 71.6% of its revenues.

Shenzhen has been spending over 4% of its GDP on R&D in recent years. In 2015, its GDP expanded by 8.9%. The value added by its seven strategic emerging industries increased by 16.1%, and GDP grew from 28% five years ago to 40% today. In 2015, Shenzhen also submitted 13,300 PCT patent applications, representing 46.9% of China's total. The city leads the world in such sectors as supercomputing, gene sequencing, metamaterial and 4G technology. It is home to 1,283 labs, including key labs, engineering labs, engineering centres and corporate technology centres.

The state of innovation in China - challenges

It is clear that innovation and entrepreneurship in China are taking significant steps forwards. Progress in science and technology is helping to dramatically improve the structure of sectors that include transportation, energy and information engineering. Companies are beginning to dominate the landscape. High-tech parks and independent innovation demonstration zones are growing rapidly.

But China still faces considerable challenges.

Core technologies lag behind

China has yet to catch up with more developed countries in some core technologies. It is the world's largest manufacturer of smartphones and personal computers but still depends on other countries for high-performance circuits and infrastructure software.

In 2015, China's imports of integrated circuits amounted to \$230 billion. This represents 13.7% of the total imported goods and the single largest item. Over 90% of China's computer central processing unit (CPU) and advanced 4G smartphone chip markets are controlled by foreign companies.

Companies must innovate more

China has only a limited number of truly innovative companies that compete globally. Mass innovation remains in its infancy. Also, a large number of SMEs focus their innovation efforts on generic products at the bottom of the value chain.

Total spend on R&D exceeded one trillion yuan for the first time in 2014⁵. But this figure still only represents 0.92%⁶ of the total income from companies' main businesses and is just half⁷ of the average spent by developed nations.

In 2015, the national technology market was valued at 983.5 billion yuan but 80% of technology transfers took place between companies. Some newly developed technologies have yet to be brought to life. The ratio of technologies converted into industrial applications is only 15% whereas in advanced economies it is 30%.

Increasing innovation-oriented regulation

Many innovative SMEs consider that China's regulatory framework is conducive to innovation. But there is still a frustration and a need for more innovation-oriented regulation and evaluation. Different regulatory authorities can have different approaches to technology planning, funding management and allocation, and planning.

Specifically:

- Red tape and lengthy licensing procedures can make it hard for new products and equipment such as drugs and medical devices to enter the Chinese market
- The development of new energy vehicles is sometimes still hampered by market fragmentation and a certain degree of local protectionism
- Entry thresholds of certain monopolized sectors may be prohibitively high, especially natural monopolies, blocking the entry of innovative SMEs
- Overregulation and limitation can still inhibit development. For example, China's slow development in general aviation is primarily a result of the excessively strict control of its low-altitude airspace.

State-owned research institutes and universities continue to encounter institutional barriers to commercializing their innovations. Also, they cannot share their robust research infrastructure and equipment openly.

Talent needs nurturing

China has the world's largest, but not strongest, pool of scientific and technological talent. Unfortunately, the rote learning and examination-oriented education model in colleges and universities is not conducive to creative thinking. Unlike countries such as Germany, training is not aligned with market needs and the state of technology.

When it comes to attracting and using talent, China has yet to create a dynamic culture that encourages innovation and tolerates failure. Under the current system, scientific and technological engineers do not enjoy any real benefits from being innovative.

Intellectual Property Rights (IPR) could be better enforced

As a result of inadequate IPR protection and leniency toward violators, infringements are rampant. Less than one-tenth of these have been punished and even then not severely. This has greatly dampened enthusiasm for innovation among companies and their R&D people.

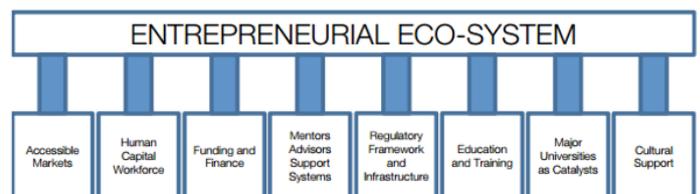
Entrepreneurial ecosystems in China and worldwide

The World Economic Forum has long recognized that SMEs are the key players in any innovation ecosystem. In 2016, the Global Agenda Council on China, in collaboration with Tsinghua University (Chen Hongbo) and Stanford University (George Foster) surveyed over 100 entrepreneurs from the Greater China region. The goal was to better understand how successful entrepreneurial companies accelerate access to new markets and become scalable, high-growth businesses.

Responses came mainly from Beijing, Shanghai, Nanjing, Xi'an and Guangzhou.

Figure 3 shows the eight pillars of an entrepreneurial ecosystem, the primary ones being accessible markets, human capital and regulatory framework/infrastructure. For the survey, entrepreneurs were asked which of the eight pillars were readily available to them as they developed their business.

Figure 3: Entrepreneurial ecosystem and components



Source: *World Economic Forum: Entrepreneurial Ecosystems around the Globe and Early-Stage Growth Dynamics, 2014*

The higher the percentage of respondents indicating ready availability, the stronger the ecosystem pillar is considered to be in that region. Results are presented as a heat map showing colour-coded progression: darkest blue is for pillars with the highest percentage of respondents citing ready availability, while the darkest red is for those with the lowest percentage.

Comparison of company growth of different pillars

Figure 4 provides a heat map comparison of the Chinese responses compared to those reported for different regions of the world in the [2014 World Economic Forum report](#).

The two most important components of the ecosystem for Chinese entrepreneurs were human capital/workforce and accessible markets. This is common to the many different continents/countries in the 2014 report.

Figure 4: Heat map analysis of the relative importance of entrepreneurial ecosystem components for growth/success of companies in their early stages

	2016 GAC Report	2014 World Economic Forum Entrepreneurial Ecosystems Reports							
Ecosystem Factor	CHINA	US - Silicon Valley	US - Other Cities	N. America (USA/CAN)	Europe	AUS/NZ	Asia (incl. China)	Middle East + Africa	S/C America + Mexico
Accessible Markets	52%	44%	59%	53%	59%	74%	65%	68%	57%
Human Capital Workforce	55%	63%	70%	67%	64%	41%	67%	59%	63%
Funding and Finance	17%	64%	62%	63%	49%	56%	56%	55%	63%
Mentors/Advisors/Supp. Sys.	12%	35%	24%	29%	23%	33%	27%	14%	22%
Reg. Framework/Infras.	16%	10%	11%	11%	21%	19%	27%	14%	33%
Education and training	4%	10%	14%	12%	17%	15%	23%	18%	9%
Major Universities as Cata.	3%	17%	9%	13%	9%	7%	5%	5%	0%
Cultural Support	1%	31%	19%	24%	10%	7%	11%	32%	11%

Figure 5 highlights the 2016 Chinese responses compared to those from different parts of the world in the 2014 report. Chinese entrepreneurs see regulatory framework and infrastructure, human capital/workforce and accessible markets as the top three factors already present in China’s innovation ecosystem.

China appears to be mid-stream in the “ready availability” area in Figure 5, having a less developed entrepreneurial ecosystem than North America and Europe. But, according to the average score, the ecosystem is better than countries in Asia due to a sound regulatory framework and infrastructure.

Figure 5: Heat map analysis of ready availability of entrepreneurial ecosystem components for growth/success of companies in their early stages

	2016 GAC Report	2014 World Economic Forum Entrepreneurial Ecosystems Reports							
Ecosystem Factor	CHINA	US - Silicon Valley	US - Other Cities	N. America (USA/CAN)	Europe	AUS/NZ	Asia (incl. China)	Middle East + Africa	S/C America + Mexico
Accessible Markets	51%	92%	83%	85%	72%	69%	68%	68%	62%
Human Capital Workforce	52%	93%	87%	90%	81%	81%	73%	50%	71%
Funding and Finance	43%	91%	76%	82%	57%	69%	44%	55%	45%
Mentors/Advisors/Supp. Sys.	42%	91%	72%	78%	52%	58%	38%	36%	35%
Reg. Framework/Infras.	60%	67%	57%	62%	54%	54%	39%	55%	42%
Education and training	42%	80%	62%	70%	60%	38%	34%	32%	27%
Major Universities as Cata.	34%	88%	67%	75%	52%	42%	30%	23%	27%
Cultural Support	44%	90%	64%	75%	33%	35%	26%	45%	16%

Analysis of Chinese entrepreneurs by key areas

One insightful and convenient way to analyse qualitative responses is to use word clouds. This tool has been applied to show the relative frequency with which words are used in the responses to the 2016 survey.

Figure 6 presents the word cloud and associated quotations for a question on “the main factors that promote a company to rapidly develop in its early stages”. The most frequently mentioned key words are:

1. Team
2. Market
3. Technology
4. Innovation

A common theme that emerged in the responses is the pivotal importance of strong teams being built to grow early-stage companies. The limited availability of talented human capital is often a major constraint on the growth of early-stage companies in China. Accessible markets are the second most frequently cited factor with respondents regularly mentioning an initial focus on the domestic market.

Figure 6: The main factors that help a company develop rapidly in its early stages



China's Innovation Policy and Regulations

Encouraging innovation in China

China's innovation ecosystem has grown steadily healthier in recent years because of five factors.

One: Research and education reforms

China has been gradually reforming the way in which higher education and research institutes are managed. Spending on basic research has increased and the government also funds institutes to carry out independent projects.

Some technology development institutes have been able to compete financially by going public or attracting investment from the private sector. These are making significant contributions to improving the way sectors including transportation, energy and information engineering function.

Two: Market-oriented technology innovation

Forward-looking companies have established engineering centres and their number is growing. Technology innovation collaborations between business and universities, driven by companies, are becoming more diverse. China has adjusted tax assessment criteria for R&D expenses and increased the business activities eligible for deduction from corporate income tax.

Industry technology alliances, SME-specific innovation service systems and technology and innovation incubators have grown rapidly.

China currently has more than 2,300 mass entrepreneurship spaces and over 2,500 technology company incubators and accelerators. These include Tsinghua Tuspark, Zhongguancun Science Park and Hangzhou Xiacheng District Technology Startup Center.

Three: Protecting intellectual property rights

China has made substantial progress in protecting, applying and managing technology innovations and IPRs. IPR courts were set up in Beijing, Shanghai and Guangzhou in 2014. These have the power to adjudicate in civil and administrative cases concerning patents, new plant species, integrated circuit layout designs, protected technology and computer programmes.

Four: Commercializing technology

In China today, finance plays a greater role in supporting innovation than ever before. Funding for innovation and entrepreneurship is growing and diversifying. Significant and rapid progress has been made in other areas such as the Growth Enterprise Market, which lists Chinese high-tech companies, emerging industry funds and intellectual property financing.

The rights to use, dispose of and benefit from new technologies are increasingly delegated to the organizations that develop them. Research institutes and corporate R&D personnel are more likely to be given ownership of and benefit from IPRs. Corporate R&D personnel are also offered stock options and dividends more often.

Five: A maturing legal and policy environment

Many administrative and non-administrative government functions have been revoked or devolved, generating unprecedented momentum for innovation and entrepreneurship.

In June 2015, the State Council issued *Opinions on Several Policy Measures to Promote Mass Entrepreneurship and Innovation* a statement of intent with regard to China transitioning from resource and investment driven development to an innovation-powered growth model. It specifies 30 actions to be taken in ten areas, including institutional innovation and optimizing fiscal and tax policy.

Recommendations for improvement in four key areas

One: Creating an enabling environment

This can be done by enhancing the power of the market to create a level playing field. Collaboration between innovators, NGOs and grass roots organizations could be encouraged. Resources must be allocated efficiently. Government should motivate companies to innovate and promote survival of the fittest.

Two: Making companies the dominant innovator

Although the market should play its part, companies must dominate innovation-related decision-making and commercialization as well as R&D spending. They can be encouraged to develop advanced R&D centres, increase spending and encourage equity crowdfunding. Business can help SMEs by forming industry and value chains.

SMEs pursuing growth through innovation could benefit from a flexible, streamlined multi-tier support system. They should be given more preferential financial, fiscal and tax treatment as well as benefit from public services. Venture capital could be made even more widely available.

At the same time, the Growth Enterprise Market should be reformed to enhance SME-specific national and regional equity markets.

Three: Nurturing innovative talent

Institutions of higher education need to improve their hands-on, inquiry-based and research-oriented learning methodologies. During basic education, student individuality, interests and creative thinking must be respected and encouraged.

The social security system should be reformed to enable a two-way flow of R&D personnel between enterprises, research institutes and universities. China must attract innovative talent by allowing R&D personnel to benefit more from the commercialization of their innovations. Increasing stock incentives for R&D personnel, for instance.

Residency criteria for foreign technological talent should be relaxed to encourage skilled migration by innovative, entrepreneurial foreign experts.

These measures will better motivate foreign and local talent to play a more positive role in China's innovation-driven development.

Four: Promoting openness

In May 2015, the CPC Central Committee and the State Council jointly released *Opinions on Creating an Open Economic System*, setting the goal of creating an economic system that is mutually beneficial, diverse, balanced, secure and efficient.

The aim is to be more proactive when it comes to integrating into the international innovation network, accessing global resources and encouraging cross-border flow. "One Belt, One Road" will improve economic openness, including innovation.

"One Belt, One Road" is a visionary development strategy and framework focusing on connectivity and cooperation among countries between China and Eurasia. It underlines China's drive to take a larger role in global affairs.

Government should involve itself in the development of key international technical standards like the 5G telecom standard. It must emphasize the quality of foreign investments. Investment promotion could be aligned with technology transfer and talent attraction. Foreign capital can be channelled to advanced manufacturing and high-tech activities as well as R&D centres.

Government support can be offered for companies engaged in overseas direct investment (ODI), which rose to nearly \$120 billion in 2015.

When conditions permit, Chinese companies should actively invest in building R&D centres overseas or take part in high-tech projects through M&A or equity participation.

Innovation and intellectual property

Now that China is changing its development model in favour of innovation, protecting intellectual property rights has become a key issue.

In December 2015, the State Council advocated a strategy to strengthen intellectual property protection.⁸ A new trademark law and amendments to the copyright law, the patent law and the unfair competition law offer stricter protection of intellectual property rights and related interests.

Intellectual property and enforcement

A dual track system serves to resolve disputes over copyright, patent, trademark or unfair competition. The rightful owner may either file a law suit in a civil tribunal or ask a competent administrative agency to resolve the dispute.

To reinforce this dispute-resolution process, China established the State Intellectual Property Office, the National Copyright Administration and the State Administration of Industry and Commerce.

It also created local intellectual property agencies for matters concerning patents, copyright, trademark and unfair competition. These are based in provinces, autonomous regions municipality cities – whether governed by the State Council or not – and in counties.

China is unique in the world in establishing *local* intellectual property administration agencies that offer owners the opportunity to protect themselves.⁹

When it comes to legal protection, China has a special jurisdiction process. Intellectual property cases are considered differently from other civil cases, especially those related to tangible property. Suits involving copyright, patent, trademark and unfair competition cases all require different skills to make decisions.

After intellectual property courts were established in Beijing, Shanghai and Guangzhou, significant changes were introduced in the way intellectual property rights are enforced and important judgements were handed down concerning patent, copyright, trademark and unfair competition. Perhaps the most significant changes concern the amount of damages awarded.

The *Report on Judicial Protection from Beijing Intellectual Property Court 2015* includes 92.45% of a total of 5432 law suits. Average trial time is 125 days. In over 70% of cases, plaintiffs received more than 100,000 RMB.¹⁰

For years, most patent owners in a law suit would choose statutory damage, where the average amount of damages awarded to the patent owners is 80,000 RMB.¹¹ However, in 2015, the average amount of damages awarded to a patent owner by the Beijing Intellectual Property Court was 460,000RMB. The average amount of damage awarded in 2015 for a trademark owner was 620,000RMB.¹²

Future challenges for protecting intellectual property

Although a strong message has been sent to the public, China faces other challenges.

Patent quality and quantity. In 2015, the number of patent applications in China was 2,799,000. Of these 359,000 were granted.¹³ For more than five years, China has been the number one country that has received the largest number of patent applications in the world. But China needs to prioritize high-quality patents offering more potential for R&D and value.

Trademark registration and use. In 2015, 2,876,000 applications for trademark registration were submitted. The all-time total number of valid trademark registrations granted was 10,348,000. For more than 14 years, China has led the way globally in trademark applications and trademark registration

There remains, however, the question of how many trademarks are actually ever used commercially. Some organizations have registered a trademark simply to stifle competition. This problem is being resolved.

Calculating damages correctly. Chinese judges, lawyers, enterprises and experts need to be sure of the value of intellectual property rights and award damages appropriately.

Establishing more courts. The three intellectual property courts in Beijing, Shanghai and Guangzhou are an experiment. Experts believe that China should establish no more than 10 intellectual property courts and only a single national intellectual property appeal court.

All of these forward-looking measures are designed to protect and enhance the ability of any Chinese enterprise to compete globally. This, in turn, increases the country's potential to compete as well as offers entrepreneurs the necessary peace of mind in which to conduct business.

Conclusion

In conclusion, China has already built certain powerful advantages into its innovation ecosystem and the country's achievements have been substantial but it also continues to face many challenges.

Achievements

China's growing R&D budget and abundant labour supply are positive contributors to innovation. Corporate R&D spending has grown from \$1.2 billion in 2005 to \$39.4 billion in 2015, a 32-fold increase in 10 years.¹⁴ In 2015, China spent a total of 1.4 trillion yuan on R&D and is ranked as the world's second largest R&D spender after the US.¹⁵

The result is that Chinese companies and R&D institutes are able to make foreign products meet the local standards, needs and expectations more quickly and flexibly. They can also meet consumer needs more effectively owing to their cost leadership in production and sales.¹⁶

Every year, more than 1.2 million college and university engineering graduates enter the Chinese workforce.¹⁷ To appeal to leading experts from overseas, China introduced the Recruit Program of Global Experts in 2008. By the end of 2015, this had attracted 5,208 experts from overseas, many of whom have already achieved breakthroughs in their fields.¹⁸

Besides growth in itself, these professionals have demonstrated considerable interest in innovation. In 2015, 87.8% of engineers surveyed in China showed an interest or strong interest in innovative activities. They also expressed a high degree of satisfaction with national policies and the corporate innovation environment.¹⁹

China's enormous and dynamic consumer market is a powerful force. Between 2005 and 2015, the disposable income of Chinese consumers grew at 10% annually. Between 2000 and 2015, over 85 million new households with an annual disposable income of between 106,000 and 229,000 yuan became mainstream consumers.

The massive potential of China's consumer market has also been a magnet for foreign R&D institutes. By the end of 2015, multinational companies had already established more than 1,500 R&D centres in China.

Chinese consumers are also more likely to participate in innovative activities such as external product tests. This makes them a highly attractive resource.

Innovators are able to rapidly source needed parts and components at a low price to convert their innovations into tangible products thanks to China's network of suppliers. Specifically, China has over 140,000 mechanical parts suppliers, 75,000 telecom equipment manufacturers and 104,000 transport equipment companies. This network is five times as large as that of Japan.²⁰

The Chinese government has recognized the importance of innovation and introduced policies to support high-tech companies and attract talent, while promoting mass entrepreneurship and innovation. All such measures are encouraging and highly conducive to innovation.

SMEs are playing an increasingly vital role in the innovation ecosystem driven by their desire to thrive. Statistics show that SMEs own 65% of invention patents and 80% of innovative products in China.

By the end of 2015, the Ministry of Industry and Information Technology had selected over 500 national pilot schemes that could offer services to SMEs and established over 800 online service platforms. In 2014, these platforms provided more than 600 entrepreneurship and innovation-related services that served 320,000 people.²¹

Challenges remaining

China's innovation model still needs to move from being an "innovation sponge" to a leader by innovating independently.²² Acting as a sponge does help Chinese companies grasp advanced knowledge and technology quickly, shortening R&D time and resources. But in the long run this approach will not help them develop much-needed core technologies.

The traditional innovation models of certain companies need updating urgently. Due to historical reasons, some state-owned enterprises (SOEs) face challenges in their management system and R&D infrastructure. Other large SOEs have to improve their resource efficiency. As industry leaders, these companies must enhance their operational efficiency and innovation capabilities.

China also needs to start using its innovation resource far more efficiently. The country has invested heavily on R&D, but there remains a wide gap between China and developed nations in terms of the amount of triadic patents awarded²³, papers co-authored with foreign academics and the number cited in academic reports.²⁴

China has to follow a more market-oriented approach to talent development. Chinese vocational schools, technical colleges and comprehensive universities produce seven million graduates a year. Over 40% of them cannot find suitable jobs because of the mismatch between their knowledge and skills and business needs.²⁵ This is causing concern.

When it comes to the role of government, the introduction of pro-innovation measures has at times been compromised by lack of foresight and the ineffective nature of local policies.

Looking forward

Despite these challenges, the World Economic Forum Global Agenda Council on China is optimistic. China has the determination to create a healthy, forward-looking and inspiring innovation ecosystem backed by the necessary resources. Given that momentum is sustained, we believe that China will continue its progress to become a game-changing world player when it comes to innovation.

Best practice case studies

The best practice case studies that follow have been chosen to reflect developments in China's innovation ecosystem. We hope they will offer lessons, inspire new ideas and stimulate debate about the country's future.

Innovating at city level in Shenzhen

Since it was designated as a Special Economic Zone (SEZ) over 30 years ago, Shenzhen has enjoyed significant economic success.²⁶ In recent years, however, growing political and economic instability associated with economic globalization have been compounded by other factors.

Technological progress, a changing business environment and intensified competition for talent have all created tough challenges.

The Shenzhen Municipal Government estimated that at the end of 2015, the city was short of 300,000 high-calibre professionals. Financial support from local government for R&D is still inadequate, with R&D investment only accounting for 10% of total social expenditure.

There are two main reasons for Shenzhen's difficulties. In the first instance, the city's chronic shortage of universities and large research institutes²⁷ has resulted in a lack of homegrown innovative talent. Secondly, infrastructure issues affecting hospitals, schools and housing make the city unattractive to the people it needs to attract.

Creating a city innovation ecosystem

Local enterprises are the key innovators in Shenzhen's city innovation ecosystem and the city has abundant resources.

Over 90% of R&D, including personnel and funding, is generated by enterprises but universities and research institutes are also powerful innovators. Since 2008, when Shenzhen became China's first National Innovative City, it has allocated more resources to develop tertiary education and research institutes.

Currently, Shenzhen has 56 national innovation platforms. Collaborating with universities, Shenzhen has established the Research Institute of Tsinghua University in Shenzhen, the PKU-HKUST Shenzhen-Hong Kong Institution, the Shenzhen Virtual University Park and other research organizations. These have become a continuous source of knowledge and technology.

Through its Basic Innovation Program, Shenzhen is supporting the development of national R&D infrastructure in the city, including key national labs, national engineering labs, national engineering research centres and the China

National Genebank. Shenzhen is now ideally equipped to carry out ambitious national strategic R&D projects.

Building on its newly-developed R&D infrastructure, Shenzhen is promoting independent innovation in areas like IT, genetic engineering and stem cell research.

Innovation intermediaries are another player in Shenzhen's innovation ecosystem. These include incubators, professional services firms, technology consultancies, trade associations and recruitment agencies.

Services provided by innovation intermediaries -- including information exchange, decision-making advice, resource allocation, technical service and technology evaluation -- enable innovators and entrepreneurs to mitigate risks and commercialize technology faster.

The city has now become a highly important innovation hub in South China.

Innovation resources

Shenzhen has implemented a number of measures to attract talent. By the end of 2015, the "Peacock Plan" had attracted 59 innovative R&D teams to Shenzhen and Guangdong. A total of 1,219 people had been designated as high-calibre foreign professionals under the Plan. In 2015 alone, the Plan attracted 18 R&D teams specializing in areas such as biology, pharmaceuticals, life sciences, software, telecommunications, microelectronics and new energy.

Among these, 2D Material Optoelectronic Devices is an emerging field of research in China.²⁸

The city has also taken steps to attract and retain talent by strengthening local universities and improving incentives and services.

Total R&D spending across Shenzhen represented 4.05% of its GDP in 2015. Municipal and district governments allocated an R&D budget of 20.93 billion yuan to support pioneering, generic and core technologies. 156 strategic technology projects were initiated.²⁹

According to the Shenzhen Municipal Government plan, total local R&D spending will be 4.25% of its GDP by 2020. As well as encouraging companies to invest more in R&D, the government will also provide additional funds. Moreover, the government will set up an investment company focused on hi-tech, innovative and entrepreneurial activities as a boost to the local venture capital market.³⁰

The innovation environment

A critical issue facing innovation ecosystems is how to balance the roles of government and the markets. These are now clearly defined in Shenzhen, with the market dominating.

Government responsibilities are mainly defined as:

- Developing strategies and plans
- Offering support - creating innovation and collaboration centres, technology parks and incubators, IT networks and providing financial and tax support, for instance
- Building the necessary infrastructure and creating a pro-innovation policy, regulatory, market, administrative and cultural environment
- Playing an organizational, coordinating and steering role.

Shenzhen has also introduced relevant laws and regulations to create a pro-innovation legal environment. The IPR system, protection and management have all been strengthened.³¹

Between 2013 and 2015, Shenzhen invested substantially in the city infrastructure. It began 40 airport and seaport, 19 rail transport, 45 water and environmental and 18 resource projects. Total investment was 528.1 billion yuan.³²

Better infrastructure greatly improves quality of life in a city and makes it far more appealing for new talent. It also helps with the flow of innovative products and services, encouraging prosperity and new growth.

Lessons for future innovation

Shenzhen's government confines itself to being a service provider and a coordinator, leaving entrepreneurs and the market to drive innovation. It also actively embraces new technologies.

Manufacturing innovation

China's manufacturing sector is suffering from declining profitability because the cost of labour, raw materials, energy and land have all grown rapidly. Over the past decade, labour cost has grown 270%. Manufacturing costs in the Pearl River and Yangtze River deltas are now as high as 95% of that in the US.³³

The ecological environment has also been severely harmed by government and business recklessly pursuing profit without regard for the environmental consequences.

Creating the manufacturing sector's innovation ecosystem

Enterprises remain the most important innovators in manufacturing. Chinese companies are building up their innovation capabilities using foreign talent, technology and resources and learning from their foreign peers.

Some companies are pursuing new business opportunities through mergers and acquisitions (M & A) overseas. Others have established R&D centres and manufacturing facilities in North America and Europe. This allows them to easily access local resources and base their R&D activities on relevant market needs.

Several leading companies in the manufacturing sector have become involved in the development of Beijing's auto industry standards. These contribute to product quality and safety improvement and promoting new energy vehicles, as well as improving energy efficiency and emissions reduction.³⁴

Many companies have appreciated the significance of environmental protection and started to develop environmentally-friendly products.

Innovation resources

Since 2009, the government's Recruit Program of Global Experts has been attracting experts from around the world to reinvigorate China's manufacturing sector.³⁵ Manufacturing has attracted foreign direct investment (FDI) to provide funding for innovation that has brought advanced technology and management expertise.

China's growing importance has meant that some engineering and technology teams of multinationals have also been relocated to the country.

Stimulated by their foreign counterparts, Chinese manufacturing companies have gradually enhanced their technological competency. The technology centres of some Chinese factories are also involved in the global R&D of multinationals.

Innovation environment

The Chinese government has introduced a number of macro policy measures to spur innovation among manufacturing companies.

In 2015, China introduced the “Made in China 2025” plan to help make China’s manufacturing more competitive. To enable companies to strengthen their innovative and technical prowess, China needs to implement strategies like collaborative innovation at national level.³⁶ The Chinese government has also introduced “One Belt, One Road” and established the Asian Infrastructure Investment Bank (AIIB).

Although these two policy moves cannot directly stimulate innovation in manufacturing, they will give birth to powerful infrastructure projects. In return, they can provide opportunity for companies to commercialize and test their innovations.³⁷

In addition to macro policy support, the Chinese government is also upgrading its infrastructure. Continuously improved transportation infrastructure should enable faster delivery of raw materials, parts, components and products.

The government is also tackling environmental issues. For example, Beijing launched a programme in 2014 to upgrade about 100 environmental technologies and has developed incentives and pollutant discharge standards for multiple industries. This is intended to reduce emissions of volatile organic compounds.³⁸

Lessons for future innovation

Upgrading technology and products requires long-term investment to pay off. Many Chinese manufacturing companies now want to upgrade their products and manufacturing technologies but they have found this very challenging due to lack of long-term investment.

With this in mind, the government should provide long-term funding and policy support for R&D.³⁹ Economic growth must be balanced with environmental protection.

Intelligent transportation

Advances in information and smart technology have dramatically changed the nature of transportation in China. In recent years, intelligent transportation has developed rapidly. However, the country remains weak in such areas as core technology and market development.

Status of China’s intelligent transportation and challenges

From the late 1970s, electronic and information technology has been used in transportation and management. Since the mid-1990s, China has constantly strengthened its intelligent transportation technology knowledge base. In 2014, the intelligent transportation market was valued at 55 billion yuan, up 34.8% from the previous year.⁴⁰ Intelligent transportation development in China is unfortunately still hampered by substantial weaknesses in areas like core technology, technical standards unification, value chain integration and market development.⁴¹

China’s innovation ecosystem of intelligent transportation

Recognizing the potential of intelligent transportation, Chinese technology companies have increased R&D investment in this field and achieved technological breakthroughs.

Leading intelligent transportation companies, research institutes and trade associations have formed the National Industrial Technology Innovation Strategic Alliance of Intelligent Transport Systems. This promotes technology sharing and intelligent transportation by leveraging innovation resources and influence and forming business-academic alliances for collaborative innovation.⁴²

Innovation resources

China’s breakthrough core intelligent transportation technologies include vehicle-infrastructure cooperation, traffic sensing and interaction, the Internet of Vehicles, environment-friendly intelligent transportation, multi-modal coordination and intelligent road safety management.⁴³ Progress in critical technologies is a powerful way of sustaining innovation in intelligent transportation.

Innovation environment

China’s policy support for intelligent transportation is provided through its national technology programmes. However, the government also needs to introduce economic policies to unleash the full potential of the market and invest capital in innovation.⁴⁴

Technological advances and new business models are changing the way people and goods move, and creating new traffic scenarios. Increased penetration of mobile broadband services has given birth to shared

transportation models Thanks to better interaction, collaborative safety enabled by coordination between multiple vehicles has arrived.⁴⁵

The welcome vogue for green travel will also encourage innovators to further improve clean energy efficiency, overcome technical challenges in new energy vehicles, promote the use of electric vehicles and pursue growth by leveraging new technologies such as big data, intelligent connectivity and vehicle-infrastructure cooperation.⁴⁶

Lessons for future innovation

Intelligent transportation is a critical factor for promoting green travel and developing sustainable transport systems. Companies and the general public should be encouraged to appreciate the benefits of environmentally friendly travel.

Science and technology parks and high-tech companies

With mass entrepreneurship and innovation on the rise, technology firms have begun to cluster in dynamic spaces such as science and technology parks. These spaces aim to help tech firms become even more driven through the provision of pro-innovation services⁴⁷.

The high-tech industry's innovation ecosystem

Independent innovation and adopting advanced foreign technologies have made the high-tech industry more proactive. Sales of innovative products have increased. The total value of exports by high-tech firms in national high-tech zones was \$491.58 billion in 2013, a year-on-year increase of 6.7%, and six times greater than in 2004.⁴⁸

Innovation resources

The government and the private sector should both be encouraged to invest in innovation. Governments could establish funds dedicated to SMEs and emerging industries to channel private-sector capital to technology firms.

Science and technology parks could create public services platforms promoting sharing resources and commercializing technologies while simultaneously improving the quality of services.

The innovation environment

High-tech clusters and incubators for tech firms can provide much-needed support for the development of tech firms.

By 2015, China had 364 high-tech zones and economic development zones, a 13.5% increase compared with the

number in 2011.⁴⁹ High-tech zones alone accounted for over 30% of corporate R&D investment, more than 50% of corporate R&D personnel, and above half of all corporate patents in China.⁵⁰

Incubators of high-tech firms have also been growing fast. As of the end of 2014, there were more than 1,600 incubators and 115 university science and technology parks. These combined are currently incubating more than 80,000 companies and providing employment for over 1.7 million people.⁵¹

Over 30% of national incubators have established some form of business accelerator. More than 50% act as angel investors and shareholder-incubators. Above 60% of staff have received professional training in incubation. Over 80% are equipped with public technical service platforms. Around 90% provide entrepreneurial mentorship to the companies they help.⁵²

In terms of the legal environment, we believe the government has to provide greater IPR protection by enhancing applicable laws and strengthening their enforcement. Park operators should strive to strengthen self-discipline among companies, combat infringements and create platforms that facilitate communication between different regions. Parks must create innovative service platforms that combine on-line and off-line communication channels, so companies can respond promptly to customer needs.

Lessons for future innovation

Our survey of companies based in Tsinghua University Science Park found that different types of high-tech companies had differing needs for innovation services.

Talent services, funding, government services, IP protection, and R&D infrastructure were top of the list for private technology companies. SOEs needed middle managers, developers and technicians and incentive systems for R&D personnel alongside funding, technical and IT services. Foreign-owned tech companies were eager for increased IPR protection.

Organizational change and talent management at Haier

Haier is one of the largest home appliance manufacturers in China. The new economy and intensified market competition have created significant challenges for the company's development.

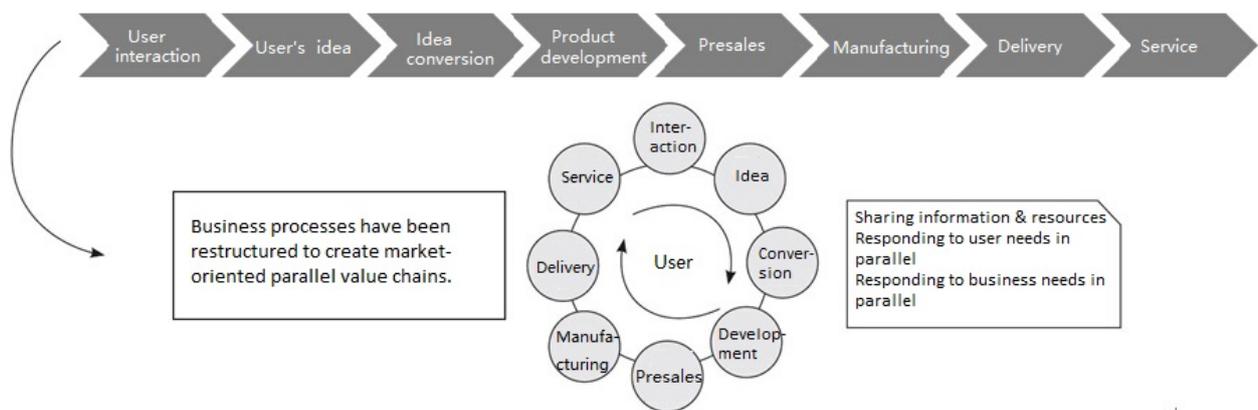
To remain competitive, Haier needed to promote innovation and entrepreneurship among employees and improve operational efficiency. So it transformed its traditional pyramid-like hierarchy into a platform composed of micro-enterprises (MEs) and resource platforms and called this the "Platform Innovation Ecosystem" (PIE).

Platform innovation

MEs are the basic components of Haier's PIE and they are divided into two categories: Entrepreneurial MEs focus on new opportunities and businesses and behave as independent business units. Non-entrepreneurial MEs grounded in Haier's existing and mature businesses have been converted into autonomous business units responsible for their own profit and loss.⁵³

Users or customers are considered important drivers of innovation. In the PIE, value chains are not structured in series, but in parallel. Users are placed at the centre of all internal activities. So all MEs and their activities are directly linked to the market and users (see Figure 5).⁵⁴

Figure 5: Change at Haier—from series to parallel value chains⁵⁵



Innovation resources

Following the change, Haier has increasingly become a decentralized, nimble company without internal boundaries, connected by the internet. Original leaders of business units and product lines have evolved into platform owners, supported by Haier's R&D and supply chain resources.⁵⁶

Our survey and interviews with employees revealed that entrepreneurial MEs are most attracted by Haier's network of suppliers. Manufacturing capabilities and marketing channels appeal to transitional and ecosystem MEs.

Innovation environment

Haier is no longer a large, slow-moving conglomerate. It has disrupted itself into an ecosystem able to mobilize and distribute internal and external resources rapidly. Today, it is a platform of business incubators composed of MEs and resource platforms. Middle management has disappeared, internal and external boundaries have dissolved and processes have been structured in parallel.

On the HR front, Haier has created an open platform to address its talent needs. In R&D, Haier has built a platform to integrate its global R&D resources called HOPE (Haier Open Partnership Ecosystem). HOPE has brought together hundreds of thousands of experts and scholars from prestigious universities and research institutes worldwide to collaborate and innovate.⁵⁷

Haier encourages employees to live its corporate culture by demonstrating a sense of ownership. It also provides support to them if they start their own business.

Lessons for future innovation

Market orientation inside an organization can improve its resource efficiency and promote healthy competition between teams. Such market orientation should be customer-focused. A proper degree of autonomy should be provided for internal innovative and entrepreneurial teams. However, such autonomy is not without limitations. MEs' financial decisions and strategic planning still remain subject to certain controls.⁵⁸

During a period of radical change, attention should be paid to employees' feelings and their intrinsic motivations for innovation.

Continuous innovation the Huawei way

Over the last 28 years, Huawei has grown from a small, privately owned Shenzhen-based firm into a global organization. Today, it is a member of the Fortune 500⁵⁹. But as it has expanded, challenges have tested Huawei's ability to quickly adapt to changing markets and to attract and retain innovative talent.

A number of factors have contributed to these challenges. Huawei built its success on price advantage, dedicated sales and customer service and the ability to imitate quickly. But now that Huawei is a market leader, this model is no longer sustainable in some areas.

Huawei has to develop its capability to survive uncertainties and explore new areas without roadmaps. Size and the company's complicated internal management system are hampering efficiency and the speed of innovation.

Huawei's innovation ecosystem

Its considerable number of R&D staff are one of Huawei's main sources of innovation. Over 45% of the company's nearly 170,000 employees are involved in R&D⁶⁰. Considerable efforts have been made to increase R&D staff autonomy.

One of Huawei's central strategies for innovation is to involve customers. The company has built 36 state-of-the-art collaborative innovation centres worldwide. Here, Huawei works with users to produce new ideas based on actual business needs, application scenarios and network construction and operation challenges.

Huawei has also reconfigured itself as "frontline" and "backstage". Frontline teams work closely with customers to discover market opportunities. They then seek backstage support. Backstage retains and allocates resources and internal service. It evaluates information fed back from the frontline, organizes the reassembly brigade, including experts from R&D, product and service, financial service, negotiation and supply chain.

This team closes a deal by delivering what customers really want. The entire organization is capable of responding rapidly to customers and the market.

Innovation resources

Huawei earmarks 10% of its annual sales revenue as capital investment in R&D. Over the past 10 years, this has cumulatively amounted to 188 billion yuan (nearly \$20 billion), nearly 40 billion of which was invested in 2014 alone (14.2% of that year's sales revenue). Huawei makes extensive use of financial incentives to attract and retain innovative talent, including virtual stocks and time unit plan (TUP).

By the end of 2014, Huawei had 84,000 shareholders who together owned about 98% of the company.

Innovation environment

Huawei's shared leadership structure is also highly unconventional. Supervised by the board, three Vice-Chairmen take turns holding the position of chairman for a term of six months⁶¹. This helps Huawei avoid the dangers of policy uncertainty and provides a stable environment for innovation by ensuring that the company's decision-making is consensus-driven.

The corporate culture is "hard-working" but paired with a reward system that emphasizes value creation and sharing. Those who can create value for the organization have the potential to receive bigger bonuses, salary increases and a bigger share allotment as well as the opportunity of promotion. Employee responsibilities and rights are allocated depending on how successfully a person can meet the customer's manifest and potential demands.

Altogether, these create an exciting customer-driven innovation environment.

Lessons for future innovation

Huawei faced several key challenges when it came to remaining competitive. The company responded by building an innovation ecosystem to absorb external resources and improving its internal review and promotion mechanism to identify and incentivize valuable R&D leaders.

Communication within the organizational structure covering customer service, product management and regional demand was simplified. Huawei is maintaining organizational efficiency and winning talent through reform, a diversified incentive plan, career development opportunities and a more open and inclusive corporate culture⁶².

Huawei's example offers an inspiring yet practical and achievable way forward for many Chinese corporations.

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Contributors

Key contributors

Zhang Xiaoqiang
Vice Chairman
China Center for International Economic Exchanges

Kevin Rudd
President
Asia Society Policy Institute, Australia

Cai Jian
Professor, Management Practice
Peking University

Long Guoqiang
Deputy Director
Development Research Center for State Council

Chen Hongbo
Vice President
Innovation Research Institute, Tsinghua University

George Foster
Professor of Management Stanford Graduate School of Business
Stanford University

Han Jian
Associate Professor of Management
China Europe International Business School

Li Mingde
Director, Intellectual Property Center
China Academy of Social Sciences

Contributors to the discussions

Dong Xia
Deputy Secretary-General
All-China Youth Federation

Fang Li
Deputy Director-General, Foreign Economic Cooperation Office
Ministry of Environmental Protection, China

He Gang
Managing Editor
Caijing Magazine

Bert Hofman
Country Director, China
World Bank

Hu Zhijian
President, Chinese Academy of Science and Technology for Development
Ministry of Science and Technology of China

Jason Li Yat-Sen
Chairman,
Vantage Asia Holdings Limited, Australia

Kevin Lu
Chief Executive Officer, Asia Partners Group, Switzerland

Carlos Shimizu
Stanford Graduate School of Business
Stanford University

Xue Lan
Dean
School of Public Policy and Management (SPPM), Tsinghua University

Zhang Xinsheng
President
International Union for Conservation of Nature

Zhang Yuli
Dean, School of Business
Nankai University

Zhu Rui
Professor of Marketing and co-director of the Branding Center
Cheung Kong Graduate School of Business

Jennifer Zhu Scott
Principal
Radian Partners

World Economic Forum Project Team

David Aikman
Chief Representative Officer, Greater China, Managing
Director, World Economic Forum

Sha Song
Specialist, Knowledge Networks and Analysis
World Economic Forum

Mike Hanley
Head of Digital Communications, Member of the Executive
Committee, Digital Content and Editing,
World Economic Forum, Geneva

Oliver Cann Head of Media Content, Media Relations
World Economic Forum, Geneva

Nina Vugman Commissioning Editor
World Economic Forum, Geneva

Kamal Kimaoui, Head of Production and Design,
Publications
World Economic Forum, Geneva

Ruslan Gaynutdinov, Graphic Designer, Publications
World Economic Forum, Geneva



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World Economic Forum
91–93 route de la Capite
CH-1223 Cologny/Geneva
Switzerland

Tel.: +41 (0) 22 869 1212
Fax: +41 (0) 22 786 2744

contact@weforum.org
www.weforum.org