OECD Food and Agricultural Reviews

Innovation, Agricultural Productivity and Sustainability in China

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BETTER POLICIES FOR BETTER LIVES

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Foreword

Innovation, Agricultural Productivity and Sustainability in China is a part of the OECD Food and Agricultural Reviews series. The review was implemented in collaboration with the Development Research Center of the State Council of the People's Republic of China.

The review examines the conditions in which farms and businesses in China undertake innovation in the food and agriculture sector to become more productive and environmentally sustainable. It starts with an overview of the food and agriculture sector and outlines development challenges and opportunities (Chapter 2). A wide range of policies which influence incentives for innovation are then examined: a favourable and predictable environment for investment (Chapter 3); capacities and public services enabling business development (Chapter 4); agricultural policy (Chapter 5); and, the operation of the agricultural innovation system (Chapter 6).

Policies in China are analysed following a framework developed by the OECD as part of its work on agricultural innovation and in response to a request from the G20 in 2012 under the Presidency of Mexico to evaluate the extent to which a wide range of policies facilitates productivity growth and sustainability in food and agriculture. The framework has been applied to Australia, Brazil, Canada, Estonia, the Netherlands, Sweden, Turkey and the United States; additional reviews are underway or planned.

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The inputs to this review also included several background reports by consultants: on agricultural policy by Mande Zhu from Guizhou University, on agricultural innovation system by Bingchuan Hu from the Institute of Rural Development of the Chinese Academy of Science, on structural change of agriculture, land and labour by Xiaobing Wang from Peking University; on agricultural and agri-environmental policy and sustainable agricultural development by Wusheng Yu from the University of Copenhagen; and on water policy by Jinxia Wang from Peking University. The review also draws on OECD analyses in other economic and social policy fields, and uses cross-country comparable indicators developed by the OECD and other international institutions, such as the World Bank and the World Economic Forum.

This report has benefitted from comments from Guoqiang Cheng (DRC), Hongxing Ni, Liang biao Chen and Yinghua Zhou (Ministry of Agriculture), Xuhua Sun and Shantao Zhu (Ministry of Finance), Hanquan Huang, Min Kang, Tianchao Qiu and Changyun Jiang (NDRC), Zhouyi Zheng (Ministry of Science and Technology), Zhixiong Du (CASS), Jikun Huang and Yu Sheng (Peking University) and discussion with them. It has also received valuable comments from Andrzej Kwiecinski, Carmel Cahill and Emily Gray of the OECD Trade and Agricultural Directorate. Feng Wei and Yingyue Wang of DRC provided valuable support in implementing the project.

This review was declassified by the Working Party on Agricultural Policies and Markets in November 2017, in which Australia and France played the role of lead discussants.

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Acronyms

ABC	Agricultural Bank of China
ACWF	All-China Women's Federation
ADBC	Agricultural Development of China
ADB	Asian Development Bank
AIS	Agricultural Innovation System
APO	Asian Productivity Organization
ASEAN	Association of Southeast Asian Nations
ASTI	Agricultural Science and Technology Indicators
ATSE	Advanced Technology Service Enterprises
BHC	Benzene Hexachloride
BOC	Bank of China
BRICS	Brazil, Russian Federation, India, China, South Africa
BRIICS	Brazil, Russian Federation, India, Indonesia, China, South Africa
CAS	Chinese Academy of Science
CAAS	Chinese Academy of Agricultural Science
CABI	Centre for Agriculture and Biosciences International
CCB	China Construction Bank
CCCPC	Central Committee of the Communist Party of China
CFDA	Food and Drug Administration
CGIAR	Consultative group on international agricultural research
CIWRHR	China Institute of Water Resources and Hydropower Research
CLGFE	Central Leading Group on Financial and Economic Affairs
CLGRW	Central Leading Group on Rural Work
CLPs	Children Living with their Parents
CO2	Carbon Dioxide
CPC	Communist Party of China
CPC	Central Party Committee
CPI	Consumer Price Index
CRDF	China Rural Development Foundation
CNY	Chinese Yuan Renminbi
CYLC	Communist Youth League of China
DDT	Dichloro Diphenyl Trichloroethane
DTF	Distance to Frontier
DRC	Development Research Center of the State Council
EITL	Enterprise Income Tax Law
ESCAP	UN Economic and Social Commission for Asia and the Pacific
EU	European Union
EUR	Euro
FAO	Food and Agriculture Organization of the United Nations
FDI	Foreign Direct Investment
FIE	Foreign Invested Enterprise
FPC	Farmer Professional Cooperative
FTA	Free Trade Agreements
GERD	Gross expenditures in R&D
GDP	Gross Domestic Product

GHG	Greenhouse Gas
GMO	Genetically Modified Organisms
GSSE	General Service Support Estimate
GW	Gigawatts
HRS	Household Responsibility System
HTNE	High-New-Technology Enterprises
IAEA	International Atomic Energy Agency
IATP	Institute for Agriculture and Trade Policy
ICBC	Industrial and Commercial Bank of China
ICT	Information and Communication Technologies
IFAD	International Fund for Agricultural Development
IFC	International Finance Corporation
IFPRI	International Food Policy Research Institute
IFS	International Foundation for Science
IIED	International Institute for Environment and Development
IMF	International Monetary Fund
IPR	Intellectual Property Right
IRRI	International Rice Research Institute
ISIC	International Standard Industrial Classification
LBC	Left-Behind Child
LSC	Land Shareholding Co-operative
LTSC	Land Transfer Service Center
MCA	Ministry of Civil Affairs
MCC	Micro-credit Companies
MEP	Ministry of Environmental Protection
MFN	Most favoured Nation
MHURC	Ministry of Housing and Urban-Rural Construction
MHRSS	Ministry of Human Resources and Social Security
MIIT	Ministry of Industry and Information Technology
MLR	Ministry of Land and Resources
MPP	Minimum Purchase Price
MOA	Ministry of Agriculture
MOC	Ministry of Communications
MOE	Ministry of Education
MOF	Ministry of Finance
MOFCOM	Ministry of Commerce
MOH	Ministry of Health
MOST	Ministry of Science and Technology
MOT	Ministry of Transport
MPS	Market price support
MRAs	Mutual Recognition Agreements
MWR	Ministry of Water Resources
NASTP	National Agricultural Science and Technology Park
NBSC	National Bureau of Statistics of China
NCSTE	National Centre for Science and Technology Evaluation
NCMS	New Cooperative Medical System
NDRC	National Development and Reform Commission
NIWA	Nanjing Institute for Water Resources and Hydrology
NPC	National People's Congress
NPSP	Non-Point Source Pollution
NRCMS	New Rural Co-operative Medical Scheme
OECD	Organisation for Economic Cooperation and Development
OLIS	OECD's Committee Information Service
PAES	Public Agricultural Extension System

PBC	People's Bank of China
PCT	Patent Co-operation Treaty
PIN	Production Index Number
PISA	Programme for International Student Assessment
PMR	Product Market Regulation
PPP	Purchasing Power Parity
PPP	Public-Private Partnership
PPIC	Plant Protection International Consortium
PSBC	Postal Savings Bank of China
PSE	Producer Support Estimate
RCA	Revealed Comparative Advantage
RCBs	Rural Commercial Banks
RCCs	Rural Credit Cooperatives
RCoB	Rural Cooperative Banks
R&D	Research and Development
RIES	Rural Household Income and Expenditure Survey
RLLS	Rural Land and Labour Survey
SCLGPAD	State Council Leading Group of Poverty Alleviation and Development
SCPPH	Specialized Custom Plowers, Planters and Harvesters
SCT	Single Commodity Transfers
SDR	Special Drawing Right
SME	Small and Medium-sized Enterprise
SNWD	South to North Water Diversion
SOCB	State Owned Commercial Banks
SOE	State-Owned Enterprise
SPS	Sanitary and Phytosanitary
TFP	Total Factor Productivity
TPSP	Temporary Purchase and Storage Price
TRAINS	Trade Analysis Information System
TSE	Total Support Estimate
UN	United Nations
UNCTAD	United Nations Conference on Trade and Development
UNESCO	United Nations Educational, Scientific and Cultural Organization
USD	United States Dollar
USDA	United States Department of Agriculture
VAT	Value Added Tax
VTB	Village and Township Banks
WEF	World Economic Forum
WTO	World Trade Organisation
WWF	World Wildlife Fund

Executive summary

The Chinese economy is experiencing a number of structural changes that also have a deep impact on the food and agricultural sector. The working age population started to decline in 2015 and the overall population is projected to peak in 2030. The population is expected to age rapidly over the coming decades. Rapidly increasing real wages since the early 2000s required the People's Republic of China (hereafter "China") to transform its growth model from one that relied on an ample supply of low wage labour from rural areas. The challenge is to shift from growth based on the mobilisation of labour and capital resources to growth based on enhancing productivity through innovation and sustainable use of natural resources, including in the food and agricultural sector.

Driven by self-sufficiency objectives for major grains, China achieved a remarkable expansion of agricultural production, but at the expense of the sustainable use of natural resources. Agriculture is the biggest user of land and water resources, and intensive use of chemical inputs has led to soil degradation, water pollution, and damaged bio-diversity. Water resources reached the limit of sustainable use, particularly in areas where irrigation is intensive or water resources are scarce. The development of the intensive livestock sector has created serious environmental stress, especially on water quality. Climate change is expected to affect agricultural production through rising temperatures, the spread of pests and disease, and more frequent and more severe droughts and floods. Growing competition from other users of land and water may also affect the future of the sector.

While China has succeeded in reducing the incidence of poverty in rural areas, rapid industrialisation has led to large income disparities between urban and rural households. In China, agriculture still accounts for close to 30% of employment, but generates less than 10% of GDP, indicating that labour productivity is significantly lower than in the rest of the economy. The total number of persons employed in agriculture is declining only slowly, and the labour productivity gap between agriculture and other industries is increasing. Because of their importance in many social and economic aspects of China's development, agriculture, farmers and rural areas (*three nong*) have been selected, since 2004, as the topics of the annual No.1 Document that determines annual policy priorities.

Dietary changes associated with income growth have been a major driver for the shift of domestic agricultural production towards livestock, and fruits and vegetables. These sectors already dominate the agriculture sector in terms of production value. Due to the limited endowment of land and other natural resources, China does not have a comparative advantage in land-intensive grain production. Policies to promote grain production are hampering the structural change towards more value-added production. Future growth opportunities of agriculture in China lie primarily in agricultural products that are intensive in capital and knowledge.

The rising cost of labour and the rapid aging of the rural population require agricultural production to concentrate on a smaller number of more productive farms. Consolidating very small and highly fragmented farm operations into larger-scale units is one of the most important pathways of productivity growth in China. It would also improve sustainability of agriculture: the small and fragmented farm structure is leading to an inefficient use of chemical inputs due to the insufficient knowledge of input use among small farmers. Small farmers tend to engage in off-farm employment and have an incentive to substitute labour with chemical inputs in order to allocate more time to off-farm activities. Although small family farms still largely dominate the sector, "new-style" farms, such as large family farms, co-operative farms, and farms run by agribusiness companies are of increasing importance. High labour costs also stimulate increrased farm mechanisation, which allows farmers to save labour input and expand farm size or engage in off-farm activities

Over the last few decades, China's agricultural policy objectives have been diversified from increasing food production to increasing farmers' income, ensuring food safety, and improving competitiveness and environmental performance. Past agricultural policies were largely targeted to achieve near self-sufficiency of major grains, but China recently shifted its food security strategy to ensure food production with available domestic resources, importing moderately and making use of science and technology. Following this new policy direction, the domestic price support programme for cotton, soybean and corn was converted to direct payments. This is an important step towards decoupling producer support from commodity production and allowing farmers to better respond to market demand.

Institutional reform in the late 1970s to allocate land contract rights to family farms contributed to productivity growth in agriculture. China has taken steps to secure land contract rights and to allow the transaction of land operational rights. Faced with a fragmented land structure and small farming units, China introduced a number of innovative formats of farm consolidation. For example, the development of private farm machine services allows small-scale producers to outsource major faming tasks and consolidate farm operation. Voluntary co-operatives consolidate the land operational rights and facilitate vertical integration of small-scale producers with upstream and downstream industries. However, China can further strengthen the long-term stability of land contracts and operational rights to provide incentives to commit long-term investments, and to promote the entry of diverse types of entities to agriculture, which can bring fresh capital from outside agriculture. A proper registration system of operational rights also allows the government to target payment programmes to the cultivator.

China's household registration (*hukou*) system restricts access to social security and education systems in urban areas for households registered in rural areas, despite the introduction of a single national resident registration system in 2014. While China is improving medical insurance, pension and public education for rural residents, an unequal access to social security systems still remains between urban and rural residents. Ensuring more equal access to social services would facilitate the migration of rural residents to urban areas and allow aged farmers to transfer farm resources to efficient and productive farmers. This would reduce the existing large income disparity between urban and rural populations and improve productivity in agriculture.

Improving the environmental performance of agriculture has become a major objective of agricultural policy in China. In 2015, China announced *the Zero-Growth Action Plan for Chemical Fertilizers and Pesticides*, which is designed to realize zero growth of the usage of fertiliser and pesticide by 2020. In addition to strengthening environmental regulations, China introduced an incentive mechanism for adopting more environmentally friendly practices and restoring and protecting the environment. However, in order to establish a solid framework of agri-environmental policies, China should further clarify the reference level of environmental quality as well as environmental targets, which are well adapted to local ecological conditions. China should also strengthen the enforcement of environmental regulations at the farm level. The coherence between existing agricultural policies and agri-environmental policy objectives can be improved.

China has been increasing public expenditure to enhance innovation and productivity growth; for example, through public investment in research and development (R&D) and infrastructure, but the share of such expenditure is still much less than the OECD average. In China, the cost of public stockholding has the largest expenditure share in its general service support, accounting for more than one-third in recent years. The portfolio of agricultural support should be rebalanced to reflect the policy emphasis on long-term productivity growth and sustainability.

China accelerated public investment in agricultural R&D in the 2000s, making it the world's largest investor in public agricultural R&D in money terms. However, the intensity of public agricultural R&D, measured as R&D expenditure relative to value-added of the sector, is still lower than in most OECD countries. The output from agricultural R&D systems has improved significantly, but there is scope to improve the productivity of agricultural R&D systems. China's global share in agri-food patents, publications and citations remains far below those in the United States and the European Union. Increasing co-ordination of research institutions and strengthening evaluation mechanisms would improve the efficiency of public funding to agricultural R&D. Moreover, in contrast to large public investment in agricultural R&D, private agricultural R&D expenditure is estimated to account for only 10-20% of overall agricultural R&D. Nearly three-quarters of R&D expenditure of public agriculture R&D institutions is directed to experimental development, in which the private sector can play a greater role. The dominance of public R&D and extension services is likely to be crowding out private agricultural R&D investment and the emergence of more diverse private farm technical services in China. Improving the enforcement of Intellectual Property Right (IPR) protection would enhance private R&D investment in agriculture, also from abroad.

Policy recommendations cover the following five key areas:

1. Enhancing incentives for private investment in agriculture

    a. Strengthen the enforcement of intellectual property rights by raising awareness of laws and increasing penalties for infringements and systematically prosecuting violators.

    b. Reduce barriers to entry and investment into services related to food and agriculture sector to enhance value addition.

    c. Improve accessibility of financial services, in particular for the emerging types of large-scale farms operators, through promoting new entrants to rural finance.

2. Improve the framework conditions for structural change and innovation at the farm level

    a. Secure long-term stability of contracts and operational rights of land by: increasing the duration of contracts and operational rights, with contracts automatically renewable upon expiration; establishing a registration system of operational rights at the local level; providing certificates detailing land rights.

    b. Reduce the cost of transferring land operational rights through implementing a registration system at the local level which provides certificates detailing operational rights.

c. Promote the consolidation of farm operations through diverse organisational formats such as land shareholding co-operatives and farm machine service providers, adapted to local conditions.

d. Scale down the subsidy to purchase farm machinery, while increasing the role of rural credit institutions in financing farm capital investment.

e. Focus public investment more on land readjustment and farm access roads to promote efficient use of farm machinery.

f. Ensure more equal access to social and education service in urban areas to facilitate the migration of rural residents to urban areas.

g. Increase vocational training opportunities and develop the broad skill sets needed to adapt and innovate in the agriculture sector; facilitate life-long learning and upgrading of skills in agriculture.

3. Improving the environmental performance of agriculture

a. Review existing agricultural policy to improve their coherence with agri-environmental policy objectives including the removal of all the implicit support to fertiliser and chemicals.

b. Establish a framework of agri-environmental policies clarifying the reference level for environmental quality as well as environmental targets.

c. Strengthen the enforcement of environmental regulations through strengthening monitoring and liability management as well as complementary measures such as making payments conditional on the recipient's compliance with environmental standards adapted to local conditions.

d. Conduct a comprehensive review of water governance to better define responsibilities, remove conflicts and ensure effective and efficient policy implementation. Implement the proposed 2016 water price mechanism. Enforce the three red-line policies on water resource efficiency, conservation and water quality with enhanced monitoring and evaluation. Prioritise policy efforts to agricultural regions concentrating the most water risks.

4. Rebalancing agricultural policy toward long-term productivity growth and sustainability

a. Further rebalance the portfolio of agricultural support from support to grain production and public stockholding to public investment in R&D and infrastructure oriented towards long-term productivity growth and sustainability.

b. Further decouple the existing commodity-specific support from production to enhance reallocation of resources based on market demand and to allow producers to set aside farmland, while maintaining production capacity.

c. Following the reform to reduce or cap the minimum purchase prices for rice and wheat, consider in the future replacing domestic price support policy with direct payments for rice and wheat, making domestic prices close to international prices.

d. Evaluate the performance of the subsidy to the agricultural insurance premium.

5. Strengthening China's agricultural innovation system

a. Focus public agricultural R&D on areas of public interest such as environment and resource conservation and on areas where the private sector would under-invest.

b. Strengthen the role of the private sector in agricultural R&D through more effective enforcement of IPR protection, more transparent biosafety regulation, lower barriers to FDI in agricultural R&D and privatising the public R&D institutions in commercially viable areas of research.

c. Improve co-ordination between government agencies and public research institutes at national and subnational levels to avoid duplication, and increase the linkage between public research institutions, higher education institutions, agri-food enterprises, and public and private extension services to reflect industries' changing demands to public agricultural R&D activities.

d. Concentrate the role of the public extension system to the services which private organisations have less incentive to provide, such as promoting sustainable production practices.

Chapter 1. Overall assessment and recommendations

This chapter presents the framework used in the report to analyse the extent to which policies in China are supportive of innovation and structural change, and how they affect access to and use of natural resources for productivity growth and sustainability. It also gives an overview of the findings of the review on a wide range of policies in China, and develops specific recommendations in each of these policy areas.

1.1. A framework to analyse policies for innovation, productivity and sustainability in the food and agriculture sector

Improvements in agriculture productivity growth are required to meet the growing demand for food, feed, fuel and fibre, and must be achieved sustainably through a more efficient use of natural and human resources and a reduction of pollution. A wide range of economy-wide policies affect the performance of the food and agriculture sector, and thus need to be considered alongside agriculture-specific policies. Recognising that innovation[1] is essential to improving productivity growth sustainably along the whole agri-food chain, this report devotes particular attention to the performance of agricultural innovation systems.

The framework used in this report to review policies in the People's Republic of China (hereafter "China") considers policy incentives and disincentives to innovation, structural change, and environmental sustainability of agriculture, which are key drivers of sustainable productivity growth (Figure 1.1).

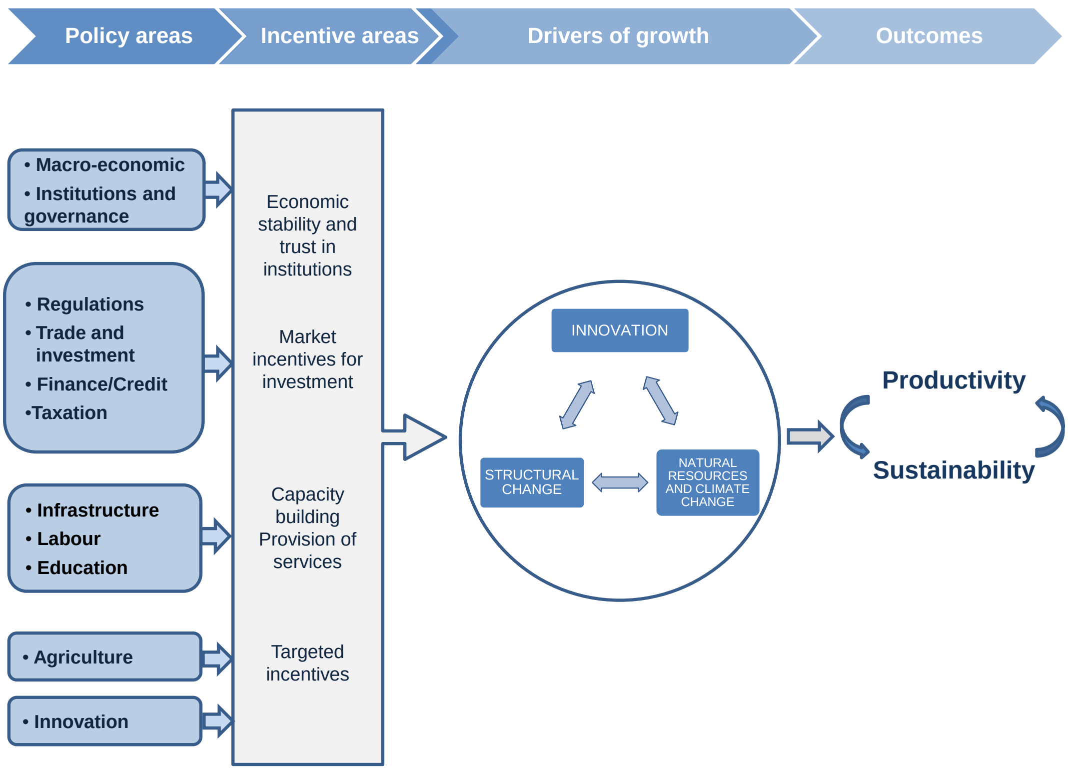
This review begins with an overview of the characteristics and performance of the food and agriculture sector and the challenges it will face in the future (Chapter 2). A wide range of policies is then considered according to the main channels or incentive areas through which they affect drivers of productivity growth and sustainable use of resources.

- Economic and institutional environment, both of which are essential to attract long-term investment (Chapter 3).
- Capacity building, including provision of essential public services (Chapter 4).
- Agricultural policy, domestic and trade-related (Chapter 5).
- The agricultural innovation system (Chapter 6).

This review draws on background information provided by the Development Research Center of the State Council and other experts, and on recent OECD agricultural, economic, rural, environmental and innovation policy reviews.

Throughout the report, the likely impacts of each policy area on innovation and sustainable productivity growth are discussed and recommendations are drawn from this review on a large range of policy areas.

Figure 1.1. Policy drivers of innovation, productivity and sustainability in the food and agriculture sector



Source: OECD (2015), "Analysing Policies to improve agricultural productivity growth, sustainably: Revised framework", www.oecd.org/agriculture/policies/innovation.

1.2. Policy challenges for innovation, agricultural productivity growth and sustainability in China

The Chinese economy has shifted into a "new normal" situation in which lower but more sustainable economic growth rates are expected. Real GDP growth rates declined from more than 10% in the 2000s to 6.9% in 2014-16. ***The economy is experiencing a number of significant structural changes that also have a deep impact on the food and agricultural sector.*** The working age population in China started to decline in 2015 and the overall population is projected to peak in 2030. The population is expected to age rapidly over the coming decades. China's remarkable economic growth in the last few decades has been sustained largely by an accumulation of capital, supported by large saving rates, rather than productivity growth (OECD, 2017a). However, increasing real wage rates since the early 2000s required China to transform its growth model from one that relied on an ample supply of low wage labour from rural areas. China is facing a challenge to shift growth based on the mobilisation of labour and capital resources to growth based on enhancing productivity through innovation and sustainable use of natural resources, including in the food and agricultural sector.

In China, agriculture still accounts for close to 30% of employment, but generates less than 10% of GDP, indicating that labour productivity is significantly lower than in the rest of the economy. However, the total ***number of persons employed in agriculture is declining slowly***, and consequently the labour productivity gap between agriculture and other industries is increasing. The growth rate of total factor productivity in primary agriculture in 2001-14 slowed down compared to the 1990s, while in other BRIICS countries the total factor productivity growth rate accelerated in 2001-14 compared with the 1990s, except for South Africa.

China's agriculture development has been achieved at the expense of sustainable use of natural resources. Agriculture uses most of the country's land and water resources. The expansion of the sector, especially for products with high self-sufficiency targets, has been aided partly by the intensive use of chemical inputs such as mineral fertilisers and pesticides. ***Intensive use of chemical inputs*** in the crop sectors have led to soil degradation, water pollution, and damaged bio-diversity. The dominance of small-scale farms also led to inefficient use of chemical inputs as small-scale farmers tend to have an inefficient knowledge of input use. They also have an incentive to substitute labour with chemical inputs in order to allocate more time to off-farm activities. W***ater resources*** reached the limit of sustainable use, particularly in areas where irrigation is intensive or water resources are scarce. The development of the livestock sector has created serious stress on China's grassland areas. The release of animal manure and wastewater from intensive livestock and aquaculture farms further pollutes the environment, especially water resources.

The rising cost of labour and the rapid aging of the rural population require agricultural production to concentrate on a smaller number of more productive farms. ***Consolidating small and fragmented farm operations in large-scale units*** is one of the most important pathways of productivity growth in China. It would also improve the sustainability of agriculture, as the small and fragmented farm structure is leading to an inefficient use of chemical inputs. Although small family farms still largely dominate the sector, "new-style" farms, such as large family farms, co-operatives, and farms run by agribusiness companies are increasing their importance. High labour costs also stimulate rapid farm mechanisation, allowing farmers to save labour input and expand farm size or engage in off-farm activities.

Dietary changes associated with income growth have been a major driver for the shift of domestic agricultural production towards livestock and fruits and vegetables. These sectors already dominate the agriculture sector in terms of production value. Due to the limited endowment of land and other natural resources, China does not have a comparative advantage in land-intensive grain production. Policies to promote grain production are hampering structural change towards more value-added production. Future growth opportunities of agriculture in China lie primarily in agricultural products that are intensive in capital and knowledge.

Growing environmental challenges have also become significant constraints to sustainable productivity growth of agriculture in China. Contamination and pollution of soil and water resources raises uncertainty about future productivity trends. ***Climate change*** is expected to impact agricultural production through rising temperatures, the spread of pests and disease, and more frequent and more severe droughts and floods. Growing competition from other users of land and water may also impact the future of the sector. The sustainable productivity growth of agriculture requires a policy strategy to curb and eventually reverse the current practice of intensive chemical inputs use. It should also increase the sector's resilience to resource-related risks.

1.3. Enhancing incentives for private investment in agriculture

Although the growth rate of GDP has slowed down, China has a favourable macroeconomic environment, considering its government's budget balance, gross national savings, inflation, government debt, and the country's credit rating. However, the quality of governance is still lower than the OECD average, most notably in the protection of property rights, both physical and intellectual**.** Effective protection of property rights is key to attracting private investment, including in agriculture. The government should strengthen the enforcement of Intellectual Property Rights (IPRs) by raising awareness of laws and increasing penalties for infringements to ensure adequate protection for domestic and foreign innovators.

Reforms have significantly reduced ***regulatory barriers to entrepreneurship***, but there is still large scope to reduce complexity and transaction costs related to compliance with regulations. Overall, China's regulations remain relatively complex and costly compared to OECD countries. China should continue its efforts to reduce administrative burdens and compliance costs for enterprises, and improve transparency and provision of public services. Specific areas where further efforts would be expected are the simplification of the licence and permit system and the reduction of administrative burdens for start-ups.

With markets playing an increasingly prominent role in resource allocation in China, the ***competitive environment should be improved further***, including by strengthening the institutional capacity to ensure effective enforcement of Anti-Monopoly Law. While the importance of State Owned Enterprises (SOEs) in China has gradually declined, some areas of the service sector (e.g. financial services) are still dominated by SOEs. An earlier OECD study finds that SOEs are not very efficient producers and users of knowledge and have inefficient incentives to undertake risky investment in R&D (OECD, 2008). The government should continue opening up more sectors to private investment.

Developing ***an efficient service sector and increasing its linkage to primary agriculture*** is an important condition to promote more value addition to China's food and agriculture products, as the share of value added from domestic service sectors to food and agricultural production remains low. Both affordability and availability of financial services in China are limited compared to most OECD countries. While allowing farmers to collateralise land use rights and gradually liberalising the entry of new financial institutions to rural financing increases the accessibility of finance for farmers, diverse financial services should be made accessible for farmers, and in particular for emerging types of large farms operated by land co-operatives and enterprises.

The trade and investment environment facilitates knowledge flows embedded in agri-food trade and Foreign Direct Investment (FDI). China has been benefiting from opening up for trade, and has lower trade barriers as measured by the level of tariffs and by trade facilitation indicators compared to other BRIICS countries. While the recent FDI reform to move from an approval-based to a filling system will bring the FDI regime closer to internal levels of openness, China still maintains ***barriers to FDI***. For example, in the food and agriculture sector, foreign companies are not allowed to conduct research on transgenic crop breeding in China. Non-transgenic plant breeding and seed production features as one of the "restricted" areas of FDI and requires foreign investors to establish a joint venture with Chinese companies.

Recommendations to improve incentives for private investment

- Strengthen the enforcement of IPR protection by raising awareness of laws, increasing penalties for infringements and systematically prosecuting violators to ensure adequate protection to domestic and foreign innovators and attract private investment.
- Continue efforts to reduce regulatory burdens and compliance costs for entrepreneurs, and improve transparency and provision of public services.
- Open up more sectors to private investment and strengthen an institutional capacity to ensure effective enforcement of Anti-Monopoly Law to develop a more competitive service sector.
- Improve the accessibility of financial services, in particular for emerging large-scale farms operated by land co-operatives and enterprises, through promoting more new entrants to rural finance.
- Continue simplifying the procedure for FDI and reduce restrictions to FDI in certain areas of agricultural R&D by foreign enterprises.

1.4. Improve the framework conditions for structural change and innovation at the farm level

China has developed ***a competitive transport and electricity infrastructure network*** which is comparable with most of the OECD countries. Economic activities benefit from a well-developed national transportation infrastructure network. On the other hand, the penetration of Information and Communication Technology (ICT) increased to one-third of the rural population but still lags significantly behind the urban population. Efforts to ***increase the penetration of ICT in rural areas*** should continue, including the promotion of ICT in agricultural production and marketing as stated in the 13th Five-Year Plan.

Institutional reform in the 1980s to allocate ***land contract rights*** to individual family farms contributed significantly to the productivity growth in agriculture during the early reform period. Since then, China has taken a number of steps to secure land contract rights and to activate the transaction of land operational rights between farms. However, the operational size of farms is small and the share of rented land is still lower than in many OECD countries. Local governments should play a proactive role in providing information on potential lenders of land and reduce the costs related to land transactions. Ensuring long-term stability of land contracts and operational rights is also important to provide incentives to commit to long-term investments in land. A proper registration system of operational rights of land also allows the government to target payment programmes to the cultivator. China should further promote the entry of diverse types of entities to agriculture including agri-business ventures and migrants from urban to rural areas, allowing them to obtain land operational rights.

China's policy approach to promote the ***consolidation of farm operations through various organisational formats*** (e.g. transaction of operational rights, establishment of land shareholding cooperatives and consolidation of farm operational by professional service provider) has the advantage of being adaptable to local conditions. Under a highly fragmented farm structure, the traditional approach to promote land consolidation through transaction of land ownership and tenancy entails high transaction costs. China's adaptable approach to promoting consolidation of small and fragmented farm operations provides a policy lesson for other countries with a similar agricultural structure. The recent policy to establish geographical zoning for grains and other crop production to target government support, if it rationalises the geographical distribution of agricultural production based on natural and environmental conditions, facilitates structural change of agriculture and more sustainable agricultural production.

Saving labour inputs through ***farm mechanisation*** is another important pathway for agricultural productivity growth in China, considering rising costs of labour in rural areas. Mechanisation allows farmers to operate larger farms or to allocate more time to off-farm activities. The development of farm machine services in China contributed significantly to the rapid increase in the use of modern farm machines, including on small farms. Outsourcing major farming operations (e.g. ploughing, planting and harvesting) by small farms to farm service providers allows small farms to benefit from economies of scale in farm operations and reduce the cost of capital inputs. However, the fragmented land structure and lack of access roads to farms limits the efficient use of farm machinery.

China provides ***a subsidy to purchase agricultural machinery***, which stimulated the replacement of inefficient smaller machines with more efficient larger ones. However, this subsidy should only have a transitory role in promoting the use of modern farm machinery. This programme should be scaled down, while increasing the role of a supporting credit to cover a wider range of farm capital investments such as a credit support programme for new types of professional farmers in 2015. Additionally, rural credit institutions should play a greater role in financing capital investment, including farm machinery. Public investment should focus more on land readjustment and developing farm access roads to promote efficient use of farm machinery. Recently announced plan to increase the investment in high standard farmland is in this policy direction.

China's ***household registration (hukou) system*** continue to restrict households registered in rural areas from accessing social security and education systems in urban areas, despite the introduction of a single national resident registration system in 2014. While China is improving medical insurance, pension and public education for rural residents, unequal access to social security systems remains between urban and rural residents. For example, it is difficult for the children of rural households living in cities to access the public school system in urban areas. On the other hand, only the members of rural collective economic organisations (villages) can receive an allocation of land contract rights. ***Ensuring more equal access to social services*** would facilitate the migration of rural residents to urban areas and allow aged farmers to transfer farm resources to more efficient and productive farmers. This would reduce an existing large income disparity between the urban and rural populations and improve productivity in agriculture.

Although most of the working age population obtains lower- and upper-secondary education, China currently has the lowest proportion of the adult population with tertiary level education among OECD and BRIICS countries. The education attainment of rural residents is largely limited to lower-secondary level. Increasing the level of attainment of ***education and training in a broad skill set*** would benefit rural regions, in particular, by improving the competence and capacity to adapt and innovate in the agriculture sector. Public support to vocational education in agriculture should be increased.

Recommendations to improve the framework conditions for structural change and innovation at the farm level

- Increase the policy effort to extend ICT to rural areas, including the promotion of ICT applications to agricultural production and marketing.
- Secure the long-term stability of contract and operational rights of land by increasing their duration, with contracts automatically renewable upon expiration, and implementing a registration system at the local level which provides certificates detailing operational rights.
- Reduce the cost of transferring operational rights of land through establishing transparent exchange platforms at the local level.
- Promote the consolidation of farm operations through diverse organisational formats such as land shareholding co-operatives and farm machine service providers, adapted to local conditions.
- Facilitate the entry of diverse types of entities to agriculture, including agri-business ventures and migrants from urban to rural areas, and allow them to obtain land operational rights.
- Scale down the subsidy to purchase farm machinery while increasing the role of the rural credit institutions in financing farm capital investment.
- Focus public investment more in land readjustment and farm access roads to promote an efficient use of farm machinery.
- Ensure more equal access to social services to facilitate the migration of rural residents to urban areas and allow aged farmers to transfer farm resources to more efficient and productive farmers.
- Ensure public support for education and knowledge institutions in rural areas to allow rural residents to obtain the equivalent level and quality of education as urban residents.
- Increase vocational training opportunities in the broad skills set needed to adapt and innovate in the agriculture sector and facilitate life-long learning and upgrading of skills in agriculture.

1.5. Improving the environmental performance of agriculture

Improving the ***environmental performance of agriculture*** has recently become one of the central objectives of China's agricultural policy. China has been increasing policy efforts through strengthening regulations as well as expanding the payments for resource conservation. The 2020 Zero-Growth Action Plan for Chemical Fertilizers and Pesticides restricts the annual growth of chemical fertiliser use to below 1% in 2015-19 and to zero by 2020 for major agricultural crops, compared to observed growth rates for nitrogen and phosphorus uses of 3.9% and 2.5% p.a. in 2000-13. However, existing agricultural policy instruments to promote grain production are not necessarily coherent such agri-environmental policy objectives. For example, the exemption of VAT on fertiliser sales was removed in 2015, but implicit support to fertiliser producers exists in the form of a subsidy on rail transport.

Designing agri-environmental policies requires the definition of reference levels and environmental targets, as this plays a crucial role in choosing policy instruments. While a reference level is the minimum level of environmental quality that farmers are required to provide at their own expense, environmental targets establish a voluntary (desired) level of environmental quality. To establish a solid framework of agri-environmental policies, China should further clarify reference levels for environmental quality and provide environmental targets which adapting both to local ecological conditions.

China developed ***a regulatory framework for environmental protection***, but its coverage and implementation can be improved. Regulations have been introduced in the agriculture sector: for instance, the Environment Protection Act and the regulation on livestock pollution prevention and control, which strengthened regulation at the production level and increased financial penalties for livestock breeders that mismanage waste. The regulation on pesticide use was also strengthened. However, regulations are often applied at the product level (e.g. maximum residue limits) rather than to production processes. Regulatory measures, as well as a monitoring system, should be applied more at the farm level, clarifying the minimum levels of environmental quality with which farmers have to comply.

The effective ***enforcement of environmental regulations*** remains a major challenge in China. Further monitoring and liability management will be necessary to make progress, but this is costly under China's small and fragmented agricultural structure. Compliance with environmental regulations can be enforced more effectively with complementary incentive measures. For example, making direct payments conditional on the recipient's compliance with environmental standards could increase the farmer's incentive to comply with environmental regulations and reduce the cost of monitoring at the farm level, considering the farm structure in China is dominated by small-scale producers. However, experience in OECD countries shows that such conditionality would not be effective unless it is adapted to the diversity of local farming practices and conditions.

In addition to strengthening the enforcement of environmental regulations to ensure compliance, the government could introduce policies to ***encourage the adoption of environmentally friendly production practices.*** Although China has introduced payments for long-term resource retirement and for environment restoration, payments linked to specific environmental actions by producers account for only 1.2% of total producer support and 4.2% of budgetary transfers to producers. In contrast, the majority of payments in the European Union and the United States are linked with improved environmental practices. In this light, voluntary targeted payments that reward better practices in key environmental areas could be employed to compensate farmers for the additional costs associated with improving environmental performance beyond the reference level. Such payments can be introduced by reorganising the existing area-based direct payments to make a portion of them conditional on additional action by farmers, such as the adoption of environmentally friendly production practices. Given China's small and fragmented farm structure, a community-based policy may also reduce the cost of monitoring small farms, e.g. a programme to support groups of farmers in localities to set up voluntary co-operative arrangements to collectively address common problems such as water pollution and soil erosion.

Sustainable agriculture productivity growth requires a sufficient and stable quantity of usable freshwater for crops and livestock, and minimised impacts of agricultural activities on ***water resources***. China has increased its efforts, investments and policies to address the multiple water challenges it faces. Recent policies, promoted in particular by the No. 1 Document of 2011 and reinforced by the No. 1 Document of 2017, have led to ambitious plans – with innovative pilot programmes – to increase conservation, water use efficiency and quality improvements. These plans include the establishment of a new agricultural water price mechanism by 2026: the mechanism aims to adjust the agricultural water price to cover the cost of operation and maintenance, control overall water use, establish new systems of accurate subsidies and water-saving rewards, as well as promote advanced water-saving technology. Given the scope and complexity of China's water challenges, prioritising future policy efforts to regions where agriculture production faces the most water risks (a water risk "hotspot" approach) could help accelerate progress at a lower cost (OECD, 2017b). In particular, upscaling successful pilot agriculture water management initiatives, for instance those focusing on groundwater pricing in the North China Plain, could be an effective means to progress water policy reform. Examples from the past have also shown that implementation and enforcement remain the key challenges for water management improvements. The co-ordination of actions across multiple agencies and implementation levels will need to be closely monitored to see if progress can be achieved effectively. This is especially important as water resource scarcity is projected to remain a major constraint to productivity growth in Chinese agriculture.

Recommendations to improve the environmental performance of agriculture

- Review existing agricultural policy instruments to improve their coherence with agri-environment policy objectives including the removal of all the implicit support to fertilisers.
- Establish a framework of agri-environmental policies clarifying the reference level for environmental quality as well as environmental targets. Regulatory measures as well as a monitoring system should be applied more at the farm level, clarifying the minimum levels of environmental quality with which farmers have to comply.
- Strengthen the enforcement of environmental regulations through strengthening monitoring and liability management, and introduce complementary measures such as taxing polluting inputs and making agricultural payments conditional on the recipient's compliance with environmental standards which are adapted to local conditions.
- Introduce targeted voluntary payments rewarding better practices in key environmental areas to compensate for the additional costs associated with improving environmental performance.
- Consider a community-based policy which supports groups of farmers in localities to set up voluntary co-operative arrangements to collectively address common environmental problems.
- Conduct a comprehensive review of water governance to better define responsibilities, remove conflicts and ensure effective and efficient policy implementation.
- Define and secure water rights for all users including in rural areas and implement the announced water pricing mechanism. Enforce the three "red

line" policies on water resource efficiency, conservation and water quality, especially in rural areas, with enhanced monitoring and evaluation. Further agriculture and water policy efforts could be prioritised to agricultural regions concentrating the most water risks. This may involve upscaling successful pilot water policy initiatives.

1.6. Rebalancing agricultural policy toward long-term productivity growth and sustainability

Over the last three decades, agricultural policy objectives in China evolved significantly, reflecting the different roles that agriculture plays at different stages of economic development. The policy objectives have been diversified from increasing the quantity of food production to ensuring food safety, increasing farmers' income, enhancing competitiveness and improving environmental performance. To enhance innovation and productivity growth, China has been increasing public expenditure on general services support such as public investment in R&D and infrastructure, but the share of such expenditure is still much lower than the OECD average. In China, ***the cost of public stockholding*** has the largest expenditure share in general services support, accounting for more than one-third in recent years. China should further rebalance the ***portfolio of agricultural support*** to reflect its policy orientation towards long-term productivity growth and sustainability in agriculture.

China's current domestic support and market price support systems strongly favour national food grain production (e.g. minimum support prices and intervention purchases). The major grain products tend to be intensive in using land resources and to rely on irrigation, especially in areas where the surface and underground water supply is already under stress. The continued pursuit of food grain self-sufficiency is becoming more costly in terms of both maintaining a large amount of public stock of grains and unsustainable use of land and water resources. Recently the emphasis on ***food security policy*** shifted to increasing use of international markets and preserving the domestic production capacity rather than boosting production itself. More integration with international markets and decoupling of support from production would optimise the domestic agricultural structure and reduce pressure on the environment and national resources. Consistent with this are recent reforms in soybean, corn and cotton policies to replace domestic price support with direct payments. The reform of the price support policy for rice and wheat, reducing or capping minimum purchase prices, is also already underway. In the future, China should consider shifting domestic price support for rice and wheat to a direct payment system.

China has developed area-based ***direct payments*** programmes such as direct payments for grain producers, agricultural input payments and an improved seed variety subsidy. The recent policy reform consolidated these payments into a single payment focusing on supporting the maintenance of grain production capacity rather than boosting production itself. It also focuses more on larger farms. However, the policy should not interfere with farm management decisions, including what to produce and what size of operation farmers choose. Moreover, the income support component of the direct payment should have only a transitory role in supporting farmers' adjustment to a new policy and market environment. The payments should be further decoupled from commodity production and introduced as a transitional measure that is time-bound. Such payments would enhance production diversification to higher value crops and allow producers to set aside farmland while maintaining production capacity. Despite the policy objective to consolidate small farms into large size ones, payments conditional on farm size could distort the farmer's decision on their operational scale.

The ***subsidy for agricultural insurance premiums*** launched in 2007 has become one of the key programmes to support producers. However, it is not a cost-efficient programme in increasing farm income as these instruments generate high transaction costs and rent-seeking behaviour by farmers and insurance companies. Insurance subsidies may lead to unsustainable choices of production and farm practices in the short term and to the adoption of maladaptive practices under a changing climate in the long term. They may also crowd out on-farm diversification strategies as well as the development of agricultural insurance markets. In general, insurance subsidies risk crowding out market-based solutions and own-farm risk management strategies, and may transfer to taxpayers a part of the risks that should be borne by farmers.

Recommendations to rebalance agricultural policy toward long-term productivity growth

- Further rebalance the portfolio of agricultural support from support to grain production and public stockholding to public investment in R&D and infrastructure oriented towards long-term productivity growth and sustainability.
- Further decouple the existing commodity-specific support from production to enhance reallocation of resources based on market demand and to allow producers to set aside farmland while maintaining production capacity.
- Following the reform to reduce or cap the minimum purchase prices for rice and wheat, consider in the future replacing the domestic price support policy with direct payments for rice and wheat, making domestic prices close to international prices.
- Evaluate the performance of the agricultural insurance premium subsidy to ensure it does not transfer risk that should be borne by farmers to taxpayers, and monitor if it is hindering the development of agricultural insurance markets.

1.7. Strengthening China's agricultural innovation system

China has developed the world's largest and most decentralised public agricultural R&D system (Chen, Flaherty and Zhang, 2012). Public investment in agricultural R&D accelerated in the 2000s, both in terms of expenditure and human resources. Agricultural R&D expenditure was almost four times greater in 2013 than in 2000 in real terms (Stads, 2015). Although the size of expenditure for public agricultural R&D in China already exceeded that of the United States, making China the largest investor in public agricultural research, the intensity of such expenditure is still lower than most OECD countries.

With a growing public investment in agricultural R&D, the ***output from agricultural R&D systems*** has improved significantly. China's share in global agri-food publications increased from 1% in 1996 to 9% in 2012. The number of applications for agricultural patents and new plant variety rights has also been rapidly increasing, with an annual average growth rate of 26% between 2006 and 2011. However, China's global share in agri-food patents, publications and citations remains far below those in the United States and the EU28. The output of agricultural R&D systems indicates scope to improve the productivity of the agricultural R&D system in China.

In China, agriculture R&D activities are dominated by public agricultural R&D institutions, and private agriculture R&D expenditure is estimated to account for only 10-20% of overall agriculture R&D. The role of private agriculture R&D is lower than in most OECD countries. In the United States, the private sector funded 76% of food and agriculture research and performed 72% of research activities in 2013. In particular, the private sector performs the majority of commercially viable areas of research, such as food and feed manufacturing, farm machinery, and plant system and crop protection (OECD, 2016). By contrast, in China nearly three-quarters of R&D expenditure of agriculture public R&D institutions is directed to experimental development research. The dominance of ***public R&D in a wide area of research is likely to be crowding out the private*** agriculture R&D investment in China.

The good performance of the agricultural innovation system comes from strong investment over the long term, and tripartite collaborations between education, research and industry. Creating ***public-private partnerships for agricultural innovation***, aimed at fostering long lasting co-operation in R&D and innovation between these actors, should be a priority to establish a high performing agricultural innovation system in China. While China has been encouraging collaboration between public R&D institutions and the private sector for the last decade, the roles of public and private agricultural R&D should be clarified to make them complementary. Public R&D institutions should concentrate more on areas of public interest, such as environment and resource conservation, and on areas where the private sector would under-invest, such as basic and pre-competitive applied areas of research, and commercially less viable commodities.

Although commercialisation of the agricultural research and extension system increased the capacity of China’s agricultural innovation system to respond to farmers’ needs, the system can be characterised as a top-down one, where scientists in the public sector create new technologies with little consideration of farmers’ changing demands. Around the world, agricultural innovation is increasingly taking place in a network-based setting, in which a more inclusive, interactive, and participatory approach fosters greater innovation in response to emerging and pressing challenges facing food and agriculture systems. China’s ***agricultural innovation system should become more collaborative and demand-driven***. The linkage between public agricultural research institutions, higher education institutions, agri-food enterprises, and public and private extension service providers should be increased to reflect industry’s changing demands to public agricultural R&D activities.

Public agricultural R&D institutions in China are composed of numerous research institutes administered by multiple ministries and agencies, both at national and sub-national levels. While the current governance structure provides local governments and research institutions with the freedom to take initiatives and to adapt and implement policies at the national level, this complex structure limits co-ordination, and has led to funding inefficiencies and duplication of research efforts and investment (OECD, 2008; Huang and Rozelle, 2014). The lack of a co-ordination mechanism between the central and provincial governments may reduce the efficiency of China’s agricultural innovation system as a whole.

The reform to hand over part of the research funding authority to a third-party agency, such as the National Natural Science Foundation, and shift public funding in agricultural R&D

from administrative allocation to a more competitive system is a step forward. ***Greater co-ordination of research institutions combined with strengthening of evaluation mechanisms*** would improve the efficiency of public funding to agricultural R&D. Moreover, the public funding system should be driven more by changing industry's demand for technologies, as public funding has been biased towards frontier-technology projects (OECD, 2017a). One example in agriculture is R&D of transgenic crops. The breeding of transgenic crops is identified as a national strategic research area and has attracted continuous public investment since the 1980s. However, bio-safety regulation so strongly limits the commercialisation of transgenic crops that only papaya and cotton are in commercial production today.

China's public agricultural extension system has undergone a series of reforms to make it more responsive to farmers' demands. The commercialisation of extension activities reduced their capacity to provide a variety of technical advice. A more positive recent reform has been to improve the quality of service to farmers by separating commercial activity from extension services and introducing a more inclusive approach at the local level. Additionally, private organisations are increasingly playing a major role in facilitating knowledge flows in China. For example, farmers' co-operatives often function as intermediate agents to facilitate the adoption of technology and reduce transaction costs, allowing small farms to overcome systematic constraints in adopting technology, integrating them in supply chains and increasing their operational size. ***The public extension system should evolve so that it can provide advisory services which private organisations have less incentive to provide***, such as promoting agricultural production technologies to conserve resources and protect the environment. A greater use of ICT would also improve the performance of advisory services.

Protection of intellectual property rights (IPRs) is an important factor influencing the performance of agricultural innovation systems. Adequate protection of IPR enhances private R&D investment in agriculture, including from abroad. While IPR policies and regulations are largely in line with international rules and guidelines, China's protection of IPR still lags behind most OECD countries, particularly in the area of enforcement.

Recommendations to strengthen China's agricultural innovation system

- Public R&D institutions should focus more on areas of public interest, such as environment and resource conservation, and on areas where the private sector would under-invest, such as basic and pre-competitive applied areas of research and commercially less viable commodities.
- Strengthen the role of the private sector in agricultural R&D through more effective enforcement of IPR protection, more transparent biosafety regulations, fewer barriers to FDI in agriculture R&D, and by privatising public R&D institutions in commercially viable areas of research.
- Improve the governance structure of the Agricultural Innovation System, in particular co-ordination between government agencies and public research institutes at national and subnational levels, including the strengthening of the evaluation of research outcomes, to avoid the duplication of research efforts and investments.

- Increase the linkage between public agricultural R&D institutions, higher education institutions, agri-food enterprises, and public and private extension service providers to reflect industries' changing demands for public agricultural R&D activities.
- Redefine the role of public extension system to services which private organisations have less incentive to provide, such as promoting sustainable production practices, leaving a greater role for private technical service providers and intermediary organisations such as farmers' co-operatives and industry associations in transferring technologies, capital and information.

Note

[1] The Oslo Manual defines innovation as the implementation of a new or significantly improved product (good or service), or process, a new marketing method, or a new organisational method in business practices, workplace organisation or external relations (OECD and Eurostat, 2005).

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Chapter 2. Overview of the food and agriculture situation in China

This chapter describes the overall economic, social and environmental context in which the food and agriculture sector in China operates, and the natural resource base upon which it relies. It provides an overview of the general geographical and economic characteristics of China; outlines the share of the agri-food complex in the economy; identifies the main structural characteristics of the food and agriculture sector; provides an overview of the main food and agriculture outputs and markets; and analyses the main trends in agricultural productivity, competitiveness and sustainability. It finally raises a number of issues the agri-food complex is likely to face in the future.

2.1. General natural and economic context

The People's Republic of China (hereafter "China") has the world's largest population (1.4 billion) and the largest area of agricultural land (515 million hectares). Since 2009, it has become the largest economy in the world, measured by the size of GDP, adjusted by PPP. However, China is a resource-scarce country: arable land per capita is only 0.08 hectare, which is less than one-third of the OECD average. Similarly, freshwater resources per capita of 2 061 m^3 are less than one-tenth of the OECD average, resulting in severe competition between agriculture and other users of water resources.

Table 2.1. Contextual indicators, 2015*

	GDP	GDP per capita	Population	Total land area	Agricultural land	Arable land per capita	Freshwater resources	Freshwater resources per capita
	billion USD in PPP**	USD in PPP**	million	thousand km^2	thousand ha	hectares	billion m^3	m^3
	(2015*)	(2015*)	(2015*)	(2015*)	(2015*)	(2015*)	(2014)	(2014)
China	19 778	14 388	1 376	9 425	515 358	0.08	2 813	2 061
(world ranking)	(1)	(81)	(1)	(2)	(1)	(133)	(5)	(104)
Australia	1 132	47 028	24	7 682	396 615	2.002	492	20 971
Brazil	3 199	15 391	204	8 358	278 808	0.39	5 661	27 721
India	8 019	6 126	1 309	2 973	180 280	0.12	1 446	1 118
Indonesia	2 842	11 058	258	1 812	57 000	0.09	2 019	7 914
Japan	4 871	38 419	127	365	4 537	0.03	430	3 378
Korea	1 754	34 647	51	97	1 769	0.03	65	1 278
Russia	3 580	24 469	146	16 377	220 200	0.86	4 312	29 982
South Africa	726	13 209	54	1 213	96 841	0.23	45	827
United States	18 037	56 066	321	9 147	405 437	0.49	2 818	8 846
OECD	52 403	40 895	1 281	34 341	1 211 805	0.31	10 483	28 117

Note: * or latest available year; ** PPP: Purchasing Power Parity.
Source: FAO (2015a), *FAOSTAT* (database), Food and Agriculture Organization of the United Nations, http://faostat3.fao.org/home/E; OECD (2015a), *OECD.Stat* (database), http://stats.oecd.org/; World Bank (2015), *World Development Indicators* (database), http://data.worldbank.org/indicator.

StatLink http://dx.doi.org/10.1787/888933829797

China achieved three decades of remarkable economic growth after the market-oriented economic reform in the late 1970s. Growth accelerated in the first 15 years of reform, starting from 1978.[1] In this early reform period, annual GDP growth rates increased from 4.9% in 1970–78 to 8.8% in 1979–84. Rising income in the initial years of reform stimulated domestic demand, and the high savings rate was transferred into capital investments in the non-agricultural sectors in particular. The growing demand in both domestic and international markets and rising investment accelerated growth of the Chinese economy, which achieved an annual GDP growth rate of 9.7% in 1985–95.

The Asian financial crisis of the late 1990s slowed China's economic growth, leading to an 8.2% annual GDP growth in 1996–2000. However, the GDP growth rate recovered to over 10% for most years of the 2000s. As a result, per capita GDP at purchasing power parity increased from less than 10% in 1995 to 35% of the OECD average in 2015. Poverty rates, measured at USD 1.90 a day (2011 PPP), declined from 57% to 11% between 1993 and 2010 (World Bank, 2015). As real GDP growth rate has fallen below 10% in recent years, China has entered into a lower but likely more sustainable "New Normal" growth path, with an official target of doubling GDP per capita between 2010 and 2020 (OECD, 2015b).

The high investment rate has been a major driver of China's high economic growth. Capital accumulation contributed to the majority of GDP growth since the 2000s, followed by Total Factor Productivity (TFP) growth. The contribution of TFP growth to GDP growth has recently declined: according to estimates by the Asian Productivity Organization, the average annual TFP growth rate fell from 5% in 2003-07 to less than 3% in 2008-12 (APO, 2015). As the rapid aging of the population is expected to reduce the national saving rate (which has been supporting the high investment rate), boosting productivity growth will be crucial for long-term sustainable economic growth in China.

Table 2.2. Real GDP growth rate

Annual percentage growth rate

	1981-85	1986-90	1991-95	1996-2000	2001-05	2006-10	2011-15
China	12.1	7.7	13.1	8.3	10.1	10.9	7.6
Japan	4.3	5.5	0.9	0.4	1.4	0.0	1.1
Brazil	2.5	0.9	3.5	2.1	3.3	4.6	1.7
Indonesia	5.0	7.4	7.6	-1.0	5.0	5.8	5.5
India	4.9	6.2	6.1	5.7	7.2	8.1	6.4
Russia	n.a.	n.a.	-10.1	3.0	6.4	2.4	1.8
South Africa	0.4	2.1	1.3	2.4	4.1	2.5	2.0
United States	3.5	3.3	3.3	4.4	2.9	0.3	2.3
EU28	2.0	3.5	1.7	3.2	1.8	0.3	0.4
OECD	2.9	3.8	2.3	3.5	2.5	0.6	1.7

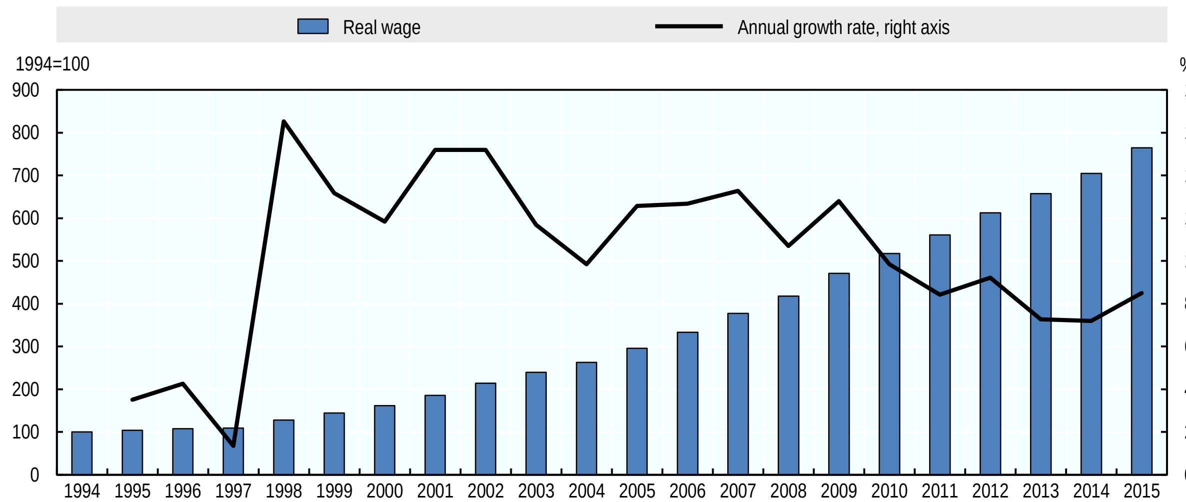
Source: World Bank (2016), *World Development Indicators* (database), http://data.worldbank.org/indicator.

StatLink http://dx.doi.org/10.1787/888933829816

China's strong economic growth has also been supported by an influx of surplus labour from rural provinces to large cities mostly located in coastal areas. Much of the debate has been about whether China is either close to, or has already reached, the Lewis turning point that unlimited supply of rural labour at constant price exhausts (Cai and Wang, 2010; Yang, Chen and Monarch, 2010; Golley and Meng, 2011; Li et al., 2012). According to Li et al. (2012), the wage rate of China's unskilled labour remained low and fairly constant until the late 1990s, but the cost of labour started to increase from 1997. The average real wage increased by 11% p.a. between 1997 and 2015 (Figure 2.1).

The increase in the real wage rate has strong implications for the structure of the Chinese economy, including the agricultural sector. It requires the economy to produce higher value-added goods and services rather than importing intermediate inputs and assembling them by making use of cheap labour inputs. With a decline in comparative advantage of labour-intensive sectors, the economic structure needs to evolve to more knowledge- and capital-intensive sectors. Higher wages also require that the agricultural sector reduce labour input and offer higher returns on family labour input. This economic pressure on agriculture to offer higher farm income increases the size of family farms which is required to generate an income that is comparable with other sectors.

Figure 2.1. Evolution of average real wage rate in China, 1994 to 2015



Source: NBSC (2016), China Statistical Yearbook 2016.

StatLink http://dx.doi.org/10.1787/888933828562

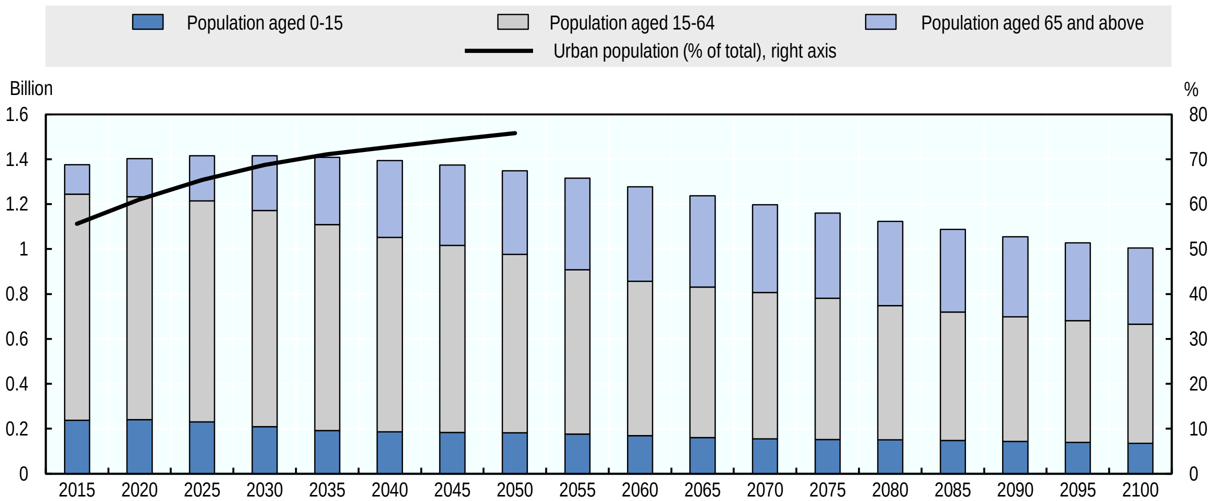
Demographic change

Demographic change is another important driving factor of the Chinese economy in the long-term. Although the population of China is currently the largest in the world, the working age population already started to decline in 2015 and the overall population is projected to peak in 2030 (United Nations, 2015). The slowing down of China's population growth is partly driven by the family planning policy in place from 1980 that has limited the majority of family units in the country to one child each.[2]

China is aging more rapidly than practically any other country. In 1982, only 4.9% of the population was over the age of 65, but by the end of 2015 this share had increased to 10.5% (NBSC, 2016). Aging of the population is faster in rural areas, where more than half of the elderly population lives. Due to a decline in the birth rate and an increase in average life expectancy (from 75.7 to 80.2 years by 2050), the share of the population over the age of 65 is expected to increase to more than 20% by 2035 and to almost 30% by 2050 (United Nations, 2015).

In addition, the share of urban population increased from less than 20% in 1980 to 50% in 2010 and is expected to reach 75% by 2050 (United Nations, 2015). Consequently, the rural population is expected to nearly halve by 2050. The expected change in demographic structure and urbanisation are crucial factors to develop a long-term strategy for the food and agriculture sector in China. The working population in agriculture will decline, with an increasing share of aged farmers. While per capita consumption of meat, dairy and fish products is expected to increase with income growth, the domestic demand for food grain is likely to decline, requiring agricultural policies to focus more on producing high value-added products. The export of agri-food products will be more important to sustain growth in domestic agriculture.

Figure 2.2. Projection of China's demographic structure, 2015 to 2100



Source: United Nations (2015), Population Division: World Population Prospects, the 2015 Revision, Department of Economics and Social Affairs.

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Natural resource use

Land and water are scarce resources in China, and both are crucial factors of production in agriculture. Due to increasing competition with urban land use, arable land area decreased by 15.3% (19.2 million hectares) between 1991 and 2014 (FAO, 2016). Agricultural land use and urban or industrial land use respectively accounted for 40% and 4% of total land use in 2015 (NBSC, 2016).

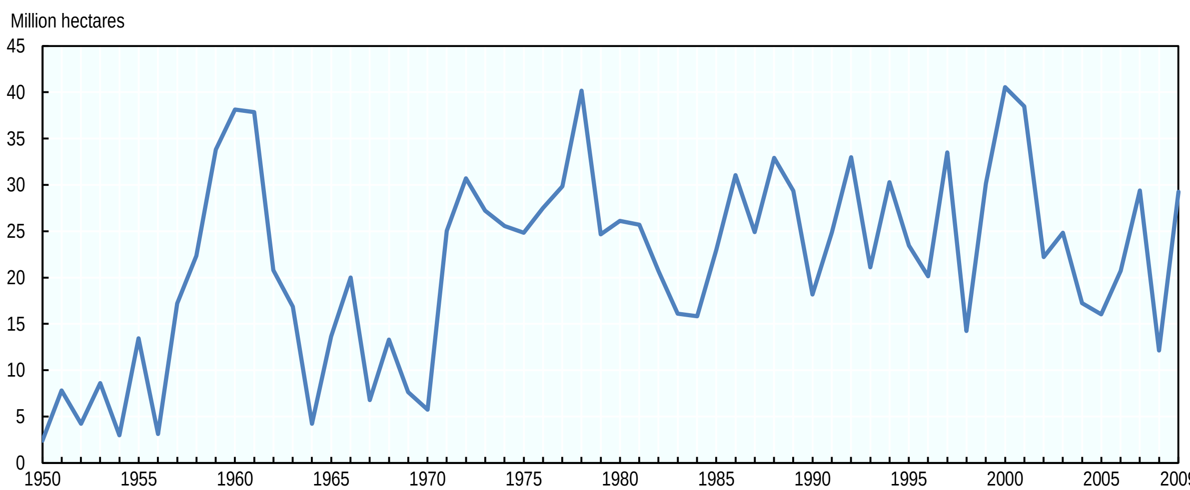
Overall, agriculture remains the biggest user of China's water resources. Water use in agriculture gradually increased from 378.4 to 385.1 billion m^3 between 2000 and 2015, but the share of agriculture water use declined from 69% to 63% in the same period due to an increase in other use of water (NBSC, 2016). China's irrigated land area has increased by 36% between 1990 and 2015, representing 48.8% of total cultivated land in 2015.[3] While irrigation consumed 55% of China's total water use, only half of the irrigated water was effectively utilised.[4] More efficient water use is critical to the sustainable growth of China's agricultural sector.

While China's freshwater resource endowment is concentrated in the southern part of China, the northern part of the country, rich in land resources and a major grain production area, suffers from water scarcity.[5] High and increasing demand from agriculture, industry, and residential development coupled with low precipitation levels has resulted in the drying of major rivers and significant surface and groundwater stress, particularly in Northeast China (Cai, 2008; Jiang, 2009; Fang et al., 2010; Giordano, 2009, Huang et al., 2010; OECD, 2007). China ranked first in a global assessment of water risks for global agriculture production, with Northeast China identified as a hotspot for future water risks for agriculture (OECD, 2017).[6] Brown and Halweil (1998) projected that yields will decline one-half to two-thirds as farmers revert to rain-fed agriculture if access to irrigated water declines. The water stress has also increased concern on water quality and ecosystems. Moreover, groundwater overdraft has generated flow cut-offs of the Yellow River and its tributaries, coastal seawater intrusion and localised land subsidence (Wang and Jin, 2006; Wang et al., 2007; Jiang, 2009; Sun et al., 2010).

Climate change

Changes in precipitation patterns across China have been observed for the past century, with northern China receiving less rainfall and southern and southwestern China receiving significantly more. China is ranked as one of the top two countries in terms of population at risk and economic damages of flood, mostly because of river flooding (Sadoff et al., 2015). Recurrent floods affect millions of people yearly, especially in southern China (Gleick, 2009; Zheng et al., 2010). Severe droughts have become a frequent occurrence – particularly in northeastern China (Paio et al., 2010). Drought-affected area shows an increasing trend over time (Figure 2.3). In recent years, southern regions have also been affected by drought; for instance, the 2010 drought in the Southwest region caused water shortages for millions of people and animals.

Figure 2.3. Drought-affected area in China, 1950 to 2009



Source: Wang, X. J. et al. (2012).

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Projections suggest that a number of climatic changes will occur in the coming decades, with implications for the agriculture sector. Temperatures are projected to continue to rise 2-4°C in Asia in the medium-term (2046-65) and 4-6°C in the long-term (2081-2100). Such trends may enable the spread of pest and diseases, increasing the vulnerability of crop production. Average precipitation in China is also projected to increase 30% in the medium-term (Hijoka et al., 2014). The retraction and seasonal melting of the Himalayan glaciers will also impact freshwater levels, contributing to a surge in annual runoff from major rivers, but also severely reducing water storage in the long term. Meanwhile, a number of studies report a drying of the northeast and more frequent flooding in the south (e.g. Piao et al., 2010). Sea level rises could also accelerate, with the East China Sea off Shanghai increasing 7.5 to 14.5 cm (Buckley, 2015). This may increase water salinity in rivers and aquifers, and land losses.

An increase in temperatures and more frequent and severe natural disasters are expected to affect the productivity of certain crops. For example, rising temperatures are already affecting planting times of rice. Some research shows that rice production is nearing heat stress limits in certain areas – particularly in eastern China – and that yields will decline as temperatures rise further (Hijoka et al., 2014). On the other hand, some studies and scenarios project that rice yields will increase in eastern China and wheat production could increase in the Huang-Hai Plain due to rising temperatures and precipitation (Hijoka et al., 2014; Xiong et al., 2010). Long-term policy strategies to improve agricultural productivity and sustainability need to take into consideration the uncertainty in the production environment imposed by climate change.

2.2. Importance of agriculture in the economy

Along with its rapid growth, the Chinese economy has experienced a significant structural change. While the annual growth of agriculture value-added averaged 4–5% throughout the post-reform period, the growth of the manufacturing and service sectors has been from two to over three times faster than that of agriculture since 1985. As a result, the share of agriculture in GDP declined from 28% in 1978 to 9% in 2015. Similarly, its share of employment fell from 71% to 28% over the same period. A larger employment share than value-added share in agriculture indicates a lower level of labour productivity than in the manufacturing and service sectors. The value added per worker in agriculture was 22% and 27 % of that in the manufacturing and service sectors in 2015, respectively.

Nonetheless, agriculture in China still accounts for a much higher share in the economy than in OECD countries (Table 2.3). The share of agri-food products in total export declined from 12% to 2% between 1992 and 2015. This is the lowest in BRIICS countries, but still higher than in Korea and Japan. Despite a declining economic share, agriculture accounts for a majority of natural resource use in China, such as land and water withdrawals. The share of agriculture in value-added and employment is expected to decline further as per capita income increases, following the experience of other countries in East Asia such as Korea and Japan (Figure 2.4).

Table 2.3. Importance of agriculture in the economy, 2015*

	Gross value added	Employment	Exports	Imports	Total land area	Total water withdrawals
	Per cent					
China	8.8	28.3	2.8	6.6	54.8	64.3
Japan	1.1	3.6	0.8	10.1	12.4	66.8
Australia	2.6	2.6	17.2	6.7	52.9	65.7
Brazil	5.0	10.29	37.6	5.1	33.8	60.0
Korea	2.3	5.2	1.2	5.9	18.0	54.7
India	17.5	47.1	11.5	5.7	60.4	90.4
Indonesia	13.5	32.9	21.6	10.0	31.5	81.9
Russia	4.6	6.7	4.7	13.9	13.3	19.9
South Africa	2.3	5.6	11.8	6.1	79.8	62.5
OECD	1.5	4.8	8.3	8.0	35.6	43.9

Note: * or latest available year.
Source: OECD System of National Accounts, OECD Annual Labour Force Statistics; UN Comtrade (2015), *United Nations Commodity Trade Statistics* (database) http://comtrade.un.org/; World Bank (2016), *World Development Indicators* (database), http://data.worldbank.org/indicator; FAO (2015a), *FAOSTAT* (database), http://faostat3.fao.org/home/E; FAO (2015b), AQUASTAT Main Database.

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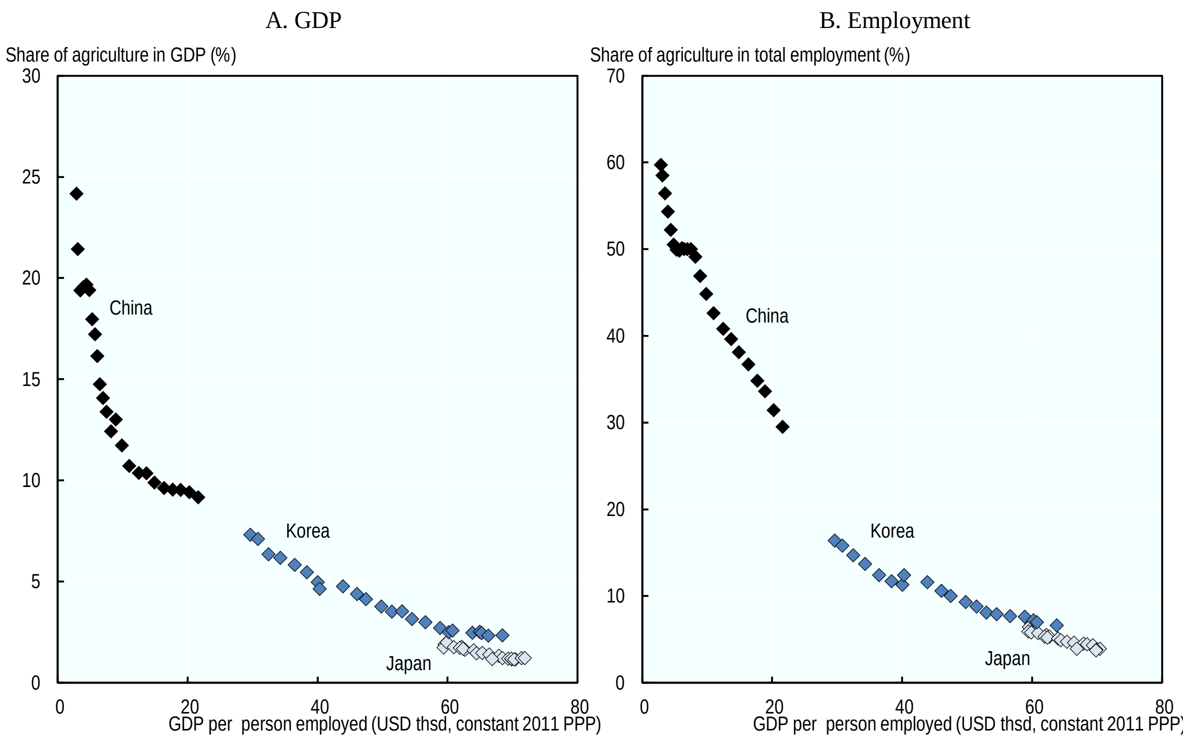
The slow decline in the total number of workers in Chinese agriculture is a major constraint to improvement in labour productivity in the sector. While the average annual growth rate of agricultural value-added in 2000-15 was higher than in most OECD countries and emerging economies, China's labour productivity growth in agriculture is slower than in such countries as the United States, the Russian Federation, Brazil, South Africa, Korea and Japan. While agricultural value-added grew at 4.0%, agricultural value-added per worker in China grew on average 4.2% p.a. in 2000-15 (Figure 2.5). This means that the improvement in labour productivity growth is almost entirely accounted for by the growth in output; this contrasts with most OECD countries, where a decline in workers in agriculture is a major contributor to labour productivity growth in the sector.

Figure 2.4. Economic development and share of agriculture in the economy



Source: World Bank (2015), World Development Indicators (database) and NBSC (2015), China Statistical Yearbook 2015.

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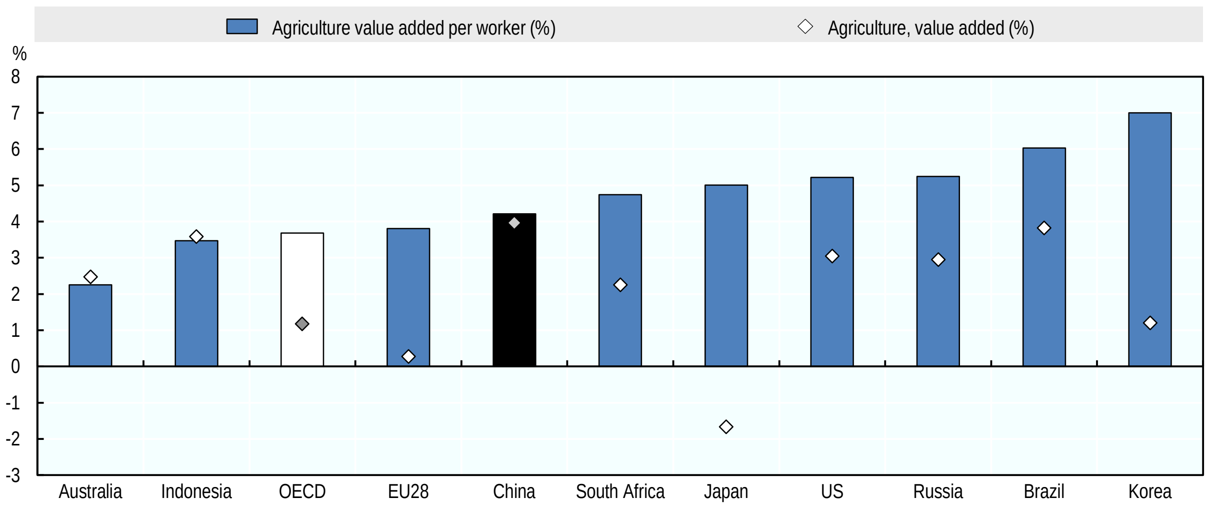
Figure 2.5. Labour productivity growth, 2000-15

Average annual growth rate



Note: The OECD aggregates do not include Lithuania.
Source: World Bank (2017), World Development Indicators (database), http://data.worldbank.org/indicator (accessed November 2017).

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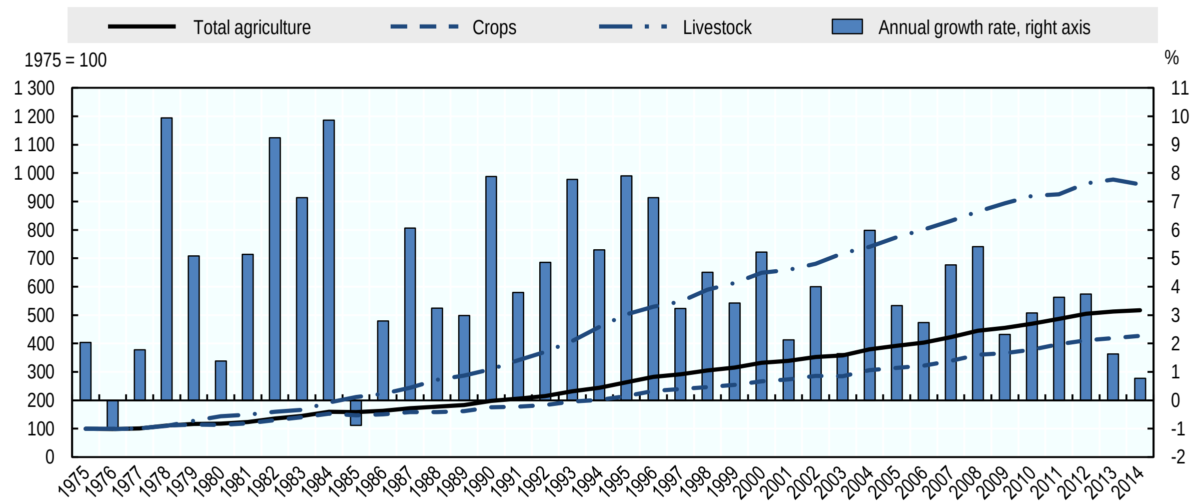
2.3. Characteristics of the food and agriculture sector

Production

China's agricultural sector expanded strongly since the implementation of economic reform in the late 1970s. Total agricultural production grew at 4.5% p.a. between 1977 and 2014, leading to an expansion of agricultural output by more than 5 times in real terms in three decades (Figure 2.6). Existing studies find that the institutional reform which shifted from collective agricultural production systems to individual household production was the main cause of agricultural growth in the early reform period (Lin, 1992; Huang and Rozelle, 1996).

The composition of agricultural output in China has changed significantly over the last decades, driven by the shift in consumption towards livestock products and more value-added agricultural products such as fruits and vegetables. In particular, the rapid expansion of the livestock and fisheries sectors reduced the dominance of the crop sector in the early reform period. The share of meat in agricultural production increased from 29% to 39% in 1980-2010 (Figure 2.7). Within the crop sector, production shifted to cash-crops, reducing the share of rice in agricultural production value from 30% to 9% in the same period. The value of vegetable and fruit production grew by 10 and 18 times in three decades, respectively, and these two sectors already accounted for one-third of agricultural production in 2010.

Figure 2.6. China's agricultural output indices, 1975 to 2014



Source: FAO (2017), FAOSTAT (database), http://www.fao.org/faostat/en/#home.

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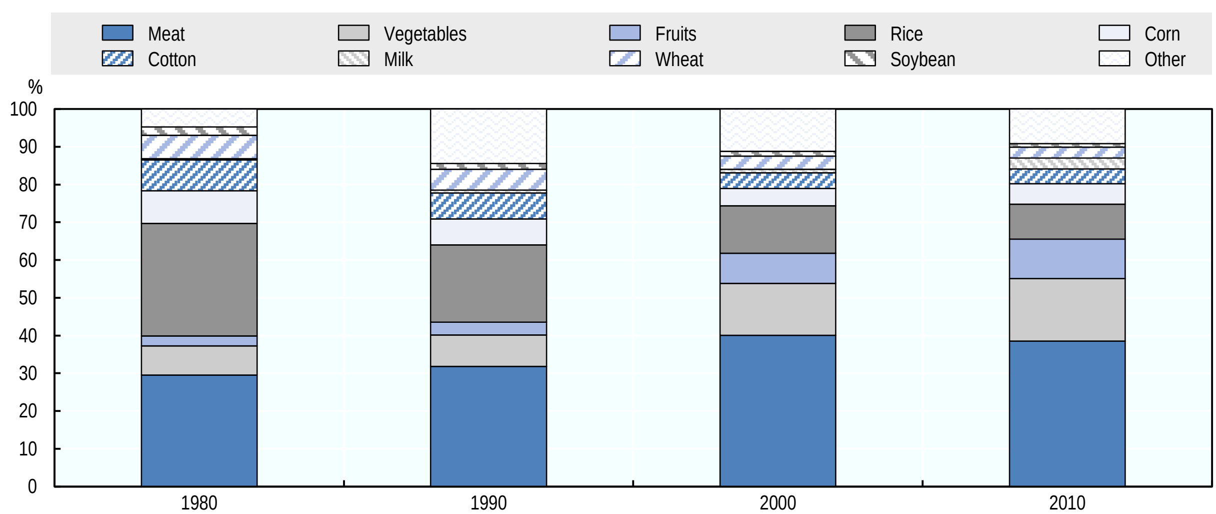
Figure 2.7. Composition of China's agricultural production value, selected years



Source: FAO (2017), FAOSTAT (database), http://www.fao.org/faostat/en/#home.

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Agricultural production in China also experienced a geographical relocation and a spatial concentration in the past three decades (Cho et al., 2007; You, 2013). For example, rice production has been concentrating in northern China, mainly in northeast China, driven by the increased costs of land and wages in the comparatively developed provinces in coastal regions (Li et al., 2013).[7] Wheat production increased only in the Huang–Huai-Hai plain, but declined significantly in the rest of China.

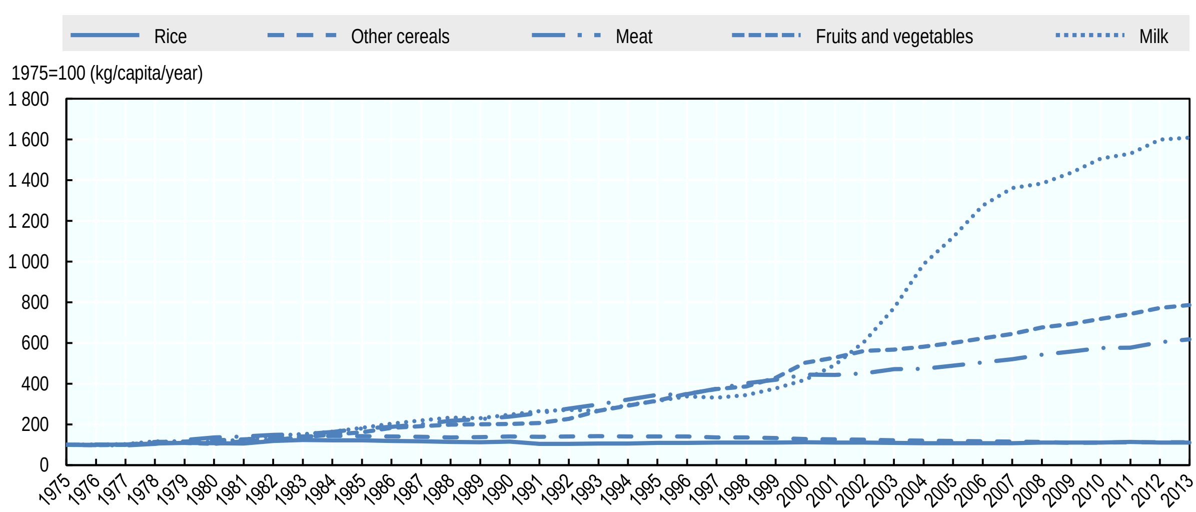
In livestock sectors, dairy production has been clustered in north China, but it is spreading to other regions, whereas the production of pork and poultry meat moved gradually to south China. These spatial variations are mainly driven by the evolution of livestock production towards specialised industries. The increased demand for livestock production concentrated in comparatively developed and populated regions like Southeast China. Dairy production is still widely distributed throughout north China, with the trend of regional concentration in three areas: Northeast China, Inner Mongolia and Xinjiang. The pattern of feed supply has important impacts on spatial distribution of livestock production. The rapid increase in soybean import relocated soybean processing enterprises to the coastal areas in the southeast, which also contributed to the relocation of pork and poultry production to this region.

Consumption and trade

The nutritional situation in China improved significantly as the per capita income level increased. The prevalence of undernourishment declined from 24% to 9% between 1990-92 and 2014-16, which represents of reduction of approximately 100 million in the total number of undernourished. Similarly, the poverty headcount ratio at USD 1.9 per day (2011 PPP) fell from 88% in the early 1980s to 1.9% in 2013 (World Bank, 2015).

The diet of the Chinese population has shifted significantly in the last decades, and this is a major driver of structural change in agricultural production. Cereal consumption started to decline on a per capita basis in the mid-1980s. Per capita supply of rice and other cereals declined from peak levels by 10% and 20%, respectively (Figure 2.8). By contrast, per capita meat supply grew at more than 6% p.a. between 1980 and 2000. Annual per capita supply of meat reached 60 kg in 2010 and exceeded that in Japan as from 2003. Considering higher annual per capita meat supply in Hong Kong, China (180 kg) and in Chinese Taipei (81 kg), per capita meat consumption in China may still increase in the future. Similarly, per capita milk supply increased more than 10 times in the last 30 years, with particularly high growth rates during the 2000s. Per capita milk consumption in China is also below that in Hong Kong, China and Chinese Taipei, implying a further increase in the future.

Figure 2.8. Food supply per capita in China, 1975 to 2013



Source: FAO (2017), FAOSTAT (database), http://www.fao.org/faostat/en/#home.

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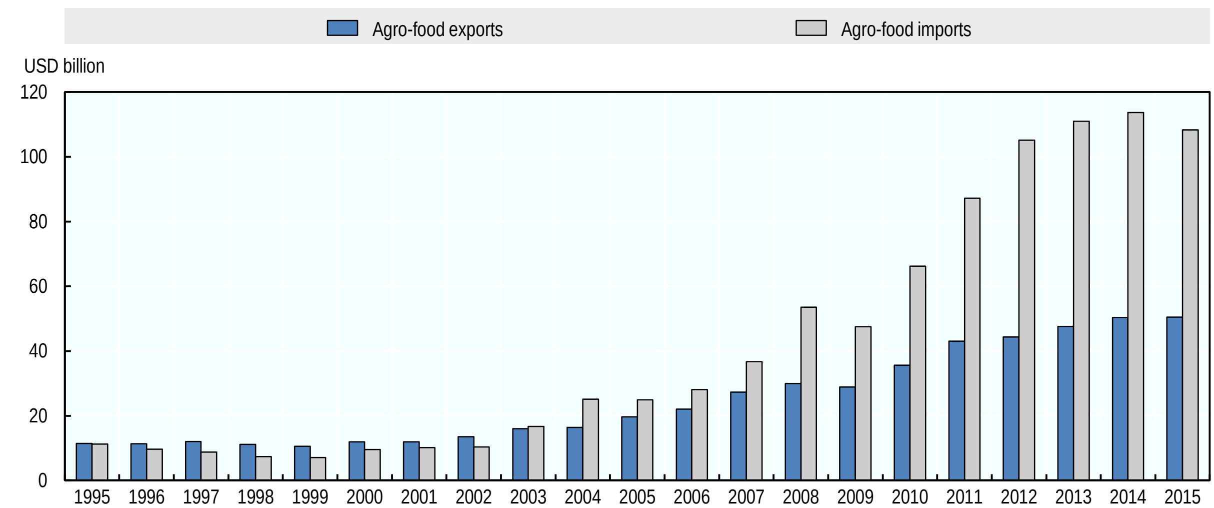
Agro-food imports have been increasing, particularly since the mid-2000s, which has turned China into a net importer of agro-food products since 2003 (Figure 2.9). Agro-food imports increased by 6.9% per annum between 2004 and 2014, while agro-food exports grew by 2.3% per annum. The trade deficit in agro-food products has widened in recent years. The composition of agro-food trade has also evolved in the last decades. The share of processed agricultural products in agro-food exports increased from 34% to 43% between 1995-99 and 2010-14 (Figure 2.10). While the share of cereal, vegetable oilseed and vegetable oils in total agro-food exports has been marginalised, these products account for more than half of total agro-food imports in recent years. These changes in trade patterns reflect the comparative advantage of China in labour intensive agro-food products rather than land-intensive crop production.

Figure 2.9. Value of China's agro-food export and import, 1995 to 2015



Source: UN Comtrade (2015), United Nations Commodity Trade Statistics (database), http://comtrade.un.org/.

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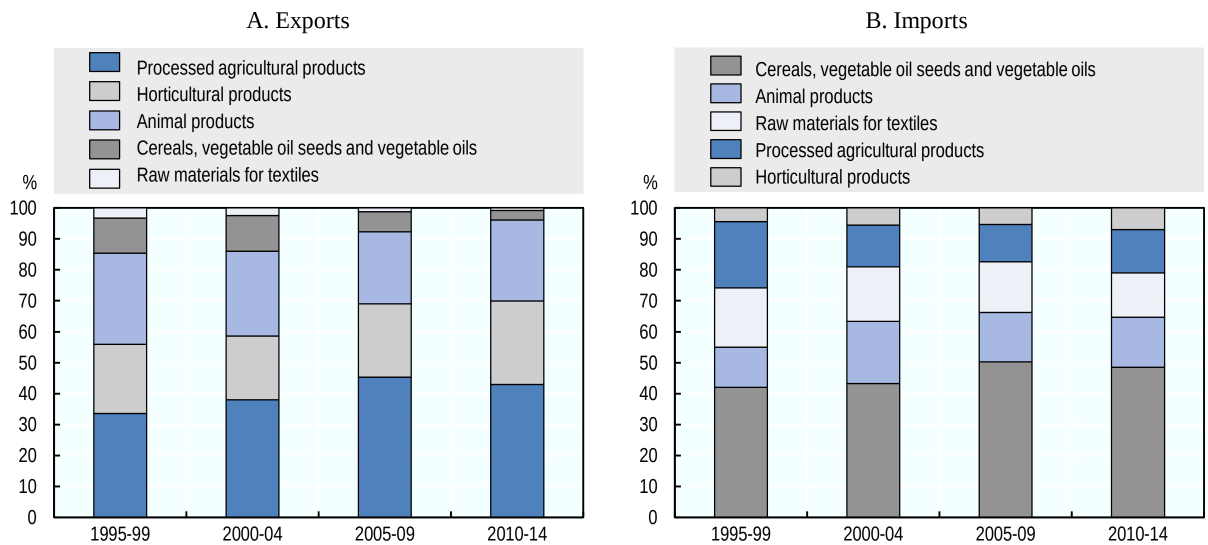
China is almost self-sufficient in bovine, pig and poultry meats, as well as rice, wheat and maize. However, decreases in self-sufficiency rates in soybean and barley production (to 16% and 47% in 2013, respectively) have increased its dependency on imports of soybean and barley (Figure 2.11). Indeed, China is currently the world’s largest importer of oilseeds, absorbing more than half of world oilseed exports.

Figure 2.10. Composition of China's agro-food trade, 1995-2014



Source: UN Comtrade (2015), United Nations Commodity Trade Statistics (database), http://comtrade.un.org/.

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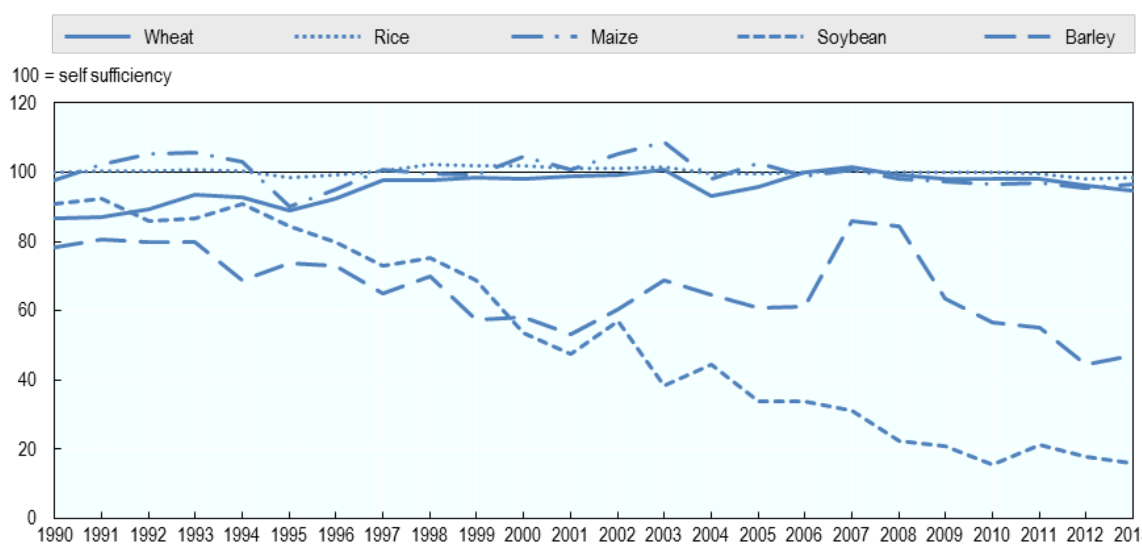
Figure 2.11. China's self-sufficiency of grains, 1990 to 2013



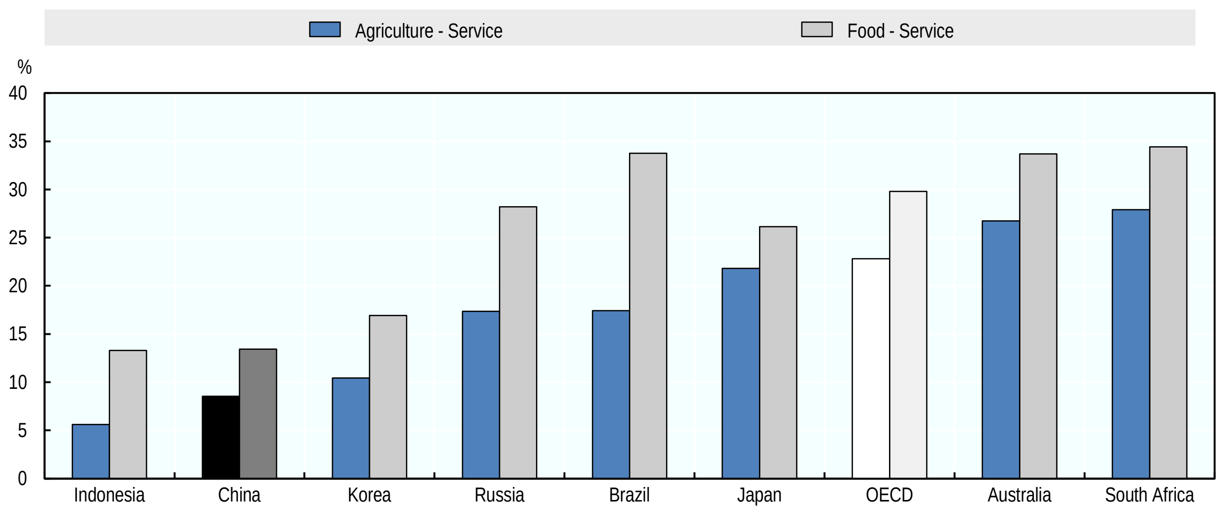
Note: Computed as net exports/domestic supply, 100 indicates full self-sufficiency, -100 indicates net imports fill all domestic consumption.
Source: FAO (2017), FAOSTAT (database), Food and Agriculture Organization of the United Nations, http://www.fao.org/faostat/en/#home.

StatLink http://dx.doi.org/10.1787/888933828752

The OECD-WTO Trade in Value Added Database, which measures trade flows in value-added terms (instead of gross value), showed that in 2011 China's domestic value-added components of gross exports for agricultural and manufactured food products were 90%

and 75%, respectively. This means that a quarter of the export value of manufactured food products is sourced from foreign industries, in particular service sectors. On the other hand, the value-added share of the domestic service sector in China increased from 6% to 9% in agriculture exports and 5% to 13% in manufactured food exports between 1995 and 2011, but remains low compared to OECD countries and some BRIICS counties (Figure 2.12). This implies that the "servicification" of agro-food industries could be enhanced to promote more value-added in the agriculture sectors in China.

Figure 2.12. Share of value added by domestic service industry in exports, 2011



Note: The OECD aggregates do not include Latvia and Lithuania.
Source: OECD/WTO (2015), OECD-WTO: Statistics on Trade in Value Added (database).

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Farm structure

Farm consolidation

As a result of the Household Responsibility System (HRS) reform of the late 1970s to reallocate village land to all rural households, China's agriculture has been dominated by small family farms. The average size of operated land per household was only 0.7 hectares in 1985, when the HRS reform was completed (Table 2.4). Each household is normally allocated, on average, 3 to 4 plots to ensure equity of land distribution in consideration of different land quality. Around 60% of the plots are less than 0.1 ha, and close to a quarter of them are larger than 0.15 ha. Average farm size fell gradually to 0.55 hectares in 2000 (Huang and Ding, 2016), but was estimated to increase to 0.78 ha in 2013, driven by an increase in the number of rural households which stopped farming.

While average farm size is still small, operational rights of land have been concentrating more on large-scale farms, particularly in Northeast and North China. These regions have seen more rapid farm consolidation recently, with an increase of average farm size from 1.03 to 1.73 ha between 2008 and 2013. Increased labour mobility and transfer of land among farmers over the past three decades have gradually adjusted the existing farm structure (Huang, Gao and Rozelle, 2012). While an expansion of average farm size is modest due to the slow reduction of farm households, agricultural production has increasingly been dominated by large-scale farm operations, including co-operative and corporate farms. Ji et al. (2016) find that 20% of China's land is cultivated by farms larger than 2 hectares and 4% of land is operated by a new class of corporate farms.

Table 2.4. Average farm size in China overall, and in Northeast and North China combined, 1985-2013

	Average farm size in China			Average farm size in Northeast and North China regions
	Including all households living in rural, based on RIES dataset	Percentage of households living in rural without farming, based on RLLS dataset	Estimated farm size in China based on (a) and (b)	
	(a)	(b)	(c)	(d)
1985	0.73			
1990	0.67			
1995	0.65			
2000	0.55	4.6	0.58	
2001	0.55	4.6	0.58	
2002	0.55	5.2	0.58	
2003	0.53	6.4	0.57	0.92
2004	0.55	7.8	0.59	0.97
2005	0.57	8.4	0.62	1.00
2006	0.58	9.1	0.63	1.02
2007	0.57	10.3	0.64	1.03
2008	0.58	11.8	0.66	1.03
2009	0.61	15.2	0.72	1.17
2010	0.61	17.1	0.73	1.41
2011	0.60	18.6	0.73	1.61
2012	0.61	19.8	0.76	1.72
2013	0.61	20.7	0.78	1.73

Note: Farm size in column (c) is adjusted by excluding rural households which fully rented out, gave up or sold their land. The formula used is: c = a /(1- b/100). Data in column (d) are based on surveys in 6 provinces in Northeast and North China.
Source: Huang and Ding (2016).

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Government policy has increasingly been focused on establishing large farm operations. Document No. 1 of 2016 aims to exploit the leading role of diverse forms of large-scale operations, promoting the consolidation of land resources to new agricultural operation entities including family farms, farming service providers and co-operatives. As of June 2015, there were more than 870 000 family farms with an average scale of 200 mu (13.3 hectares), over 1.4 million farmers' co-operatives, and 120 000 leading enterprises of agricultural industrialisation, all of which have gradually become major management units of agriculture in China. Farming is becoming a professional choice instead of a matter of family succession, as more and more migrant workers, college graduates, veteran soldiers and even urban residents begin to return to rural areas to start agricultural businesses, injecting new vitality into China's agriculture.

The co-operative organisation of small family farms is increasing its role in establishing large-scale farm operations, connecting to markets and adopting new technologies. In contrast to the former state-led co-operative established under the collective farming system, the new co-operative organisation emerged in the late 1980s as a voluntary organisation of farmers to disseminate agricultural technology and carry out marketing activity (Ji et al., 2012). Farmer Professional Co-operatives (FPC) and other types of voluntary co-operatives are expected to constitute a new farm management system in China, playing key roles for small-scale family farms to adopt technology, integrate with supply chains and benefit from economy of scale in farm operation (Box 2.1).

Box 2.1. Development of voluntary co-operatives in China

The institutional framework to provide a legal status to Farmer Professional Co-operatives (FPC) was promulgated in 2007. The governance of FPC is based on the principles of "voluntary participation, free withdrawal, democratic control and return of surplus to co-operative members". Farmers are required to constitute at least 80% of the co-operative members, each having a single vote. The central policy and local governments have been trying to promote and foster FPCs since the late 1990s and increased the role of FPCs as a recipient of government financial support (Chen 2016). With the development of a clear legal environment, the number of FPCs increased by 8.8 times between 2008 and 2013, reaching a membership of 28.5% of all farm households in China (Hoken, 2016).

FPC services typically include technical training, processing, marketing and purchasing inputs. The co-operatives often function as a broker of technologies through sharing information and providing advisory and training services. In other cases, the co-operatives allow smallholder farms to obtain more competitive prices in input and output markets through their bargaining power. While retailers and food processors often face high transaction costs when contracting directly with small-scale farms, the co-operatives facilitate contract farming and the integration of smallholder farms to value chains.

On the other hand, other types of voluntary co-operatives to consolidate land operational rights have been developed in China. Farmers established Land Shareholding Co-operatives (LSC) in which they trust their land operational rights and receive dividends every year according to their share (Ren, et. al, 2017). These voluntary co-operatives are increasingly playing an important role in rationalising the structure of agricultural production through integrating the farming operation and land use rights. By the end of 2013, 4.6 million hectares of land had been transferred to co-operatives, accounting for 20.4% of total land transfer (Zhong, 2016). These co-operatives also provide mechanisation service and consolidate the farm operation without transaction of land rights. Co-operatives now account for 13% of total mechanically ploughed area (Zhong, 2016). The consolidation of farm operation through co-operatives is becoming a core unit of large farm operation in China.

The government supports the development of co-operatives as a new type of farm management unit. In addition to providing a legal status and standard operational rules for the farmers' co-operatives, the government is increasing direct support to them. For example, it provides them with financial and technical support through preferential treatment for value-added tax and stamp duties, credit guarantees and personnel training (Zhong, 2016). The co-operatives have also become a major recipient of producer subsidies, receiving 30% of the national subsidy for purchase of agricultural machinery in 2012.

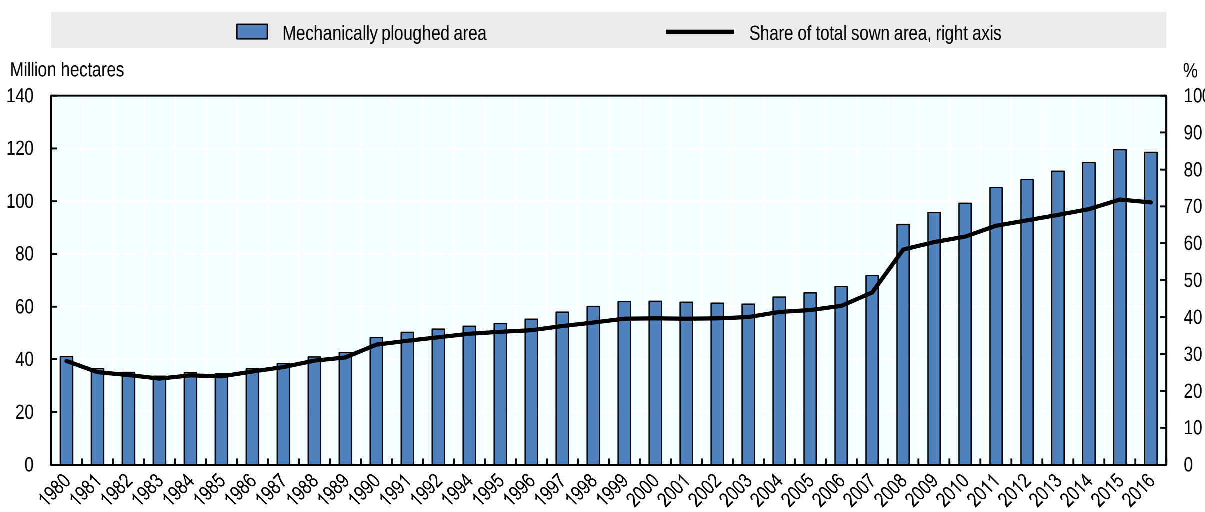
Farm mechanisation

Under the collective farm system, agricultural machinery stations were established at different administrative levels to provide machine operation services at a fixed price. The use of mechanical ploughing declined in the early 1980s after the introduction of Household Responsibility System, but in the late 1980s farmers were again induced to adopt labour-saving technology by a rapid increase in off-farm employment opportunities. An increase in the real wage rate since the 2000s further accelerated the incentive to mechanise farm operations.

In the past decade, the number of rural residents who have off-farm employment as well as the number of permanent migrants to urban and sub-urban areas has increased significantly. Farm mechanisation allowed some farmers to expand farm size, but also helped others to spend more time on off-farm activities to increase their income. As the opportunity costs of farming increase, the number of days that China's farmers devote to on-farm work has fallen significantly. By 2014, the average number of labour days spent on farm had fallen to less than 100 per hectare, which is half of the level in the 1990s.

Mechanically ploughed area more than doubled between 1980 and 2013, with an annual growth rate of more than 3% between 1983 and 2006 (Figure 2.13), accelerating to over 5% between 2008 and 2016. More than 70% of cultivated area was mechanically ploughed in 2016. By contrast, mechanically harvested area increased only around 1.5 times in the 1990s. Mechanical sowing and reaping have started to accelerate since 2003, with annual growth rates of 4.9% and 9.5% in 2003-16, respectively. By 2016, more than half of sown area was mechanically sown or reaped.

Figure 2.13. Evolution of mechanically ploughed area in China, 1980 to 2016



Source: NBSC (2017), China Rural Statistical Yearbook 2017, China Statistics Press.

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An important feature of farm mechanisation in China is the large contribution of farm machine service providers to the rapid expansion of mechanical operations in ploughing, sowing and harvesting and the use of large-size farm machines (Box 2.2). In 2013, service providers accounted for two-thirds of the total area benefiting from farm machines (Zhang, Yang and Reardon, 2015). The use of farm machine service providers allows small scale farmers to save their labour input and to avoid a large capital investment and maintenance cost associated with farm-owned machines. The development of farm mechanisation services in China is a remarkable organisational innovation to enhance productivity growth in a country dominated by small-scale family farms. However, fragmented farmland is a constraint to the efficient use of large-size farm machines. Complementary investment in infrastructure such as land adjustment and developing farm roads would further reduce the production cost through more efficient use of farm mechanisation.

Box 2.2. Evolution of mechanisation service providers

Generally, two types of mechanisation services exist in China. One is mechanical services provided by Specialized Custom Plowers, Planters and Harvesters (SCPPH) teams, who own large machines. The other is machine rental markets, where households operate rented machines. There has been a rapid rise in SCPPH teams' activities. Most typically, SCPPH teams provide mechanical operation services from ploughing to harvesting to smallholders. The smallholders supervise the process of mechanical operations and pay a fee to the machine service provider.

Mechanical operation teams have extended their activities beyond simply providing mechanical operation services. For example, in northeast China, these teams have started to rent land and consolidate land use rights. They use large machines on the consolidated land and upgrade their machines with subsidies provided from the government. However, they also face some constraints on keeping or expanding land consolidation. First, the land rental contracts are mainly short-term, often subject to annual renewal. The farmers who rent out their land tend to hesitate to sign long-term contracts. The tenure insecurity discourages the operators from investing in the land. Secondly, the operators may not be able to obtain the quota to buy the subsidised large machines, even though they would like to upgrade their current ones.

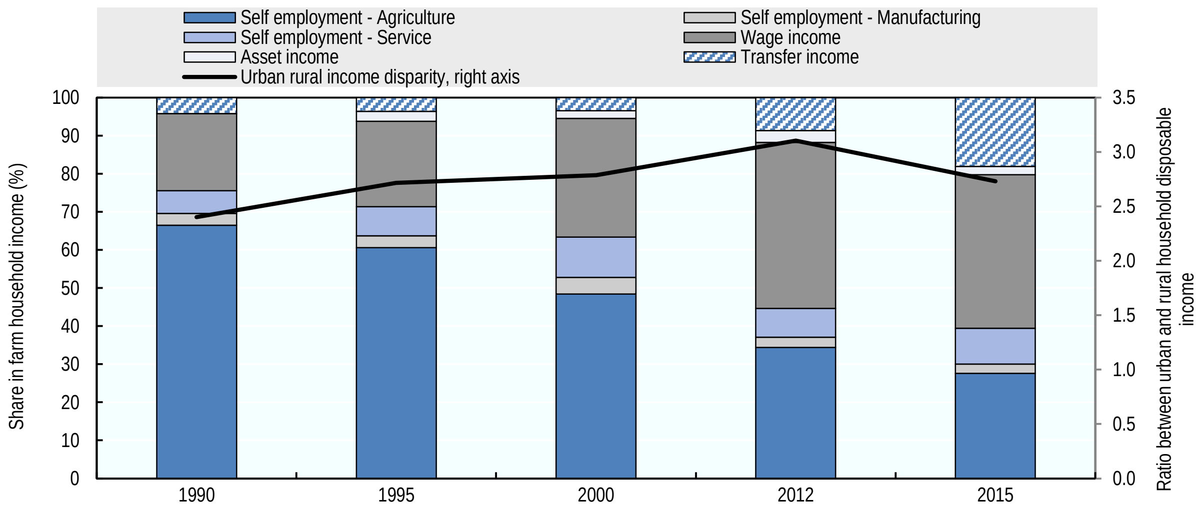
Farm income structure

Although the average income of rural households grew at 12% p.a. in 1990-2012, average urban household income grew at 13.7% p.a. in the same period. As a result, income disparity between rural and urban households, measured by the ratio of average urban and rural household disposable income, increased from 2.4 to 3.3 between 1990 and 2005, but declined to 2.7 in 2015 (Figure 2.14). Income disparities are also significant among regions, between urban and rural households, and among households within the same location (Cai et al., 2002; NSBC, 2015). Nonetheless, increasing rural household incomes reduced the poverty rate in rural areas from 30.7% to 5.7% between 1978 and 2015.[8]

Rural households are increasingly sourcing their income from off-farm activities. The share of income from family farming declined from two-thirds in 1990 to less than one-third in 2015. In contrast, the share of wage income increased from 20% to 40% over the same period. The increasing share of off-farm income indicates increasing employment opportunities in local non-farm sectors. The mechanisation of farming also allowed farm households to spend more time in off-farm activities. The recent increase in the importance of transfer income shows that rural households are more dependent on remittance and social security payments.

China's Rural Public Investment Survey shows that the share of the rural labour force working off the farm increased from 45% to 60% in 2000-11. Li et al. (2013) find that more than 90% of young male workers in rural areas were participating in off-farm employment, compared to more than 80% of young female workers.[9] In the 1980s and 1990s, most migrants moved to the large cities on the east coast. Some research showed that over 50% of migrants moved to China's eastern regions during the first two decades of reform (Cai and Wang, 2003; Fan, 2005. Li et al. (2013) show the shifts in the destination of migrants. In 2011, about two-thirds of migrants worked within their own province. This is mainly because investment in the manufacturing sector is moving from the eastern coastal regions to interior provinces and because the government implemented a number of economic policies to promote regional industrialisation in the central and western parts of China.

Figure 2.14. Income structure of rural household in China, selected years



Source: NBSC (2016), China Rural Statistical Yearbook 2016, China Statistics Press.

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2.4. Productivity, competitiveness and sustainability performance

According to US Department of Agriculture estimates, TFP growth in primary agriculture in China is much higher than in most OECD countries. However, the TFP growth rate slowed from 4.3% p.a. in 1991-2000 to 3.3% in 2001-14 (Figure 2.15). China achieved the highest TFP growth among BRIICS countries in primary agriculture both in 1991-2000 and 2001-14, but from this group only China and South Africa saw productivity growth slow in the more recent period.

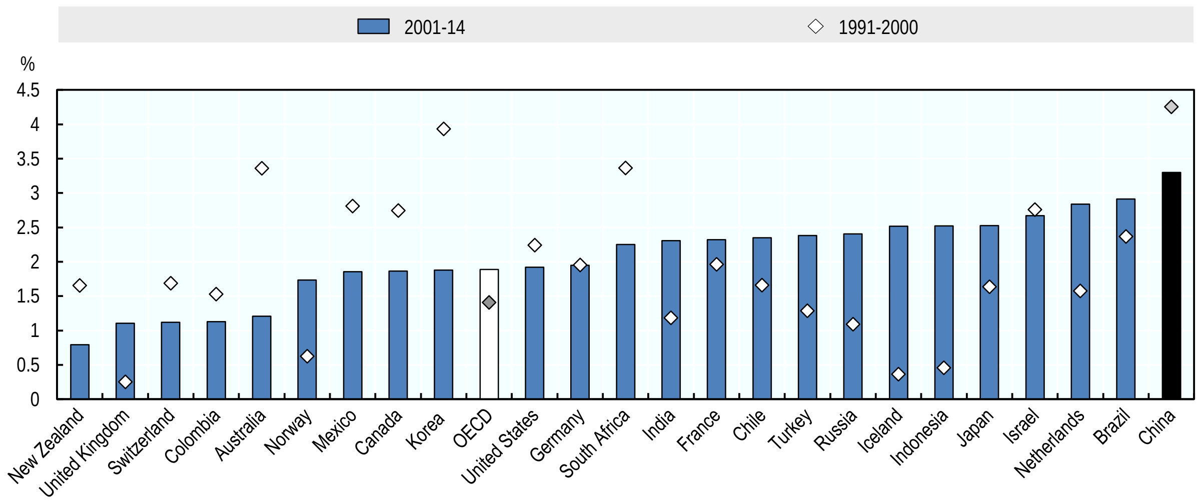
China's agriculture TFP had stagnated until the early 1980s, following the transformation of its collective farming system to the household responsibility system (HRS) in the late 1970s. Under the collective farming system, a group of farmers formed a production team and shared the residual profit depending on the work points they earned. However, this system lacked an individual work incentive: farmers tended to receive fixed work points for a day's work regardless of the quality and quantity of their work (Lin, 1988).

To provide individual work incentives in agricultural production, the Chinese government decided to de-collectivise production and granted land use rights and residual income rights to individual farmers from 1978. The positive effect on productivity of implementing the HRS, which was mostly completed between 1979 and 1983, was immense: the average annual TFP growth rate of primary agriculture went up to 4.8% in 1978-1984, compared to -0.1% in 1971-77 (Figure 2.16). By using growth-accounting techniques, McMillan, Whalley and Zhu (1989) identify that 78% of the increase in agricultural productivity in China between 1978 and 1984 can be attributed to the incentive effects of HRS.

Despite the initial success of HRS, the high growth rate of grain production did not last long. In fact, the growth rate of grain production was negative between 1984 and 1987. Average TFP also slowed to 0.3% in 1985-91. Of the many possible reasons for the stagnant agricultural production growth, one of the main causes suggested by researchers and policy makers was weak tenure security (Prosterman, Hanstad and Ping, 1996). TFP growth has been driven more by a low (sometime negative) growth rate in overall input since the 2000s

(Figure 2.17). Farm consolidation, mechanisation and reduced labour input in farming have become important drivers of productivity growth. The growth in agricultural output is now mainly driven by the improvement in productivity rather than an increase in input.

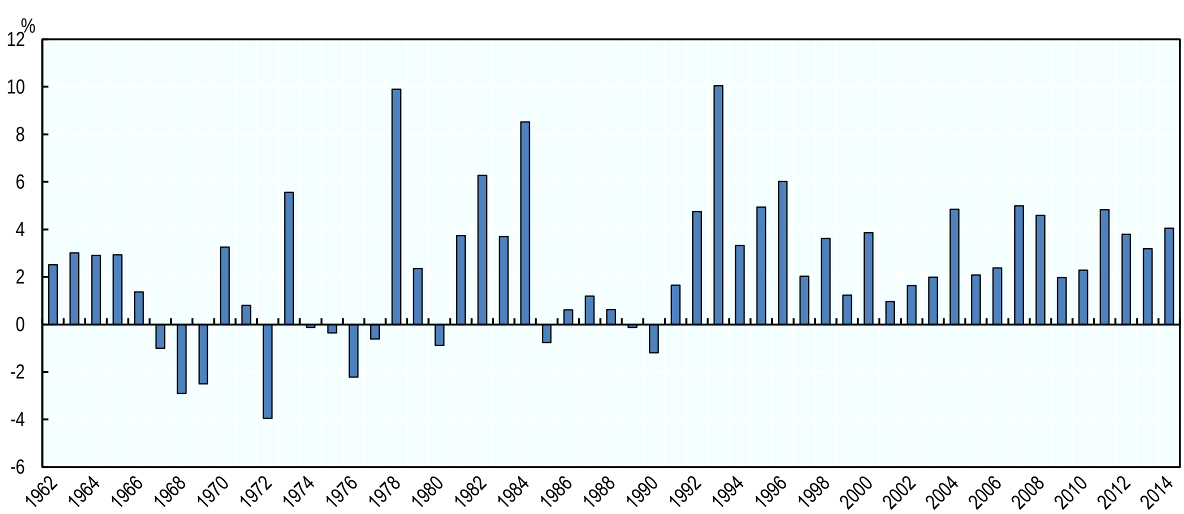
Figure 2.15. Annual agricultural Total Factor Productivity (TFP) growth rates, 1991-2000 and 2001-2014



Note: The OECD aggregates do not include Lithuania and Slovenia.
Source: United States Department of Agriculture (2017), USDA Economic Research Service, International Agricultural Productivity (database), https://www.ers.usda.gov/data-products/international-agricultural-productivity (accessed November 2017).

StatLink http://dx.doi.org/10.1787/888933828828

Figure 2.16. China's annual agricultural Total Factor Productivity growth rates, 1961 to 2014



Source: United States Department of Agriculture (2017), USDA Economic Research Service, International Agricultural Productivity (database), https://www.ers.usda.gov/data-products/international-agricultural-productivity (accessed November 2017).

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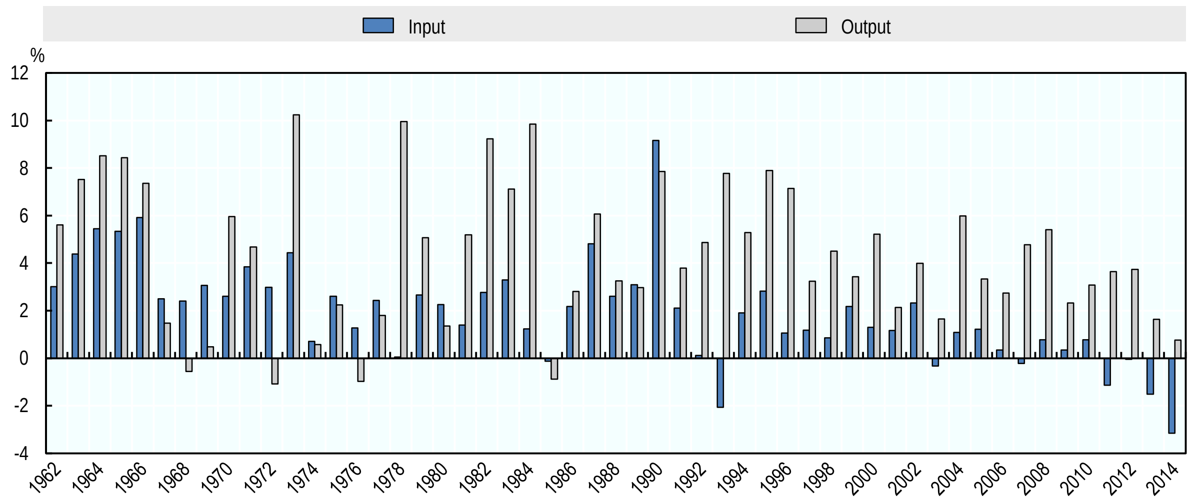
Figure 2.17. China's annual growth rates in agricultural inputs and outputs, 1961 to 2014



Source: United States Department of Agriculture (2017), USDA Economic Research Service, International Agricultural Productivity (database), https://www.ers.usda.gov/data-products/international-agricultural-productivity (accessed November 2017).

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Competitiveness of agro-food industries

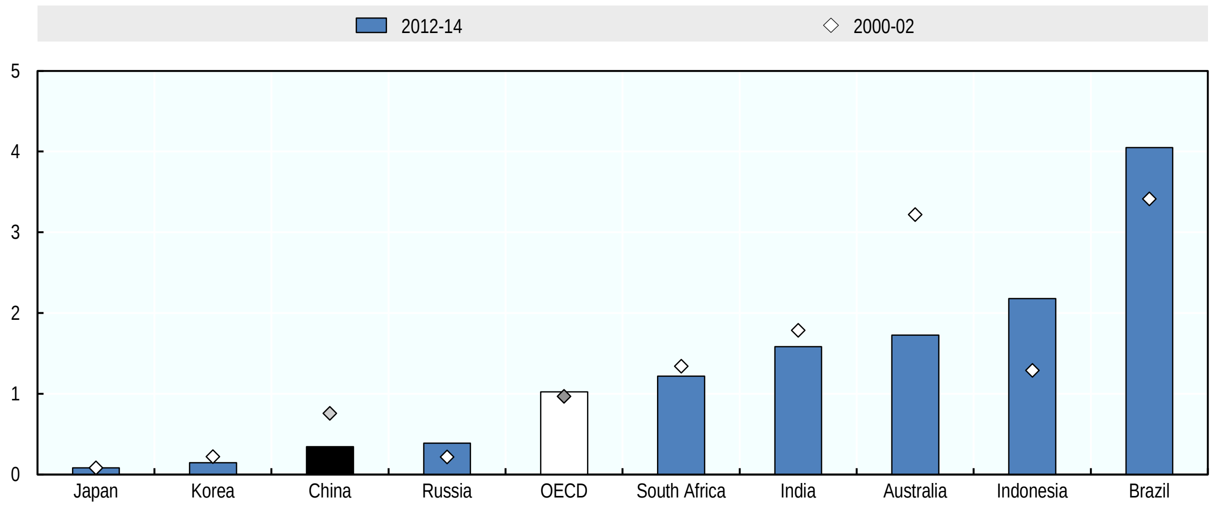
In contrast to the concept of productivity, competitiveness is a relative concept, in which the competitiveness of firms or nations can be measured only relative to other firms or nations (Latruffe, 2010). Among a number of competitiveness indicators, the Revealed Comparative Advantage (RCA) index (Balassa index) is a trade measure of competitiveness that calculates the ratio of a country's export share of a commodity in the international market to the country's export share of all other commodities.[10]

China's RCA index of the agro-food sector was less than one in 2012-14, indicating that China does not have a comparative advantage in this sector. Along with a declining share of agro-food products in total export in China, the RCA index of the agro-food sector declined from 0.75 to 0.34 between 2000-02 and 2012-14, leading to the lowest score among the BRIICS countries (Figure 2.18). The evolution of its RCA index implies that China's comparative disadvantage in the agro-food sector deepened in the last decade.

Following the classification of the agro-food sector based on land and labour input intensity by Chen (2006), RCA indices of land-intensive and labour-intensive agro-food sectors are calculated separately (Figure 2.19). The indices show that China has a comparative advantage in labour-intensive agro-food products such as processed agricultural products and horticulture, but does not have a comparative advantage in land-intensive agro-food products such as cereals. Indeed, the RCA index of the land-intensive sector has declined significantly in the last decade.

Figure 2.18. Revealed comparative advantage in agro-food products, 2000-02 and 2012-14

RCA index



Notes: Agro-food products include food, beverage and raw materials for textiles.
The OECD aggregates do not include Latvia and Lithuania.
Source: UN Comtrade (2015), United Nations Commodity Trade Statistics (database), http://comtrade.un.org/.

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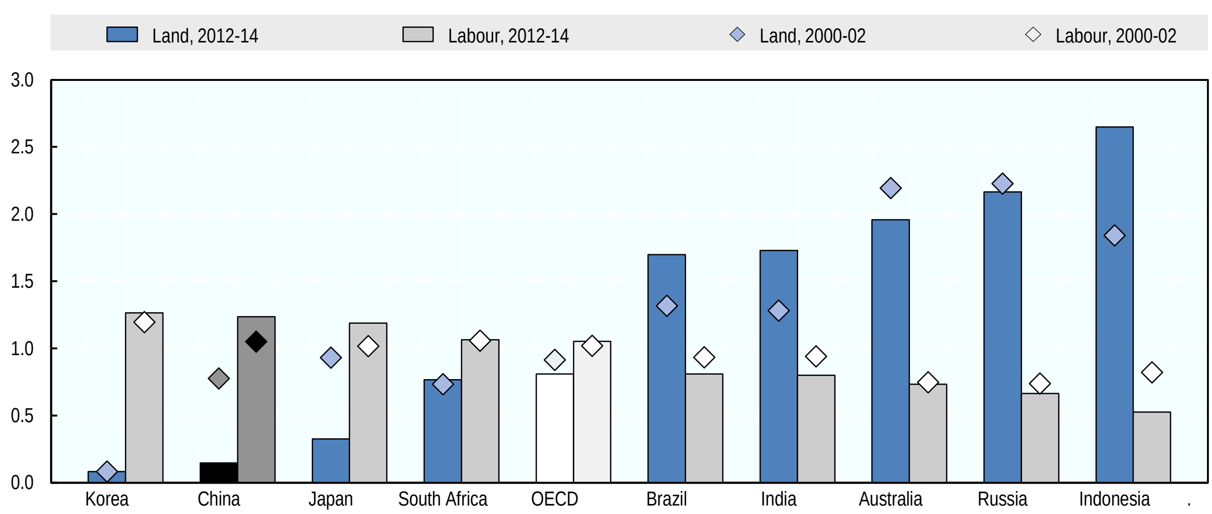
Figure 2.19. Revealed comparative advantage in agriculture sector by land and labour intensity, 2000-02 and 2012-14

RCA index



Notes: Land-intensive agriculture products include cereals, vegetable oil seeds, vegetables and raw materials (excluding silk) for textiles. Labour-intensive agriculture products include processed agricultural products, animal products, horticultural products and silk.
The OECD aggregates do not include Latvia and Lithuania.
Source: UN Comtrade (2015), United Nations Commodity Trade Statistics (database), http://comtrade.un.org/.

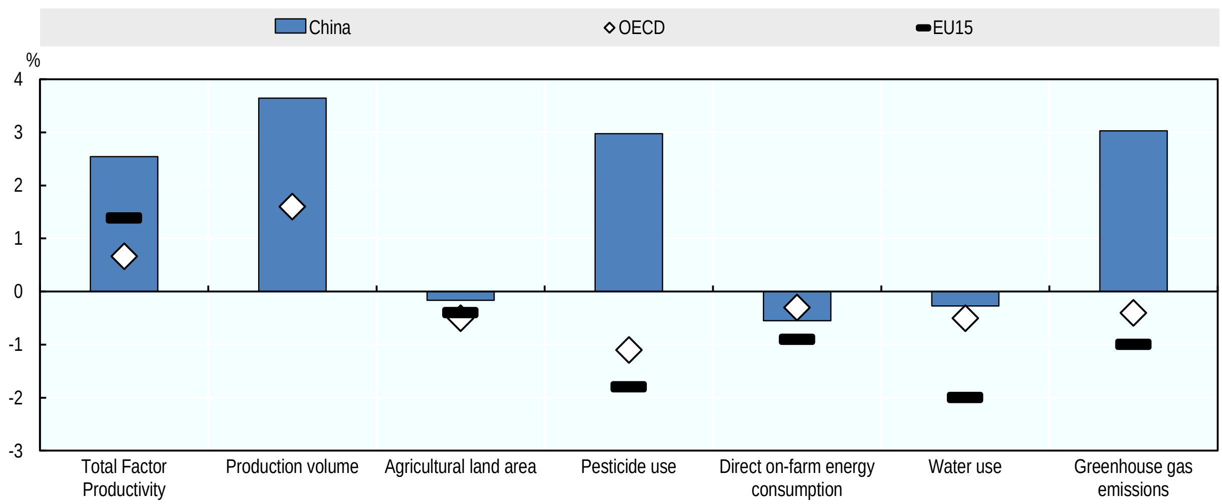
StatLink http://dx.doi.org/10.1787/888933828904

Sustainability performance of agriculture

As the previous section highlighted, China's agricultural production volume has steadily increased over the last decades – rising by 21% from 1993 to 2013 (13% for crops and 39% for livestock). Although the increase in agricultural production helped China to meet the growing food demand and to increase farm income, it also led to an intensive use of natural resources and purchased inputs, increasing the environmental pressure from agriculture. Figure 2.20highlights the contrast between rising environmental pressures in China and average declines in the EU15 and OECD countries.[11] Sustainable agricultural productivity growth in the coming decades increasingly depends on sustainable use of natural resources.

Figure 2.20. Trends in selected agriculture and environmental indicators

Average annual percent change between 2000-02 and 2010-12*



Notes: * or nearest available period.
The OECD aggregates do not include Lithuania.
Source: OECD (2017), Agri-environmental Indicators (database); OECD (2017), Environmental Database for water use; International Energy Agency (2016), IEA World Energy Statistics and Balances (database) for energy consumption; USDA, Economic Research Service, International Agricultural Productivity (database) for Total Factor Productivity.

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Soil quality

China faces serious soil contamination due to both industrial and agriculture pollutants. Waste water, waste gas and solid waste residues from industries are contributing to heavy metal pollution. Within agriculture, the main pollution sources are chemical fertilisers and pesticides, plastic mulch, animal manure and wastes, and crop residues. Contamination is particularly high in areas bordering factories, mines and intensive farming. According to the first National Soil Pollution Situation Survey for the April 2005 – February 2013 period, 16% of the surveyed sites suffered from soil pollution; this rate is even higher for cultivated land, at 20%. Pollutants are mainly inorganic, in particular heavy metals such as cadmium, mercury, arsenic, copper, lead, zinc, and nickel.

Several studies have demonstrated the linkage between soil contamination and the safety and quality of agricultural products. For instance, Williams et al. (2010) find significant heavy metal pollution in rice produced from many of the principal rice production provinces based on surveys conducted during the period 1999-2009. Li, Wu and Liang (2008) also report the impacts of soil pollution on food quality and safety, especially the impacts of pollution from heavy metals, fertilisers and pesticides on vegetables and grains.

Water quality

The sustainability of agriculture productivity growth is also threatened by water quantity and quality issues across China. Water quality problems trigger different types of water shortages, threaten drinking water supplies, and increase risks for humans, agriculture and the environment (Jiang, 2009). In particular, increases in water usage and pollution have raised a concern on the future capacity to irrigate agricultural production. Water pollution has forced cutbacks in irrigation and resulted in increasing food safety hazards (Jiang, 2009; Khan, Hanjra and Mu, 2009; HSBC, 2014).

Agricultural, industrial and residential pollution of surface and groundwater continues to be significant in many regions (Liu and Speed, 2009; Shen, 2015). According to MEP (2014), groundwater pollution has worsened since 2011. A 2016 study by MWR found that 80% of groundwater wells tested were improper for drinking or for agricultural use (Buckley and Piao, 2016).[12] The rapid increase in livestock production is a key source of pollution; waterways are increasingly polluted by the 4 billion tonnes of manure produced annually. Pesticides and fertilisers are a second prominent source of pollution, due to inefficient usage and intensive production of mono-crops such as soybeans, corn and other feed crops (Schneider, 2011).

Eutrophication (the excessive richness of nutrients in a body of water, often caused by run-off from the land) is a serious challenge to Chinese agriculture due to the pollution of China's water resources. A number of key lakes and reservoirs are under national-level monitoring and testing. According to China Environmental Bulletins, between 25% and 56% of key lakes and reservoirs were in some state of eutrophication in 2006-14 (Table 2.5).

Table 2.5. Eutrophication in key lakes and reservoirs in China, 2006 to 2014

	Number of key lakes and reservoirs with eutrophication				Share of total number under national monitoring (%)	Total number under national monitoring
	Severe	Medium	Mild	Sum		
2006	2	4	9	15	55.6	27
2007	2	3	9	14	50.0	28
2008	1	5	6	12	42.9	28
2009	1	2	8	11	42.3	26
2010	1	2	11	14	53.8	26
2011	0	2	12	14	53.8	26
2012	0	4	11	15	25.0	60
2013	0	1	16	17	27.9	61
2014	0	2	13	15	24.6	61

Source: MEP (2015).

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Nutrients

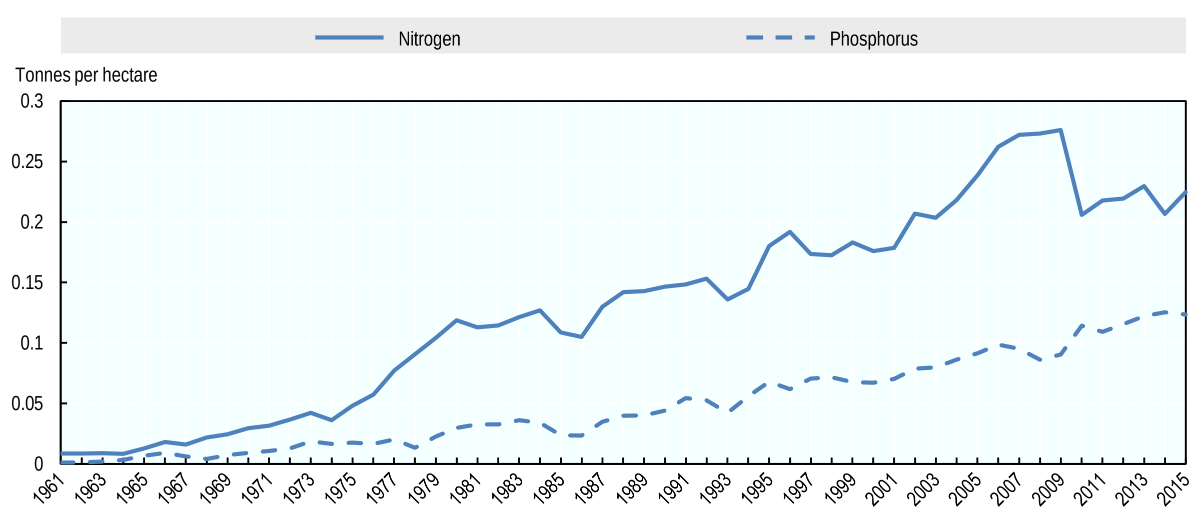
Nutrient inputs in China have steadily increased over the last three decades, promoting production levels but also raising a concern about the risk of soil pollution and water eutrophication. Nitrogen use increased by 174% from 105 kg to 288 kg per hectare between 1986 and 2013. Phosphate inputs increased by 294% from 23 kg to 92 kg per hectare over the same period (Figure 2.21). With government initiatives to curb the growth of fertiliser use, increases in the nitrogen and phosphorus inputs have levelled off to some extent since 2007.

The average fertiliser use in China of 400 kg per hectare is one of the highest in the world. More specifically, the intensity of nitrogenous and phosphate fertiliser consumption on cultivated land in China is 2.5 and 1.9 times the world average, respectively (Zhao et al., 2008). This trend contrasts with that in OECD countries, where nitrogen and particularly phosphorus use have declined sharply in recent decades. The trend in China shows that increases in nutrient input use have exceeded yield growth, suggesting diminishing marginal contributions of nutrient input to yield growth.

Although data on nutrient balances is more limited, Wang et al. (2014) find that China recorded nitrogen and phosphate surpluses of 6.95 million tonnes and 6.75 million tonnes in 2010, respectively. However, significant variation exists across China, ranging from −259 kg to 896 kg per hectare for nitrogen and −97 kg to 774 kg per hectare for phosphates at county level. The highest nitrogen surpluses were recorded primarily in eastern and north-eastern China. Wang et al. (2014) also find that fertiliser use is an important source of non-point source pollution, and that reducing fertiliser levels and improving the efficiency of nutrient use is key to improving the environmental performance of the agriculture sector. Indeed, only 40% of nitrogen fertilisers are applied efficiently; the remainder evaporates or runs off before being absorbed by crops (China Org, 2006). Small and fragmented holdings as well as transfer of farm labour to non-farm employment have been associated in some areas with higher rates of nutrient application (Tan et al., 2008).

Figure 2.21. Nitrogen and phosphorus inputs in China, 1961 to 2015

Tonnes per hectare of arable land and permanent crops



Source: International Fertilizer Association (2017).

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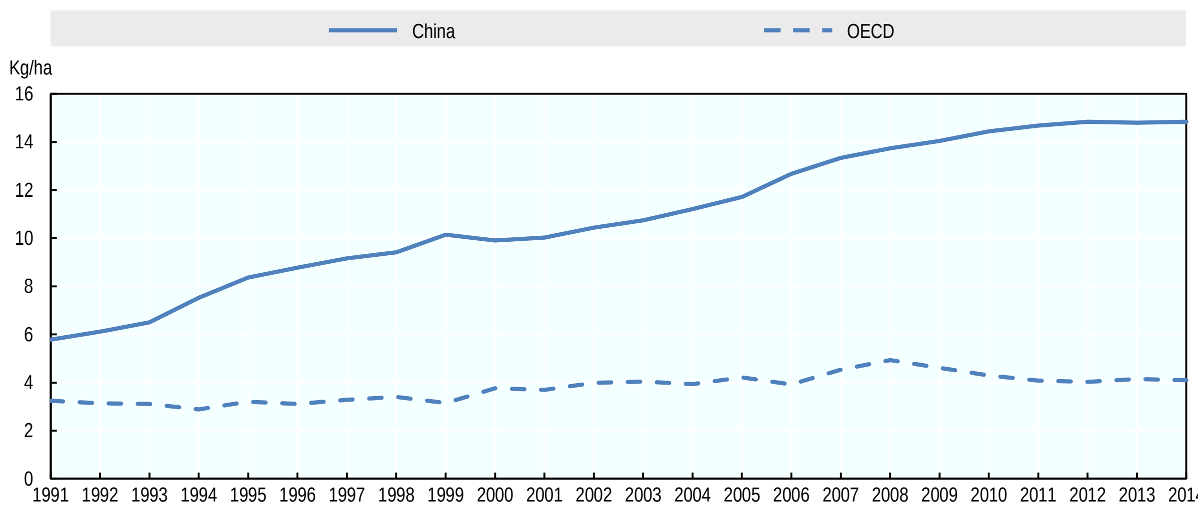
Pesticides

Increases in pesticide use boosted agricultural production by reducing pest damage, but also polluted water systems and affected human health and ecosystems. The use of chemical pesticides in China has steadily increased since the early 1990s, paralleling the upward trend in crop production (Figure 2.22). Pesticide use per hectare in China rose by 135% from 5.8 kg to 14.6 kg in 1991-2012. By contrast, the intensity of pesticide use in OECD countries increased by 18% in the same period and has shown a declining trend since 2008. While the gradual elimination and ban of high-toxicity and high-residue improved the safety of pesticides in China, per hectare use of pesticides there remains twice the world average.

Figure 2.22. Pesticide use per hectare, 1991 to 2014



Source: FAO (2017), FAOSTAT (database), http://www.fao.org/faostat/en/#home.

StatLink http://dx.doi.org/10.1787/888933828961

Agricultural ammonia emissions

Ammonia emissions have increased significantly in China in the past decades, contributing to China's atmospheric pollution. Increases in fertiliser application and livestock manure are the main contributors to rising ammonia emissions. In particular, rising livestock production has increased the share of manure in total ammonia emissions, from 37% to 46% in 1978-2008. At the same time, the contribution from synthetic fertilisers decreased from 43% to 39% in the same period. Without proper treatment and management of animal manure, ammonia emission from livestock production are projected to increase with rising demand for livestock-based products (Xu et al., 2015).

While official statistics of agricultural ammonia emissions are not available, a number of studies suggest that China is the largest emitter of ammonia emissions globally. In a recent study, Xu et al. (2015) estimate that total agricultural ammonia emissions in China were 8.4 million tonnes in 2008. Other studies estimate emissions between 4.3 to 13.7 million tonnes. For example, Liu et al. (2013) estimate that total ammonia emissions in China more than doubled in the 1980-2010 period, from 6 million to around 14 million tonnes per year.

Biodiversity

Maintaining biodiversity is another key to achieving sustainable growth in agriculture in China. In addition to providing genetic resources, biodiversity supports agricultural production through pollination and soil and water conservation. China is one of the most biodiverse countries in the world, home to 17 300 animal and plant species. However, the benefits of biodiversity for crop production may start to wane as large number of species are nearing extinction. Urbanisation, industrialisation, logging, mining, hunting and climate change are altering ecosystems and degrading the habitats of many species (OECD, 2007).

Air quality

Air quality is also an issue for sustainable productivity growth in the agriculture sector. In particular, ground-level ozone can trigger widespread losses in sensitive crops, while other pollutants – such as sulphur dioxide and nitrogen dioxide – can have significant effects on production in localised areas. A number of studies highlight the negative effect of air pollution on crop yields in China. For instance, Marshall, Ashmore and Hinchcliffe (1997) assert that air pollution may reduce yields of certain crops by more than 15% in a significant number of cultivated areas. Wang and Mauzerall (2004) estimated yield losses of up to 9% for wheat, rice and maize and 23% to 27% for soybeans. Carter et al. (2017) find a statistical significant nonlinear relationship between ozone concentration and rice yields in Southeast China; they estimate that an additional *day* with a maximum ozone concentration greater than 120 ppb is associated with a yield loss of $1.12\% \pm 0.83\%$ relative to a day with maximum ozone concentration less than 60 pp. Assuming the ozone level continues to increase, Tai, Val Martin and Heald (2014) project further declines in production of wheat, rice, maize and soybeans by 2050.

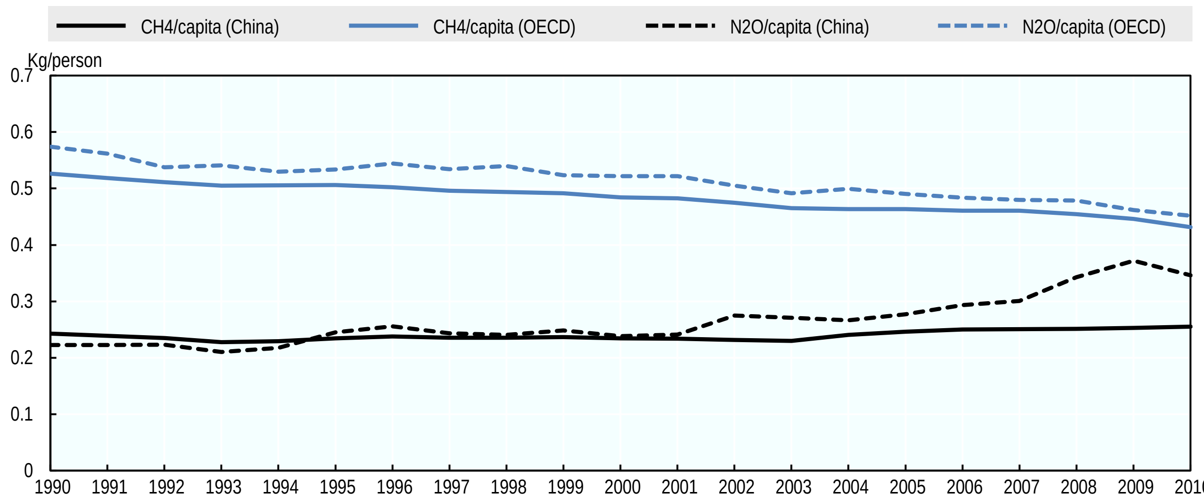
GHG emissions

Sustainable agricultural productivity growth in China is exposed to challenges from a changing climate – from rising temperatures to increasingly severe and frequent shocks. Total annual greenhouse gas (GHG) emissions from agriculture increased 51% from 543 to 818 thousand tonnes (CO_2 equivalent) in 1990-2010. China's agriculture GHG emissions are nearing the total emissions for all OECD countries (1.092 million tonnes in 2010), but remain below the OECD total on a per capita basis (0.60 versus 0.88 kg/person in 2010). GHG emissions from agriculture are projected to rise further, partly due to increased livestock production.

Methane was formerly the largest source of agriculture emissions, accounting for 52% of the total emission in 1990, but nitrous oxide emissions increased at a faster rate, exceeding methane emissions in 1995. By 2010, the share of nitrous oxide emissions in total agricultural emissions reached 58%. As shown in Figure 2.23, emissions per capita of both gases have been converging with those of the OECD. From 2000, the GHG emissions from agriculture increased at about 2.6% annually, with methane and nitrous oxide emissions rising at 1% and 3.9% per year respectively.

Figure 2.23. GHG emissions (methane and nitrous oxide), 1990 to 2010

CO2 equivalent in kg/person



Note: The OECD aggregates do not include Latvia and Lithuania.
Source: FAO (2015a), FAOSTAT (database), http://www.fao.org/faostat/en/#home and OECD (2015a) OECD.Stat (database), for population, http://stats.oecd.org.

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2.5. Policy challenges for innovation, agricultural productivity growth and sustainability in China

The Chinese economy has shifted into a “new normal” situation in which lower but more sustainable economic growth rates are expected. The economy is experiencing a number of important structural changes. The working age population in China started to decline in 2015 and the aging of the population as a whole is expected to advance rapidly over the next decades. The rapid increase in the real wage rate since the early 2000s required a change in the growth model, which had relied on an ample supply of low wage workers from rural areas. China’s remarkable economic growth in the last few decades has been sustained largely by an accumulation of capital, supported by large saving rates. These structural changes in the economy suggest that China’s economic growth will increasingly depend on productivity growth through innovation, including in the food and agricultural sector.

In China, agriculture still accounts for nearly 30% of employment, but generates less than 10% of GDP, indicating that labour productivity is significantly lower than in the rest of the economy. A slow decline in the total number of workers in agriculture is a major constraint to improvement in labour productivity, which grew at a slower pace than in the United States, the Russian Federation, Brazil, South Africa, Korea and Japan in 2000-15. The growth rate of total factor productivity in primary agriculture for the period 2001-14 slowed down compared to the 1990s, while other BRIICS countries (except for South Africa) experienced an accelerated growth rate in recent years compared to the 1990s. Productivity growth has become a key driver to achieving sustainable growth in the agricultural sector in China.

The rising cost of labour and a rapid aging of the rural population require agricultural production to concentrate on a smaller number of farms and on less labour-intensive ones. Although the sector is largely dominated by small family farms, "new-style" farms, such as large family farms, co-operative farms, and farms run by agribusiness companies, have emerged and are increasingly significant. Higher labour costs drove rapid farm mechanisation, allowing farmers to save labour input and expand farm size or engage in off-farm activities.

The development of farm mechanisation service providers across China has enabled small-scale farms to save labour input and improve productivity. Farmer Professional Cooperatives have become a key institution through which small-scale farmers can have access to technology, finance and farm mechanisation services and can integrate with agri-food value chains. Considering the structural characteristics of Chinese agriculture, which is dominated by small-scale family farms, the development of diverse farm management units is a key organisational innovation to enhance agricultural productivity and profitability in China.

Rural households are increasingly obtaining their income from off-farm activities, which have already become the major source of income. Reducing the existing large income disparity between urban and rural households depends largely on the development of non-farm sectors in rural areas and migration of the rural population to urban areas.

The diet shift in China associated with income growth has been a major driver of shifting domestic agricultural production towards livestock and fruit and vegetable production. These areas are already dominating the agricultural sector in terms of the production value. Future growth in the food and agricultural sector in China comes largely from such high value-added agricultural products. Low value added from China's domestic service sector in its food and agricultural export also implies that more linkage between agriculture and service sectors would add value to agriculture and food products. While China maintained near self-sufficiency in grain production, the country lost comparative advantage in land-intensive products. Policies to maintain the near self-sufficiency of grain production constrains the structural evolution of Chinese agriculture towards more value-added production.

China's agriculture development has been achieved at the expense of sustainable use of natural resources. Agriculture uses most of the land and water resources in China. The expansion of the sector, especially for products with high self-sufficiency targets, has been aided partly by the intensive use of chemical inputs such as mineral fertilisers and pesticides. Intensive use of chemical inputs in the crop sectors have led to soil degradation, water pollution, and damaged bio-diversity. The availability of water resources has reached its limit of sustainable use, particularly in areas where irrigation is intensive or water resources are scarce. Small-scale farming and engagement in non-farm employment activities also led to inefficient use of chemical inputs. The development of the livestock sector has created serious stress on China's grassland areas. The release of animal manure and waste water from intensive livestock and aquaculture farms further pollutes the environment, especially water resources.

Growing environmental challenges have also become significant constraints to sustainable productivity growth of agriculture in China. Contamination and pollution of soil and water resources raises uncertainty about future productivity trends. Climate change is expected to impact agricultural production through rising temperatures, the spread of pests and disease, and more frequent and more severe droughts and floods. The sustainable productivity growth of agriculture requires a policy strategy to curb and eventually reverse the current practice in chemical inputs use and to mitigate these environmental constraints where natural resources are currently exploited.

Notes

[1] The “reform period” refers to the years since 1978, when the Government of China instituted its policy of “reform and opening up”. The years 1979 to 1984 are considered as the “early reform period”.

[2] China announced a change in family planning policy to allow family units to have two children from 2016. This policy is expected to mitigate the projected decline in population.

[3] Irrigated land increased from 48 390 ha in 1990 to 65 973 ha in 2015 (NBSC, 2016). Total cultivated land progressed from 95 656 ha to 135 067 ha in the same period (MLR, 2016).

[4] The effective utilisation ratio of water improved from 44% in 2002 to 52% in 2013, but remains approximately 20 percentage points below the ratio in developed countries. China’s open-channel irrigation system is particularly susceptible to leakages and other losses, and only a fraction of irrigation land is equipped with modern water-saving irrigation technologies. Approximately 140 billion m3 of water is lost every year, which means that producing 1 kg of grain requires 0.96 m3 of water in China (twice the water needed in developed countries) (Zhao et al., 2008).

[5] Large differences in climate translate into a gradient of precipitation from the dry northwest plateaux to the humid southeast coastal areas (Jiang, 2009). On the other hand, China’s population, agriculture and economic activities are concentrated in the relatively dry northeast regions, closer to coasts, and far from the glaciers, and therefore depend on key river systems and aquifers (Liu and Speed, 2009). The rapid development of the Chinese economy has led to significant surface and groundwater quantity and quality issues in this region (e.g. OECD, 2007; Jiang, 2009; Jiao, 2010; Sadoff et al., 2015).

[6] Simulated impacts of surface- and ground-water risks in Northeast China by 2050 show in particular that without further efforts national maize and wheat production could decline by 8-12% (OECD, 2017).

[7] Other potential drivers include more intensive investment in infrastructure, such as water conservation facilities, and the demand shift towards higher quality japonica rice produced in this region.

[8] In 2010, the Chinese government raised the rural poverty standard, to equal or even exceed the global standard.

[9] In spite of the emergence of a migrant wage-earning subsector, many individuals found off-farm jobs as self-employment (Rozelle et al., 1999; Zhang et al., 2006). According to de Brauw et al. (2002), between the early 1980s and 2000 the number of rural labourers that found an off-farm job in the city or another rural area rose from 9.3 million to 56 million. During the same period, the number of rural individuals that began small, non-farm self-employed enterprises rose from 26.1 million to 79.5 million.

[10] The trade measure of competitiveness is based on the concept that trade flows reflect differences in production costs among countries and that a country will specialise in the production of a good in which it has a cost advantage. For the i-th country and j-th commodity, the RCA is defined as follows:

$$\mathrm{RCA}_{ij} = \mathrm{RXA}_{ij} = \left(X_{ij} / X_{ik}\right) / \left(X_{nj} / X_{nk}\right)$$

where X are exports; k denotes all commodities other than j; n denotes all countries other than i. An RCA index greater than 1 indicates that the country has a comparative advantage in the commodity under consideration, since it has a strong export sector. This reveals higher competitiveness.

[11] Annex Table 2.A.1 summarises selected agri-environmental indicators in China.

[12] 32.9% of wells tested had Grade 4 quality water – only fit for industrial uses but not for agriculture or drinking uses; an additional 47.3% of wells were at the lower Grade 5 – not even usable for industries.

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Annex 2.A. Background table

Annex Table 2.A.1. Selected agri-environmental indicators in China, 1990 to 2011*

	1990	1995	2000	2005	2010	2011
Land						
Forest area (% of land area)	16.7	17.8	18.9	20.6	22.0	22.3
Agricultural land (% of land area)	54.2	56.3	56.3	56.2	55.6	55.7
Agricultural land use (in %):						
Arable land	24.5	23.2	23.0	22.6	21.5	21.5
Permanent crops	1.5	2.0	2.1	2.4	2.8	2.8
Permanent meadows and pastures	74.0	74.8	74.8	75.0	75.7	75.7
Conservation area over 30% ground cover	..	..	..	0.02	..	0.6
Water						
Share of irrigated land (% of cultivated land)	50.6	53.1	42.0	45.1	44.6	45.6
Annual freshwater withdrawals:						
Total (billion cubic meters)	..	500	525.4	..	554.1	554.1
Agriculture withdrawals (% of total)	..	83	77.6	..	64.6	64.6
Air and climate change						
Agricultural methane emissions:						
(thousand metric tons of CO2 equivalent)	523 333	..	485 703	516 884	589 862	..
(% of totalmethane emissions)	51.5	..	46.5	38.9	35.9	..
Agricultural nitrous oxide emissions:						
(thousand metric tons of CO2 equivalent)	253 402	..	303 561	347 092	415 149	..
(% of total)	79.6	..	77.4	74.9	75.4	..
Livestock						
Livestock[1] number per ha of agricultural area	0.71	0.81	0.84	0.82	0.92	0.91
Fertiliser and pesticide use						
Fertiliser[2] use on arable and permanent crop area (tonnes per thousand ha)	..	..	..	314.67	412.90	..
Pesticide[3] use on arable and permanent crop area (tonnes per thousand ha)	0	0	9.75	8.84	17.81	..
Energy						
Energy use in agriculture and forestry (% of total energy use)	3.83	3.56	3.08	3.15	2.08	..
Bioenergy production (% of total renewable energy production)	94.83	92.29	90.7	84.11	76.02	..

* or latest available year.
1. Cattle, buffaloes, pigs, sheep, goats, and poultry.
2. Nitrogen and phosphate nutrients.
3. An active ingredient.

Source: FAOSTAT (2015); AQUASTAT (2015); World Bank (2015), *World Development Indicators* (database), http://data.worldbank.org/indicator, *China Statistical Yearbook* and *Land Resources Bulletin.*

StatLink http://dx.doi.org/10.1787/888933829892

Chapter 3. Economic and institutional environment in China

This chapter gives an overview of the performance of the overall economy, macroeconomic developments and challenges, governance and institutions, and general incentives in China for investments by firms, including farms, input suppliers, and food companies. It discusses basic conditions for investment established by the overall regulatory environment; trade and investment policy, which influences the flow of goods, capital, technology, knowledge and people needed to innovate; and access to credit. The general fiscal policy and the treatment of agriculture are then discussed. Specific obstacles and incentives for investment in the agricultural sector are dealt with in later chapters of this report.

3.1. Macroeconomic policy environment and governance

Stable and sound macroeconomic policies are integral in creating a favourable environment for innovation. At the broadest level, policies that lead to high economic growth and low and stable inflation help to create a basic condition for long-term investment. Higher productivity and better use of natural resources are in turn helped by long-term investments, which introduce new products, production methods, or business practices (OECD, 2015a).

The People's Republic of China's (hereafter "China") economic rise has often been described as one of the greatest economic success stories in modern times. Behind the strong growth rates were key reforms which increased the role of the market and reduced direct control by the government. In the early years of economic reform, introducing the Household Responsibility System (HRS) in agriculture, which reallocated all arable land from collective farms to individual households, laid the foundation for strong agricultural productivity growth.

Rising incomes in these initial reform years stimulated domestic demand, and the high savings rate was transformed into physical capital investments in non-agricultural sectors in both rural and urban areas (FAO, 2006). Moreover, under the 9th Five Year Plan (1996-2000), large state-owned enterprises (SOEs) were restructured, corporatized, and were expected to operate on profit, while small- and medium-sized firms were privatised, all of which contributed to China's successful performance. The productivity gains from these reforms along with large-scale investment in capital produced remarkable achievements in China's economic development (World Bank, 2013).

Table 3.1. Key indicators of economic performance

	1990	1995	2000	2005	2010	2012	2013	2014	2015	2016e	2017e
Real GDP growth[1] (%)	..	11.0	8.4	11.3	10.6	7.9	7.8	7.3	6.9	6.7	6.4
General government financial balance[2]	..	-1.1	-2.8	-0.9	-0.7	0.1	-0.5	-0.6	-1.3	-1.8	-2.3
Current account balance[2]	3.2	0.7	1.7	5.8	3.9	2.5	1.5	2.7	3.0	2.4	2.4
Inflation (annual %, CPI all items)	3.1	16.8	-0.8	1.8	3.2	2.6	2.6	2.1	1.5	2.1	2.2

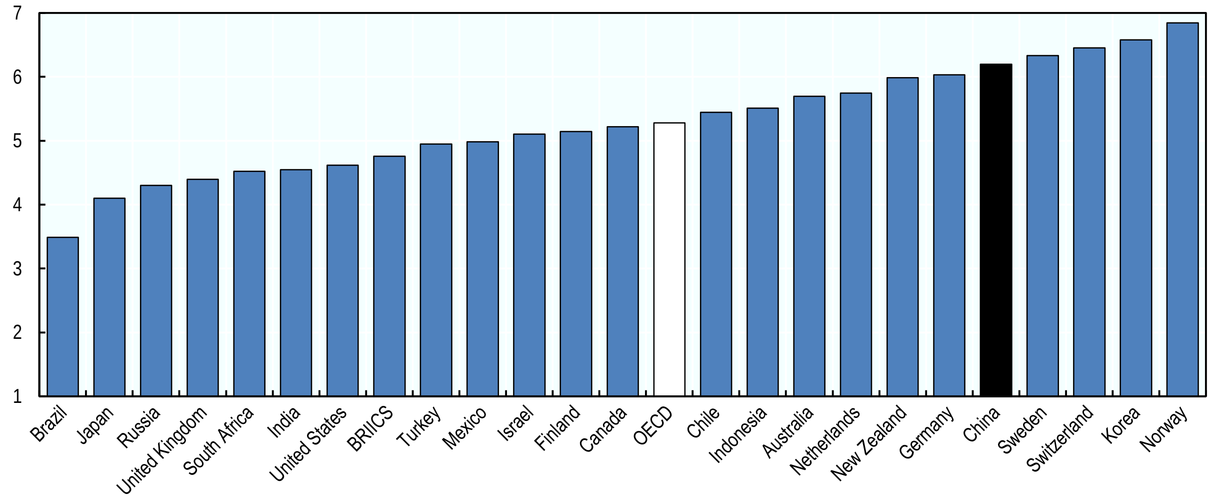
Note: e: OECD Economic Outlook estimate.
1. Year-on-year increase.
2. As a percentage of GDP.
Source: OECD (2017a), *OECD Economic Outlook*, http://dx.doi.org/10.1787/eco_outlook-v2017-1-en.

StatLink http://dx.doi.org/10.1787/888933829911

Although China has entered into a lower but likely more sustainable growth trajectory, its macroeconomic environment remains competitive (Figure 3.1). When considering macroeconomic factors such as government budget balance, gross national savings, inflation, government debt, and the country's credit rating, China ranks among the top countries globally. Helped by its low and stable inflation rate, relatively strong growth, and stable market, the Chinese economy should remain attractive for private investment.

Figure 3.1. Global Competitiveness Index: Macroeconomic Environment, 2016-17

Scale 1 to 7 (best)



Note: Indices for BRIICS and OECD are the simple average of member-country indices. The OECD aggregate does not include Lithuania.

Source: World Economic Forum (2016), The Global Competitiveness Report 2016-2017: Full data Edition, https://www.weforum.org/reports/the-global-competitiveness-report-2016-2017-1.

StatLink http://dx.doi.org/10.1787/888933828999

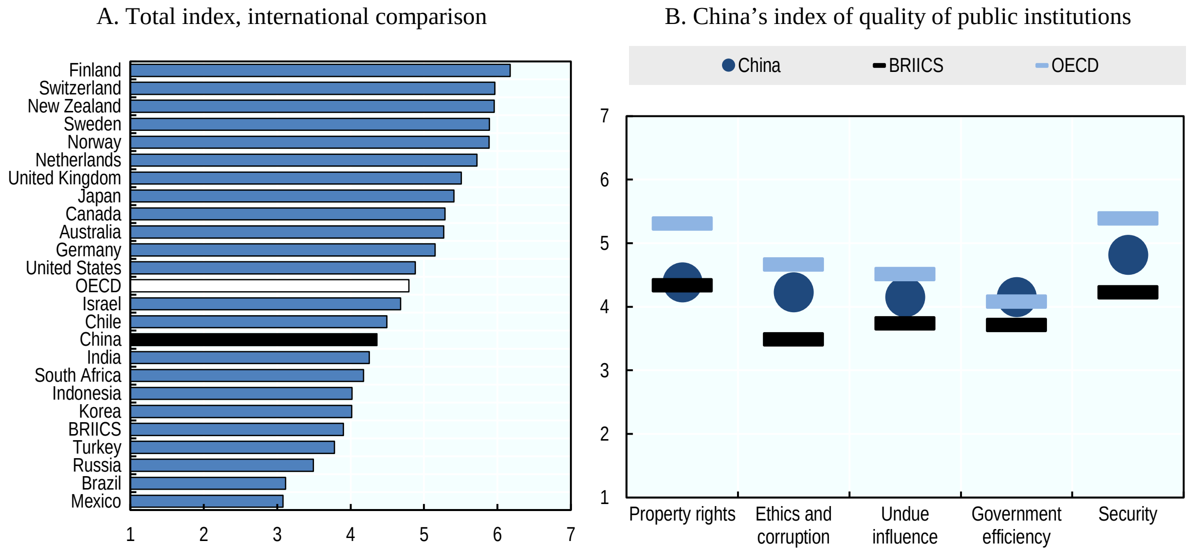
Governance and institutions

Good governance systems and high-quality institutions provide economic actors with the assurance that the government is accountable, transparent and predictable. They are a fundamental pre-condition both to encourage public and private investment in the economy and to enable those investments to achieve the intended benefits, both for investors and the host country. Moreover, governance systems play an important role in addressing market failure, influencing the behaviour of firms as well as the efficient functioning of input and output markets (OECD, 2015a).

The government of China has always played a strong role in the development of the country. China's position in the governance indicator sets the quality of its institutions just below the OECD average, but the highest among the BRIICS (Figure 3.2.A). The breakdown of quality indices of public institutions show that property rights and security are among the relatively low performing factors of governance, but government efficiency is scored higher than OECD average (Figure 3.2.B).

Figure 3.2. Global Competitiveness Index: Quality of public institutions, 2016-17

Scale 1 to 7 (best)



Note: Indices for BRIICS and OECD are the simple average of member-country indices. The OECD aggregates do not include Lithuania.
Source: World Economic Forum (2016), The Global Competitiveness Report 2016-2017: Full data Edition, www.weforum.org/reports/the-global-competitiveness-report-2016-2017-1.

StatLink http://dx.doi.org/10.1787/888933829018

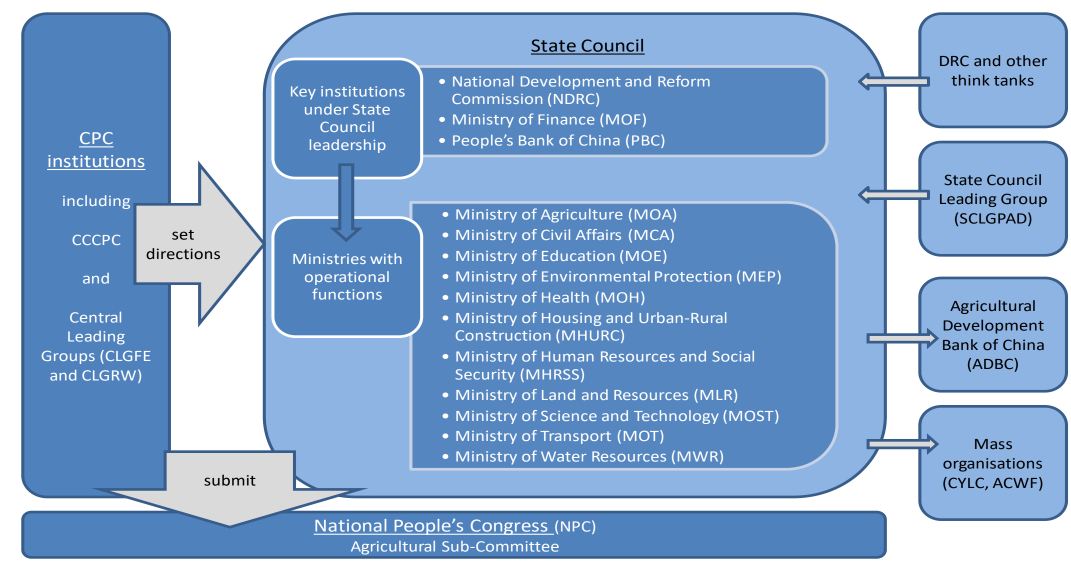
Box 3.1. Political institutions in China

The **Communist Party of China** (CPC) occupies the dominant political role in China. The CPC, by its own definition, represents the population at large and interprets and expresses the will of the people. The CPC governs all central and sub national level State organs. Currently, the head of the CPC is also the President of the State.

According to the Constitution, the **National People's Congress** (NPC), and its permanent office the Standing Committee, is the "highest organ of state power". The NPC exercises the power of legislation, decision, supervision, election, appointment and dismissal. The President is the head of state, and among other functions promulgates laws, appoints the premier, vice premiers, state councillors, ministers of various ministries and state commissions according to decisions of the NPC and its standing committee. The State Council is the highest body of state administration, and it supervises ministries, commissions and bureaus.

The **Central Committee of the Communist Party of China** (CCCPC) sets the country's broad policy directions. Elected by the Party, the CCCPC issues top priority political documents and determines the long-term strategy for the country's social, economic and political development. The co-ordination institutions under the CCCPC function as a platform for policy discussions with related government bodies, determine general policy principles and work jointly with three key State Council institutions including the **National Development and Reform Commission** (NDRC), **Ministry of Finance** (MOF) and **People's Bank of China** (PBC). Think tanks under the State Council such as the **Development Research Center of the State Council** (DRC) provide advice in this process. Finally, the ministries and agencies perform operational functions involving them in day-to-day operations and the practical implementation of rural policies and directives under the State Council's leadership.

Figure 3.3. Central-level institutional framework for rural policy



Source: OECD (2009), *OECD Rural Policy Reviews: China 2009*, http://dx.doi.org/10.1787/9789264059573-en.

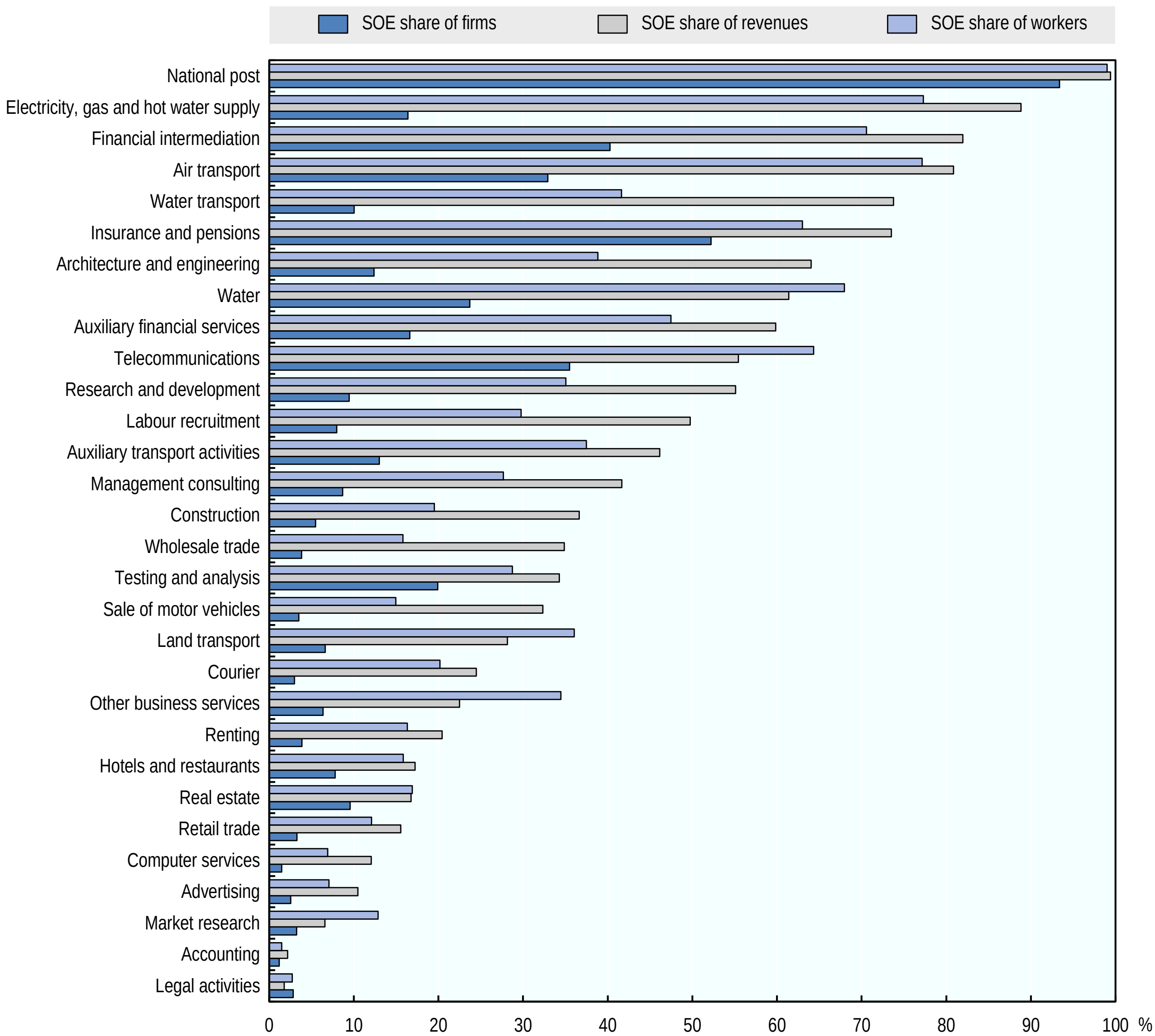
Competitive environment

Many sectors in China face low competition as some have been dominated by the State-Owned Enterprises (SOEs). However, a number of SOE reforms have been directed towards liberalising the business sectors for private investment. In particular, policies have promoted restructuring and sale of small and medium-sized SOEs. The achievements of SOE reforms have been twofold: the importance of SOEs in the overall economy has diminished since the start of liberalisation, and those that remain have been forced to improve their efficiency.

The relative importance of SOEs in the Chinese economy has declined over time. In 2012, only 5% of enterprises were state-owned, and SOEs accounted for about a quarter of revenue and profits (OECD, 2015b). In some sectors, oligopolistic market conditions still hinder the competition and entrepreneurship (OECD, 2017b). Some areas of the service sector are still dominated by SOEs in terms of revenue and workers (4). Sector-specific guidelines calling for an opening to private capital were issued in 2010 and 2012 covering energy, finance, telecommunications, transport and other areas. While lifting restrictions, the guidelines lack detail on what forms of investment will be permitted and whether any other limitations might apply (OECD, 2013). In agriculture, the share of SOEs is one of the lowest across the sector, accounting for 4% of sown land area in 2013. While SOEs account for 28% of cotton production, their share in grain and meat production was as low, at 6%

and 3% in 2013, respectively. However, the role of SOEs are increasing its prominence in grain trading and farm inputs markets such as COFCO, Sinograin, Beidahuang Group and ChemChina.

Figure 3.4. Share of SOEs in workers, revenues and the number of firms in China, 2013



Notes: Sectors are classified according to the United Nations ISIC Rev. 3 two-digit sector codes except for the following services, which are classified according to the four-digit sector codes: national post, courier services, legal activities, accounting and auditing, architecture and engineering, advertising, market research, labour recruitment, testing and analysis, and management consultancy.
Source: OECD (2015b), *OECD Economic Surveys: China 2015*, http://dx.doi.org/10.1787/eco_surveys-chn-2015-en.

StatLink http://dx.doi.org/10.1787/888933829037

Of particular concern is the financial services sector, where five state-controlled banks account for 48% of net profits and 57% of gross profits. The portion increases to almost three quarters among development and commercial banks, where are partially owned by the government. All the main operating entities in the insurance and securities sector are either SOEs or have a link to the state (OECD, 2015b). Rates of return of SOEs – the amount of output relative to the amount of capital and raw materials they consume – are lower than their private sector counterparts.

Ensuring fair competition in the input and output market is also a key role of the government in improving competitiveness of the agricultural sector. Developing an efficient and reliable service sector is particularly important to promote more competitive agriculture in China: the OECD-WTO Trade in Value Added Database indicates the share of domestic services in the value added of food and agriculture industries is significantly lower than in OECD countries. Continued restructuring and reform of state-owned enterprises and introducing more competition to the service sector would improve the innovation environment and enhance more "servicification" of agriculture and food industries.

3.2. Regulatory environment

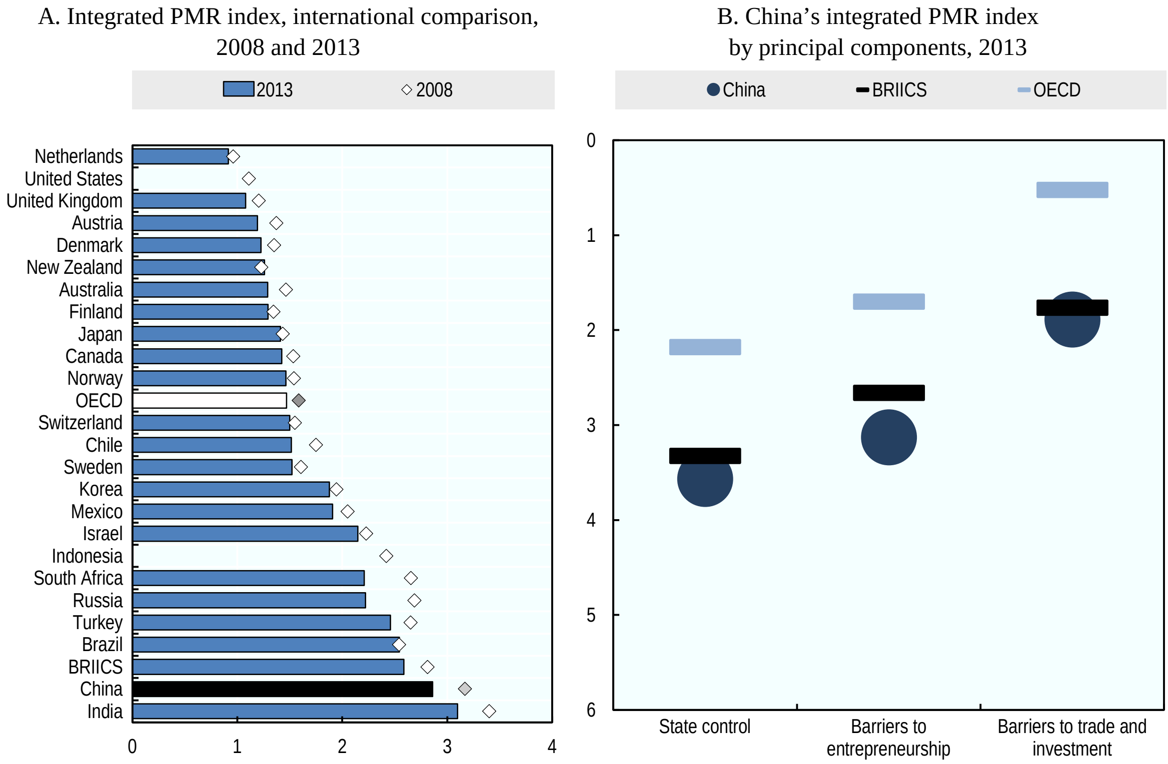
Regulations constitute a basic economic environment within which all firms operate and make investment decisions. The regulatory environment affects how agricultural productivity and innovation will be affected by the operation and investment decisions of input suppliers, food companies, farms, and firms. Competitive market conditions such as low barriers to entry and exit can enable innovation, technological transfer and productivity growth, particularly by entrepreneurs. Regulations also play an important role in the creation of incentives to use natural resources in an environment-friendly manner. This section reviews regulatory environment in China from the perspective of the ease of entry for business into a new market, the ease of conducting business in a given market, and the standards that must be adhered to in order to operate.

Regulatory environment for entrepreneurship

As a result of China's continuous reforms, markets play an increasing role in resource allocation. The 2008 Anti-Monopoly Law provides a modern competition policy framework and prices of most goods are market determined with a few exceptions such as water and electricity. However, the OECD's Product Market Regulation (PMR) indicators, which measure the degree to which a country's regulatory framework promotes or inhibits competition in product markets, show some areas for improvement. While the PMR indicators cover state control, barriers to entrepreneurship and barriers to trade and investment, the integrated PMR index for 2013 indicates that China is more restrictive than all OECD countries and BRIICS countries, with the exception of India. A more disaggregated analysis shows that China is more restrictive than OECD and BRIICS countries on average on the components including state control, barriers to entrepreneurship and barriers to trade and investment.

Figure 3.5. Integrated Product Market Regulation (PMR) indicator

Scale 0 (least) to 6 (most) restrictive



Notes: Indices for BRIICS and OECD are the simple average of member-country indices. The OECD aggregates do not include Latvia and Lithuania. For Indonesia and the United States, 2013 data are not available.
Source: OECD (2014), *Product Market Regulation Database*.

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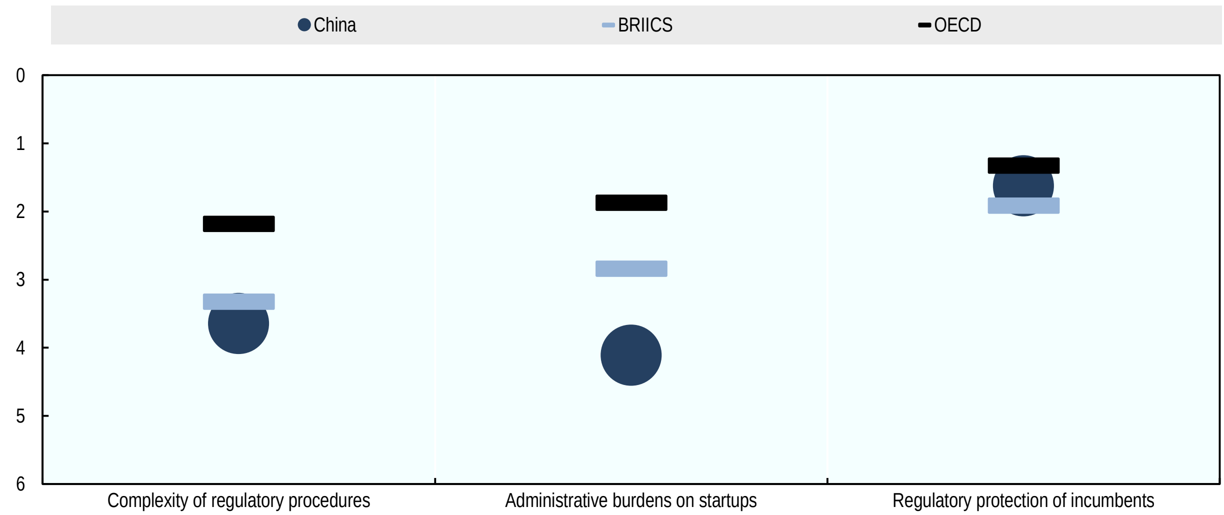
The dominance of SOEs in some sectors is a key factor explaining China's poor performance on the index of state control and on corresponding indices such as state ownership, government involvement in network sectors, and direct control over business enterprises.

The index of barriers to entrepreneurship in the OECD PMR database is composed of start-up and exit constraints, an efficient licensing and permit system, clarity of procedures, and ease of administrative processes on firms. China's indicators are particularly restrictive for license and permit systems and administrative burdens for entrepreneurship. Administrative burden is the most restrictive factor for entrepreneurship in China. Recently, China has increased its policy efforts to simplify regulatory procedures. The business system reform includes the simplification of business registration and the integration of different business certifications to a single certificate. As yet, the impacts of these reforms are not reflected in the indicators.

Figure 3.6. Barriers to entrepreneurship indicator for China by regulatory area, 2013

Scale 0 (least) to 6 (most) restrictive



Notes: Indices for BRIICS and OECD are the simple average of member-country indices. The OECD aggregates do not include Latvia and Lithuania.
Source: OECD (2014), *Product Market Regulation Database*.

StatLink http://dx.doi.org/10.1787/888933829075

The Ease of Doing Business Report of the World Bank provides a comparative assessment of the business regulatory environments globally. Countries are ranked according to the distance to frontier (DTF) scores, which is an aggregate of ten criteria elaborated upon in the report. Criteria include the ease to start a business, register property, get credit and trade across borders. China is ranked at number 78 out of 190 economies in the 2017 Report (Table 3.2). Among BRIICS countries, the Russian Federation and South Africa are ranked higher than China. Among the specific regulatory areas, the report finds that dealing with construction permits, protecting minority investors, starting a business, getting electricity and paying taxes are particularly affecting the business environment in China. This is consistent with the OECD PMR indicators, suggesting that the regulatory environment could be further improved to foster entrepreneurs and attract foreign direct investment.

Table 3.2. China's ranking in World Bank's Ease of doing Business, 2016

	Rank (out of 190 economies)
Overall rank	78
Ranking by specific regulatory area:	
Starting a business	127
Dealing with construction permits	177
Getting electricity	97
Registering property	42
Getting credit	62
Protecting minority investors	123
Paying taxes	131
Trading across borders	96
Enforcing contracts	5
Resolving insolvency	53

Source: World Bank (2017), *Doing Business 2017: Equal Opportunity for All*, World Bank.

Regulations on natural resources

Regulation on natural resources are central to ensuring the long-term sustainable use of natural resources and in large part determine access to and use of land, water and biodiversity resources. They also impose limits on the impact of industrial and agricultural activities on natural resources (e.g. water pollution, soil degradation, greenhouse gas emissions). The design of natural resources and environmental policies is important in terms of their incentives for innovation and sustainable productivity growth. As Chapter 4 provides a more in-depth review of regulatory policies on land and water use, this section covers other areas of environmental regulations in China.

As discussed in Chapter 2, a number of studies have highlighted the negative effect of air pollution on crop yields in China (e.g. Marshall, Ashmore and Hinchcliffe, 1997; Tai, Val Martin and Heald, 2014). The basic legal regulation to address air pollution in China is the *Law on Atmospheric Pollution Prevention and Control*, which states that the improvement of atmospheric environment quality must start with the control of all the sources of pollutants, including those from agriculture. The law lays out atmospheric pollution prevention and control measures for pollution arising from agricultural and other activities. For example, it requires agricultural producers to improve the method of applying fertilisers, to reduce the use of pesticides and to reduce emissions of ammonia, volatile organic compounds and other atmospheric pollutants. The law also applied a coordinated control to particulate matters, sulphur dioxide, nitrogen oxides, volatile organic compounds, ammonia and other air pollutants, as well as greenhouse gases.

At national level, the Ministry of Environmental Protection (MEP), in co-operation with relevant State Council agencies, is responsible for the monitoring and assessment of the implementation of these targets and publicly releases the assessments. In particular, the MEP is tasked with developing atmospheric emission standards, based on atmospheric quality standards and national economic and technologic conditions.

China's Environment Protection Act went into effect in January 2015. Together with the Regulations on the livestock pollution enacted in 2014, the Act strengthened the regulation on livestock manure management at the farm level, including increased financial penalties for livestock breeders that mismanage waste. Local authorities are using tougher environmental rules to close down or relocate pig farms, in particular those located close to densely populated areas. It is reported that more than half of small farms in Guangdong province were shut down while the remaining farms were requested to reduce their herds. Similarly, in Fujian province, local authorities closed more than 13 000 backyard farms over pollution worries (GAIN Report-CH15034, 2015).

While the government emphasises the importance of preventing and controlling agricultural non-point source pollution, regulations on fertiliser are not applied at the farm level. Provinces produce guidelines on fertiliser application, but these remain advisory and non-enforceable (Smith and Siciliano, 2015). However, China has recently strengthened the comprehensive regulation on pesticide initially enacted in 1997, covering its registration, production, marketing and application, prohibiting the use of pesticide beyond the range of application or recommended dosage as well as the use of highly toxic pesticide.

Regulations on food safety

Since 2004, No. 1 Documents of the CCCPC and State Councils have been emphasising the efforts to enhance regulation and supervision of the quality and safety of agricultural products, and to make comprehensive improvements in these aspects. In developing an appropriate sanitary and phytosanitary (SPS) regulatory environment, including implementation provisions, experience has shown that technology-neutral, science-based approaches are most effective in diffusing innovation and least market-distorting, provided that care is taken to ensure agricultural specificities and societal choices are taken into account.

In China, food safety and quality issues have become the national strategic objective, responding to a growing public concern. In 2013, China established the Food and Drug Administration (CFDA) on the basis of the former State Food and Drug Administration. CFDA is responsible for supervising food safety covering the entire food chain from production to circulation and consumption, as well as drug safety. The Food Safety Law was also revised in 2015 to establish a more scientific and strict supervision system of food safety. First, the Law strengthened regulations in the entire process of food manufacturing, retail, and catering services, including prohibiting the use of highly toxic pesticides for vegetables, fruits, tea and Chinese herbal medicine, and other crops. Second, the Law increased both regulatory penalties and the accountability of local government officials and regulators. Third, it improved the risk monitoring, assessment and food safety standards and other systems. Fourth, it introduced compensation for whistle-blowers, a liability insurance system and created a monitoring system with the involvement of consumers, industry associations, media and other bodies.

The No. 1 Document of 2016 calls for a national strategy on food safety and quality which is to include the monitoring of chemical residues in agricultural products, standardisation in farm operations, a food safety regulatory system, and an information platform for full traceability. The new strategy targets: 1) the development of a quality and safety standard system for agricultural products, covering origin and production processes; 2) the strengthening of law enforcement in food safety and quality; 3) the introduction of risk monitoring on a quarterly basis in 150 large and medium-sized cities in the five major categories of products; 4) creating the first batch of 107 cities, which will serve as a basis for establishing production standards and applying the social co-governance model of supervision to improve quality and safety of agricultural products; and 5) establishment of the national quality and safety traceability platform of agricultural products in 2017.

The government also decided that the limits on pesticide and veterinary medicine residues must be close to those established in the Codex Alimentarius by 2020. To reach the target, stricter regulations on agricultural inputs will be enforced and the use of pesticides with high effectiveness, low toxicity and low residues will be more widely adopted. Standardised agriculture, horticulture, and livestock and aquaculture demonstration areas will continue to receive support for purposes of safety and quality assurance.

China also started a campaign to establish counties of quality and safe agricultural products focusing on counties specialising in producing vegetable products. The central government set aside funds for supporting this initiative, mainly to establish and design institutions and rules and to provide personnel training. China has also started to develop its quality and safety traceability system for agricultural products, which is expected to cover the full supply chain ranging from production to final consumption. In 2015, the priority has been put on the construction of a national traceability information platform.

3.3. Trade and investment

Trade facilitates the flow of goods, capital, technology, knowledge and people needed to innovate. Openness to trade and capital flows is conducive to innovation as it increases access to new technologies, ideas and processes, including from foreign direct investment (FDI) and related technological spill-overs, reinforces competition, provides a larger market for innovators, and facilitates cross-country collaboration. Trade and investment openness can influence innovation throughout the food supply chain, from input suppliers to food service and retail firms. Input and output markets that operate effectively can foster productivity growth. Trade and investment openness can also facilitate the development of market mechanisms to foster more environmentally sustainable production (OECD, 2015a).

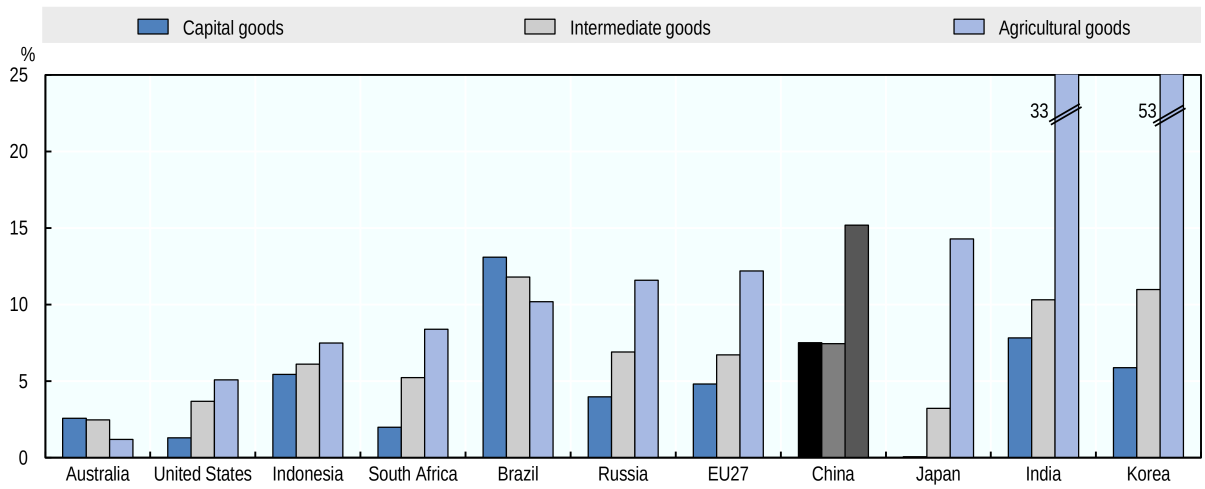
China joined the WTO in 2001 and during its accession process agreed substantial liberalisation as regards both import and export restrictions. The entirety of China’s import duties is bound and most bindings are very close to applied rates. Due to its WTO commitments, China has very little room to raise its level of tariff protection. On goods overall, China bound its tariffs at 10% (simple average), which is substantially lower than many BRIICS countries (e.g. Brazil’s simple average bound rate is 31%) but substantially higher than OECD countries (e.g. the United States rate is 3.5%).

China’s applied import duties are slightly higher than those of the European Union and some other emerging economies such as Brazil and the Russian Federation (Figure 3.7). China’s applied tariff rates were 9.6% overall, averaging 15.2% for agricultural goods and 8.6% for non-agricultural goods. Import tariffs on capital goods, however, are lower, averaging 7.5%. Investment goods are major imports for China: machinery comprised 28% and transport equipment 6% of its total imports, respectively. Tariffs on imports of intermediate goods, very significant in determining China’s integration in global value chains, were comparable to the Russian Federation and the European Union, at 7.4%.

China's overall main trade policy objective is to accelerate its opening up to the outside world. This policy is enshrined in the Decision on Major Issues Concerning Comprehensively Deepening Reforms, adopted in November 2013, which calls for “the construction of a united and open market system with orderly competition that will play a decisive role in allocating resources” (WTO, 2014). One of the main objectives of the ongoing reform agenda, this policy is included in China’s five-year plan for 2016-2020. China’s strategy of trade opening has included negotiating preferential regional trade agreements.

Figure 3.7. Tariffs for industrial and agricultural goods, 2015*

Simple average MFN applied tariff rates



Notes: * or latest available year; MFN: Most favoured Nation.
Tariff rates for agricultural products include both ad valorem duties and specific duties in ad valorem equivalent, while tariff rates for non-agricultural products only include ad valorem duties.
Source: UNCTAD (2017), Trade Analysis Information System (TRAINS) for non-agricultural products and WTO (2017), World Tariff Profiles for agricultural products.

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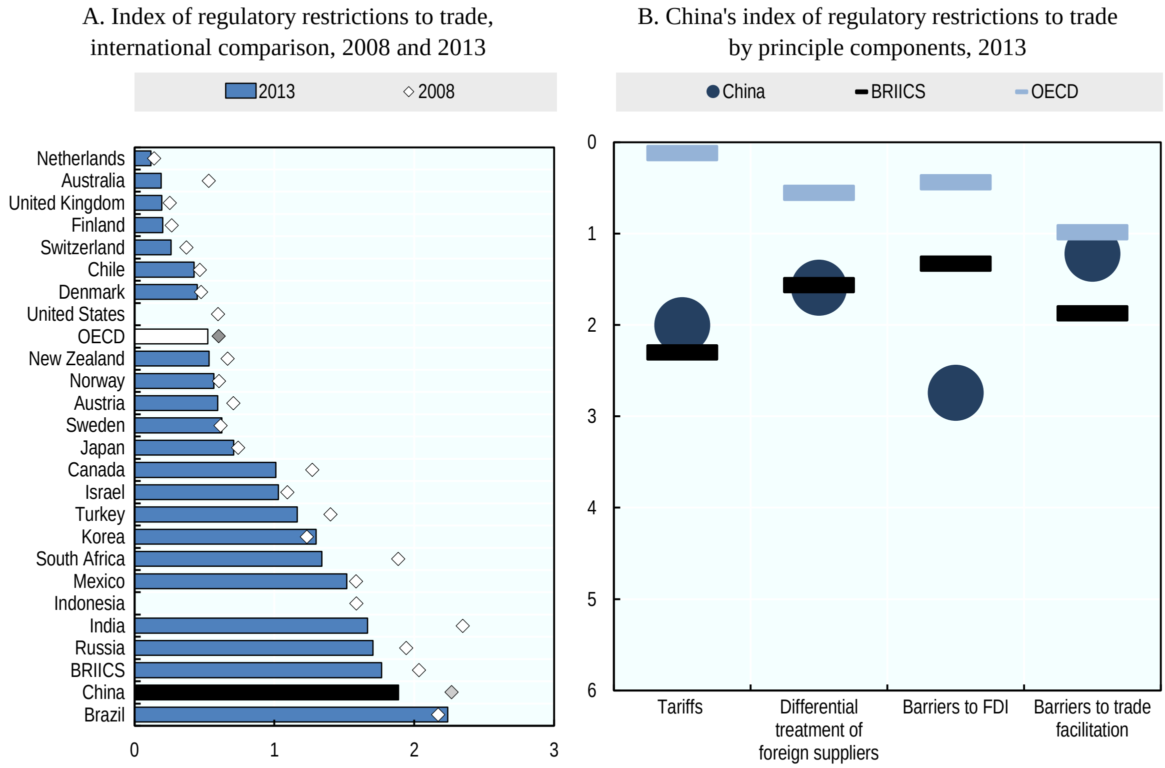
China has pursued a "going out" policy encouraging Chinese companies to invest and acquire market share abroad. China's state-owned enterprises (SOEs) have a prominent role in this process. The key objective cited for both the government's "going out" policy and by the firms themselves is the acquisition of natural resources (Kowalski et al., 2013). The role of SOE in exporting agro-food products is relative minor, and the SOEs attached to State Owned Farms such as Bright Foods and Beidahuang Group are actively engaging in overseas investment. The strategy of overseas investment in agriculture has shifted from acquiring agricultural land and production abroad to a broader scope of investment. Contrary to the situation in many OECD countries, Chinese SOEs are more successful at exporting than their private counterparts (Manova and Zhang, 2009). This export premium has been attributed to their large size and their easier access to credit. Increased support to Chinese firms exporting or investing abroad through finance and taxation, as well as through diplomatic, legal and information services is also provided.

China's integration into global supply chains over the past decades has brought many changes to its regulations on trade and investment. Today, its restrictiveness to trade and investment is of a similar magnitude to that of other BRIICS countries (Figure 3.8.A). One area China has made great strides since joining the WTO is in tariff levels, where it is now more open than many other BRIICS countries. It is at a similar level to other countries in terms of discriminatory regulation toward foreign suppliers. In terms of overall barriers to trade facilitation it ranks closer to many OECD countries (Figure 3.8.B). China has continued to strengthen its IPR enforcement system, both at the administrative and judicial levels. However, despite the efforts undertaken by the authorities to combat infringement, enforcement of IPRs continues to be a major challenge (WTO, 2016).

Figure 3.8. Index of regulatory restrictions to trade and investment

Scale from 0 (least) to 6 (most) restrictive



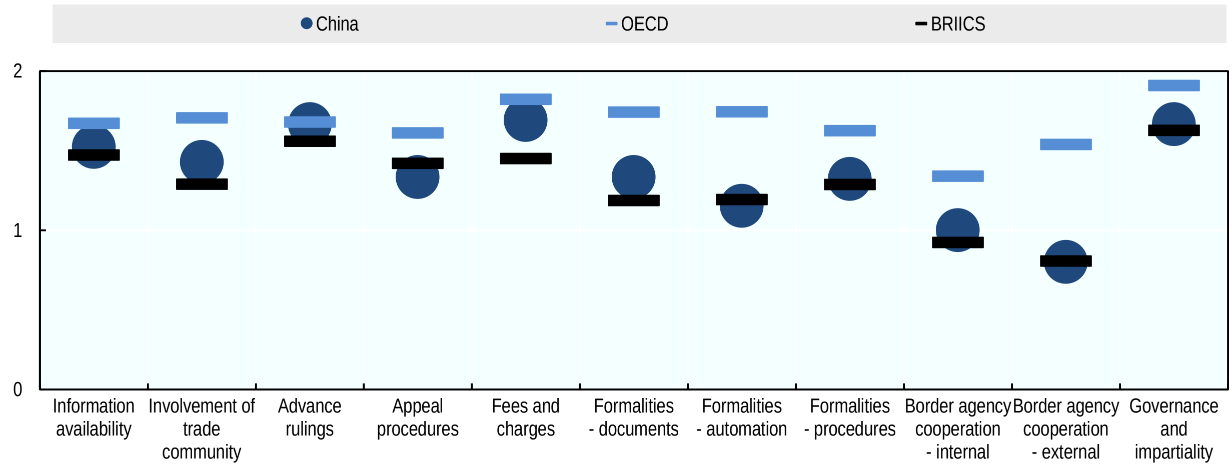
Notes: Indices for BRIICS and OECD are the simple average of member-country indices. The OECD aggregates do not include Latvia and Lithuania. For Indonesia and the United States, 2013 data are not available.
Tariff index is based on an average of effectively applied tariff, scaled within a range between 0 and 6 points, whereby a tariff below 3% is attributed zero points and a tariff above 19.6%, 6 points.
Barriers to trade facilitation refer to the extent to which the country uses internationally harmonised standards and certification procedures, and Mutual Recognition Agreements (MRAs) with at least one other country.
Source: OECD (2014), *Product Market Regulation Database*.

StatLink http://dx.doi.org/10.1787/888933829113

Trade and investment performance is determined by many factors, one of which is the ease of importing and exporting. Fast and efficient border procedures and port clearance reduce costs and costly delays, in turn benefiting business and final consumers. China ranks similarly overall to other BRIICS countries in terms of trade facilitation performance (Figure 3.9). In a few areas, however, there is room for improvement. In particular, China is found to rank quite poorly on automated border procedures as well as co-operation with neighbouring and third country border agencies.

Figure 3.9. Trade Facilitation Indicators: China's performance, 2017*

Scale from 0 to 2 (best performance)



Notes: * or latest available year.
Indices for BRIICS and OECD are the simple average of member-country indices. The OECD aggregates do not include Latvia and Lithuania.
Source: OECD (2017c), Trade Facilitation Indicators, http://www.oecd.org/trade/facilitation/indicators.htm.

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China is the world's second-largest recipient of foreign direct investment (FDI) after the United States. Foreign investment in China can take several forms, including joint ventures, wholly foreign-owned enterprises, participation in partnership enterprises, or mergers and acquisitions of Chinese domestic enterprises. FDI is destined in its vast majority to the eastern region of the country and is still largely concentrated in the manufacturing sector, although FDI in real estate and services has been growing in recent years. However, the share of FDI in overall gross capital formation declined to 2.7% in 2015, one-fifth of the share 20 years ago (OECD, 2017b).

FDI used to be concentrated on the manufacturing sector, but inflows into the service sector have increased more rapidly in recent years and it has become the dominant sector for the receipt of FDI. In 2006, the inflow of FDI to the service sector was half that of the manufacturing sector, but it increased to more than double that of the manufacturing sector in 2015. However, many service sectors remain off-limits to foreign investors, limiting the competition in those sectors (OECD, 2017b).

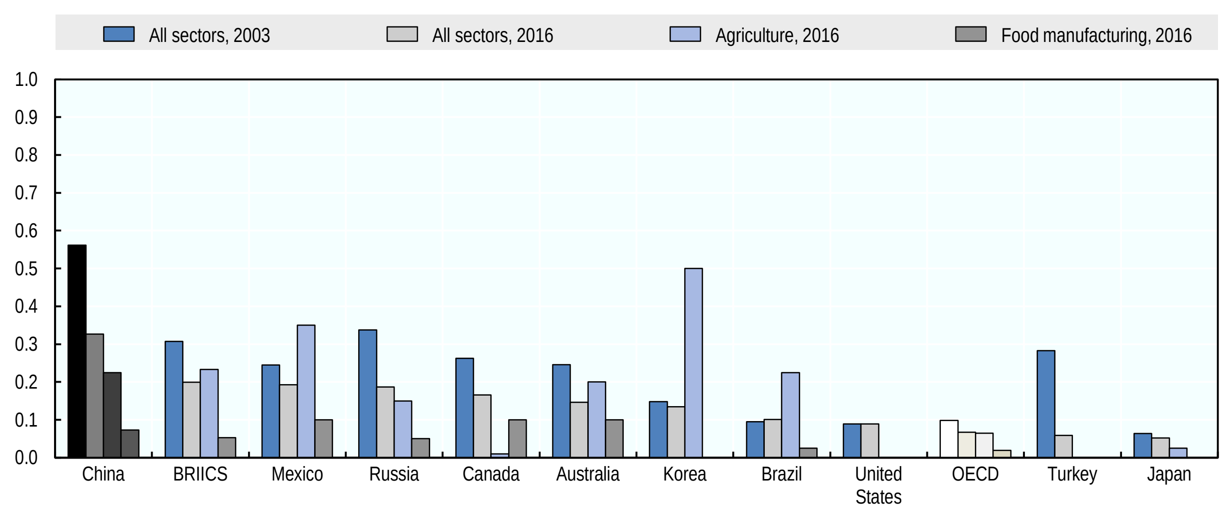
China's policy towards foreign investment has been to encourage direct inward FDI as well as joint ventures between Chinese and foreign companies, particularly with regard to R&D activities. Foreign enterprises that engage with domestic firms in R&D activities benefit from preferential enterprise income tax treatment. In some cases, they are encouraged to apply for government-sponsored R&D projects and innovation capacity-building projects. Eligible foreign-invested R&D centres have been exempted from customs duties, value-added tax, and consumption tax on imported inputs needed for R&D consumables since 2009. China also actively guides foreign investment in the regions, which have not traditionally been strong recipients of FDI.

China took measures aimed at simplifying the rules governing FDI and easing restrictions on use of capital for investment between 2012 and 2013. As a result, measures of its restrictiveness to FDI have fallen. In particular, China implemented simplified procedures and regulations for foreign currency registration and opening and use of accounts. The restrictions on reinvestment in yuan for foreign companies were abolished. Despite recent measures to reduce barriers to foreign investment, China remains more closed than the OECD average (Figure 3.10). The recent FDI reform in October 2016 to move from approval-based to a filling system will further bring the FDI regime closer to international levels of openness (OECD, 2017b). In part, this is due to the substantial state-owned and state-controlled sector, which does not often welcome foreign investment (although foreign investors are allowed to own shares in state-controlled enterprises in some sectors).

The Ministry of Commerce (MOFCOM) and NDRC issue a “Catalogue for the Guidance of Foreign Investment in Industries”, which lists the sectors where foreign investment is “encouraged”, “restricted”, and “prohibited”. According to the most recent catalogue released in 2015, the FDI in breeding of transgenic crops, livestock aquatic animals and production of transgenic seeds or seedlings is prohibited, together with R&D, breeding, planting and production of rare and unique varieties. The restriction means that foreign companies are not allowed to conduct transgenic breeding technology research in China. Non-transgenic plant breeding and seed production are in one of the “restricted” areas of FDI and require a joint venture with Chinese companies.

Figure 3.10. Foreign Direct Investment (FDI) Regulatory Restrictiveness Index by sector, 2003 and 2016

Scale from 0 (least) to 1 (most) restrictive



Note: The OECD aggregates do not include Lithuania.
Source: OECD (2017d), "OECD FDI Regulatory Restrictiveness Index", OECD FDI Statistics (database), http://www.oecd.org/investment/fdiindex.htm.

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3.4. Finance policy

A well-functioning financial system is critical to efficiently channel funds and finance to firms looking for innovation and growth. Innovation typically requires borrowing or other types of external funding, particularly by start-up businesses. A domestic financial system with sufficient provision of varied services to borrowers of different profiles facilitates the innovation process. As innovation usually requires long-term investment, a strong long-term finance segment is of critical importance. An adequate domestic financial system is important from the perspective of innovating small- and medium-sized enterprises (SMEs), as they are likely to depend more on self-financing.

China’s financial sector is dominated by large state-owned commercial banks (SOCBs), which account for more than 50% of commercial bank assets in China. While reforms of the SOCBs resulted in improved efficiency and health of the financial system, gaps remain in terms of financial access for SMEs. Lending, particularly by the largest banks, is still concentrated on SOEs, where carrying out the state’s development plans is the primary objective (OECD, 2013).

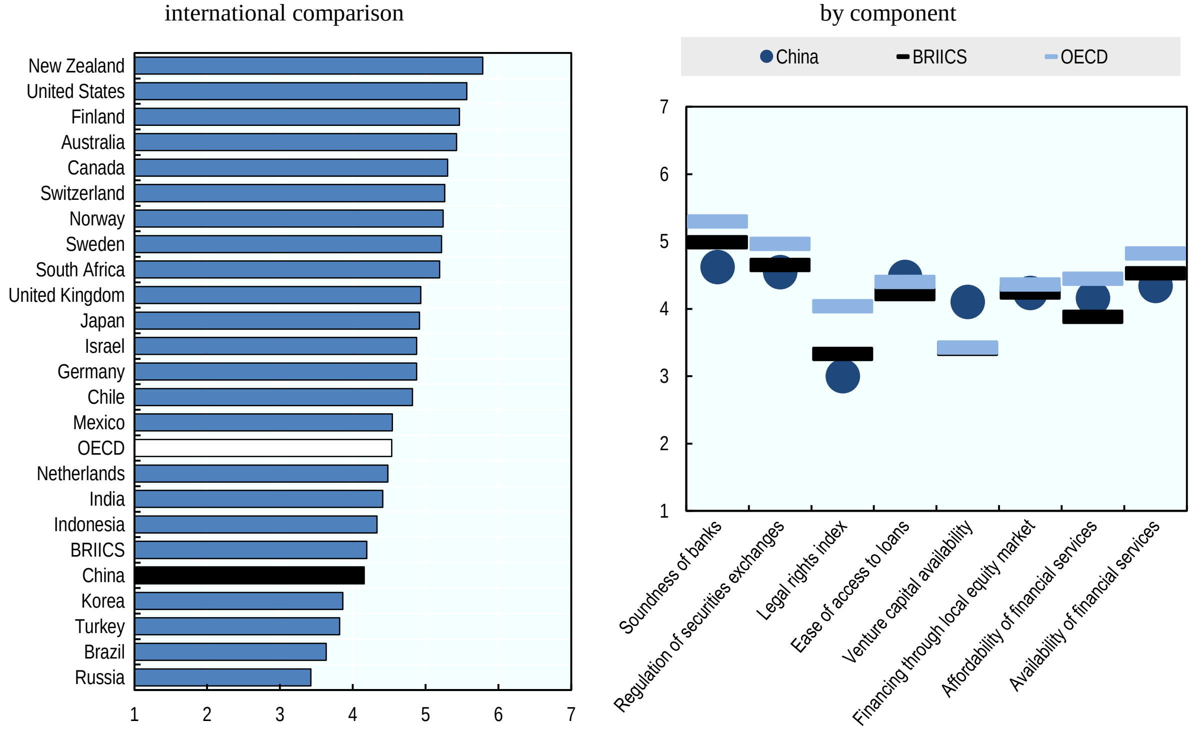
According to the Global Competitiveness Report, China’s index of financial market development ranks lower than the OECD and BRIICS averages (Figure 3.11A). Among seven components of the total index, ease of accessing loan and venture capital availability are above OECD and BRIICS averages. However, on the legal rights index and regulation of security exchanges components, China scored lower than OECD and BRIICS averages (Figure 3.11B).

Figure 3.11. Global Competitiveness Index: Index of financial market development, 2016-17

Scale 1 to7 (best)

A. Total index of financial market development, international comparison

B. China's index of financial market development by component



Note: Indices for BRIICS and OECD are the simple average of member-country indices. The OECD aggregates do not include Lithuania.

Source: World Economic Forum (2016), The Global Competitiveness Report 2016-2017 (Executive Opinion Survey), https://www.weforum.org/reports/the-global-competitiveness-report-2016-2017-1.

StatLink http://dx.doi.org/10.1787/888933829170

Access to financial services is a critical element to unleashing innovation. In China, rural financial institutions play a vital role in the agriculture sector, in addition to informal rural finance such as familial lending, and rotating saving and credit association in the local community. The government of China has made some efforts to strengthen the rural financial landscape. Since the early 2000s, institutional reforms and policies have aimed towards greater market orientation and increased access to formal financing for rural households and SMEs. The government has also taken steps to promote the development of the bond market by expanding coverage of corporate issuers to include all SMEs, adding an additional source of funding to small businesses. Rural financial institutions have improved their ability to support agriculture. Agriculture-related loans and loans to farmers are playing a dominant role in providing continued support to agriculture and rural development (IMF, 2015). The government also expanded the mandate of the Agricultural Development Bank to finance food industries and rural development projects.

At the same time, the government has gradually liberalised access of new financial institutions to rural financing such as village and township banks, micro-credit companies, farmer cooperatives, mutual financial cooperation. It also includes the establishment of county-level small and medium-sized banks and financial leasing companies. The government also broaden the scope of mortgage collateral to include rural land contract management rights, farmers' homestead use rights, farmers' housing and other assets to improve accessibility to credit for farmers.

In China, rural credit co-operatives (RCCs) have been the largest provider of small-scale rural credit. RCCs used to belong to the China Agricultural Bank until being separated from it in 1996, but remain under the control of local governments. To promote more competition in rural financial markets, the government promoted the entry of newly created financial institutions targeting rural households and SMEs, such as Village and Township Banks. However, these have been slow to penetrate the lending market and have not been able to meet the demand for very small-scale agriculture and household businesses (ADB, 2014a and 2014b). The rural financial market is still largely dominated by of RCC system, which includes Rural Commercial Banks and Rural Cooperative Banks (Box 3.2).

To improve financial access in rural area, the government is creating a policy incentive to increase rural credit. For example, interest income from small loans to farmers and premiums from agricultural insurance are exempted from financial institutions' sale taxes. Financial institutions are allowed to deduct certain loan loss reserves for agriculture-related loans from corporate income tax. New rural financial institutions also receive subsidies equivalent to 2% of loan balance.

The current credit environment and financial system available for the agriculture sector can be improved. For example, the availability of acceptable collateral for loans remains a challenge. Real estate is the most common form of collateral used for borrowing. However, in China the state or collective owns the land and the farmer only has contract rights. Prior to 2014, land contract rights and farmhouses, two major properties owned by farmers, could not be collateralised. In October 2014, the Minister of Agriculture announced a pilot programme that grants farmers the right to "possess, use, benefit from and transfer their land, as well as the right to use land contract rights as collateral or a guarantee". The results of the pilot programme prompted the government to expand the programme nationwide in 2015 (Yining, 2015).

Emerging farm operation units with more complex organisational structures have added demands that the current rural financial system cannot meet. New types of operation (e.g. large family farms, farmer professional co-operatives and agri-business enterprises) should be able to collateralise a wider variety of farm assets. Moreover, the government should enhance competition among financial institutions and facilitate the entry of new players.

Box 3.2. Development of rural financial institutions in China

Rural Credit Cooperatives (RCCs), Rural Commercial Banks (RCBs), and the Postal Savings Bank of China (PSBC) are the three main financial institutions in rural areas. RCCs are the largest provider of small-scale rural credit. Restructuring of the RCCs in the early 2000s resulted in many being converted into RCBs. RCBs are the fastest growing banking institution in rural China. Annual assets growth from 2010-14 was 44% while all other institutions grew only 16% annually (CRBC 2014 report). Further restructuring of China's financial system in 2007 created the Postal Savings Bank of China (PSBC). The PSBC has a mandate to "to develop commercially viable loan products for rural enterprises, migrant workers and farmers." In 2014, there were 39 000 PSBC office outlets, 70% of which were in county and village locations (ADB, 2014b).

Table 3.3. Rural financial institutions in China

	Number of banks 2014	Total assets at end-2014 (CNY billion)	Share of total banking assets (%)	
			2011	2014
Rural Credit Cooperatives (RCC)	1 596	8 831	6.4	5.1
Rural Commercial Banks (RCB)	665	11 527	3.8	6.7
Rural Cooperative Banks (RCoB)	89	957	1.2	0.6
Postal Savings Bank of China (PSBC)[1]	1	6 300	3.8	3.7
Village and Township Banks (VTB)[2]	1 153	520	0.3	0.3
Rural Mutual Cooperatives & Lending Companies	63	278	--	0.2
Micro-credit Companies (MCC)[3]	7 893	819*	--	0.5

Note: NGO Microfinance institutions numbered about 100 in 2012 (ADB, 2014a). *Loan portfolio.
1. 2014 assets from http://english.chinapost.com.cn/html1/report/161048/2953-1.htm.
2. Assets as of August 2013 (ADB, 2014b).
3. 2014 assets (ADB, 2014a).
Source: Adapted from Jinchang Lai 2012 presentation (Lai, 2012). CRBC annual report, unless otherwise stated.

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Despite more liberalisation of the financial sector in China, new entities have been slow to enter the market for lending to rural households and SMEs due to the higher risk and transaction costs of micro lending. Assessing credit risk requires gathering information which may be difficult to quantify and verify, requiring more personal contact and visits by a credit officer. Banking policies that prohibit VTBs and MCCs to operate beyond county boundaries constrain access for households and SMEs beyond their operational borders. Moreover, there may be private lenders wanting to lend to SMEs, but these small businesses cannot meet the collateral requirements of commercial banks (ADB, 2014a).

3.5. Tax policy

The principal link between tax policy and innovation is that taxation affects the returns to innovation and thus the decisions of firms and individuals to invest. Taxation also affects the relative price of production factors and therefore priority areas for innovation. Beyond that, taxation often acts as a targeted tool to stimulate innovation, e.g. through providing preferential treatment to private businesses that invest in R&D, preferential regimes for young innovative companies, VAT concessions on innovative products, etc. Furthermore, tax policy can steer innovation towards specific areas, for example, to address particular societal concerns and towards greener technologies and practices, or environmental R&D.

Tax policies can also work on the consumer side of innovation by creating incentives for households to purchase products with particular characteristics, for example, by providing consumer tax concessions on newly developed national products or environmentally friendly goods.

Enterprises operating in China are subject to several different types of taxes, including corporate income taxes and indirect taxes (including value added tax, business tax, and consumption tax), as well as mandatory contributions related to labour. The overall tax burden in China remains relatively low compared to OECD countries. The tax revenue to GDP ratio in China was 18.5% in 2015, which is lower than most of the OECD countries (WTO, 2016). However, the tax burden on enterprises is relatively high and the government is now in the process of tax reform shifting from business tax to value-added tax (Figure 3.12). The total tax an enterprise must pay in China in 2015 is among one of the highest in the world, at 68.5% of profit. Mandatory social security contributions account for the bulk of China's total tax rate on enterprises (48.8%).

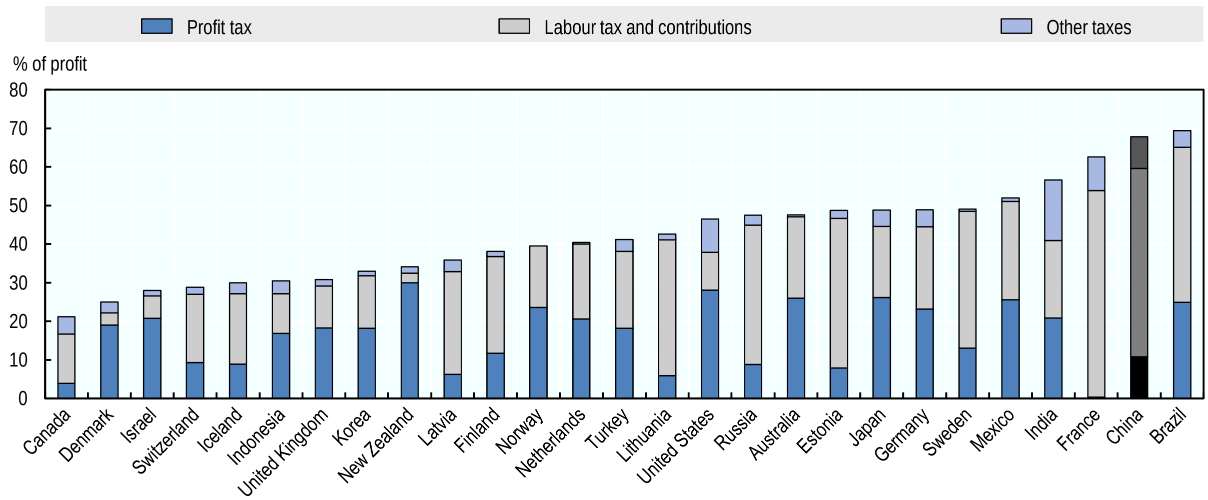
Despite its higher total tax rate on enterprises, China offers some reductions and tax rebates to provide incentives in certain priority areas. For example, corporate income tax is exempted on the profits earned from agricultural production and primary processing of agricultural products. China also provides an exemption from value-added tax on the sales of self-produced primary agricultural products. The sales of non-self-produced agricultural products are also subject to a reduced rate of value-added tax. Since 2009, agricultural machines in 14 major categories enjoy a low value-added tax rate of 13%. Additionally, income tax is exempted for income received from transferring agricultural machinery technology for entities with an annual net income below CNY 300 000 (USD 45 180). China was exempting value-added tax on the sales of fertiliser, but this exemption was removed in September 2015 as part of the effort to achieve the policy goal of zero growth of fertiliser consumption by 2020.

Until the early 2000s, farmers were subject to agricultural tax and levies imposed by the local governments. In 2000, China started a pilot reform of the rural tax system in Anhui Province to reduce the burden of farmers and regulate the tax system, and the reform was extended nationwide in 2003. The government phased out agricultural tax by 2006, removing all informal fees and formal agricultural tax.

In many OECD countries, the government offers tax incentives to encourage private enterprises to invest in R&D. China also offers tax incentives specifically to agriculture R&D activities. An additional 50% of R&D costs is deductible for corporate income tax and 150% amortisation of intangible assets. These provisions aim to promote private R&D and encourage collaboration between public R&D performers and private enterprises. Tax breaks are given to technology companies but also to any companies for expenditures on staff education or R&D. Corporate income tax can be reduced from 25% to 15% for qualified High-New-Technology Enterprises (HTNE) as well as Advanced Technology Service Enterprises (ATSE). ATSE businesses can also deduct education fees up to a certain amount. Agricultural machinery manufacturing enterprises receive a preferential treatment of 15% deduction of corporate income tax as HTNE.

Multiple incentives are also directed to the agribusiness sector. Under the Enterprise Income Tax Law (EITL), Foreign Invested Enterprises (FIEs) or domestic companies investing in forestry, animal husbandry and the fishing industry are exempted from corporate income tax. China also offers these companies a variety of value-added tax (VAT) exemptions and reductions.

Figure 3.12. Total tax rate on enterprises, 2015



Source: World Bank Group and PwC (2017), Paying Taxes 2017: The Global Picture, PwC, World Bank and IFC, http://www.doingbusiness.org/data.

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3.6. Summary

Although its GDP growth rate has slowed recently, China enjoys a favourable macroeconomic environment which ranks among the top of both OECD and emerging countries in terms of budget balance, gross national savings, inflation, government debt, and credit rating. However, the quality of governance is still lower than the OECD average, most notably in the area of property rights protection. Effective protection of property rights is key to attracting private investment, including in agriculture. The government should strengthen the enforcement of intellectual property rights by raising awareness of laws and increasing penalties for infringements to ensure adequate protection for domestic and foreign innovators.

Reforms have significantly reduced regulatory barriers to entrepreneurship, but there is still a large scope to reduce complexity and transaction costs related to compliance. Overall, China's regulations remain more complex and costly to comply with compared to OECD countries. China should continue its efforts to reduce administrative burdens and compliance costs for enterprises, and improve transparency and provision of public services.

With markets increasingly playing a primary role in resource allocation in China, the competitive environment should be improved further, including strengthening the institutional capacity to ensure effective enforcement of Anti-Monopoly Law. While the importance of State Owned Enterprises in China has gradually declined, some areas of the service sector (e.g. financial services) are still dominated by SOEs and oligopolistic companies. An earlier OECD study finds that SOEs are not very efficient producers and users of knowledge and have inefficient incentives to undertake risky investment in R&D (OECD, 2008). The government should continue opening up more sectors to private investment based on clear rules.

China has built a regulatory framework for environmental protection. For example, the Environment Protection Act recently introduced provisions for increased financial penalties for livestock breeders that mismanage waste. China also recently strengthened the regulation on pesticide use. However, regulations often control at the product level (e.g. maximum residue) rather than at the production process one. Regulatory measures as well as a monitoring system should be applied more at the farm level, clarifying the minimum (mandatory) levels of environmental quality with which farmers need to comply.

Effective enforcement of environmental regulations and increasing producer awareness remain a major challenge in China. Further monitoring and liability management will be necessary to make progress, but this is costly under China's small and fragmented agricultural structure. Compliance to environmental regulation can be enforced more effectively with complementary incentive measures. For example, making direct payments conditional on the recipient's compliance with environmental standards could increase the farmer's incentive to comply with environmental regulations; such a measure would also reduce the cost of monitoring environmental regulations at the farm level, given the domination of China's farm structure by small-scale producers. However, experience in OECD countries shows that such conditionality would not be effective unless it is adapted to the diversity of local farming practices and conditions.

China has been benefiting from opening up for trade, facilitating knowledge flows embedded in agro-food trade, and has lower trade barriers in both tariffs and trade facilitation compared to other BRIICS countries. The recent FDI reform to move from an approval-based to a filling system will bring the FDI regime closer to international levels of openness, but China still maintains barriers to FDI. For example, in the food and agriculture sector, foreign companies are not allowed to conduct research on transgenic crop breeding in China. Non-transgenic plant breeding and seed production is one of the "restricted" areas of FDI and requires foreign investors to establish a joint venture with Chinese companies.

Both the affordability and availability of financial services in China are limited compared to most OECD countries. Recent reforms allowing farmers to collateralise land use rights and gradually liberalising access of new financial institutions to rural financing increases the accessibility of finance by farmers, but diverse financial services should also be made accessible for farmers, in particular emerging types of large farms operated by land co-operatives and enterprises.

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Chapter 4. Capacity building and public services in China

Capacity building, including provision of essential public services, is one of the main channels or incentive areas to support innovation and sustainable development. This chapter concerns five relevant policy areas: infrastructure and rural development; land use planning and regulation; water; labour market and social security; and education and skills.

4.1. Infrastructure and rural development policies

Infrastructure investment has played a key role in the People's Republic of China's (hereafter "China") economic growth, and continues to do so. Infrastructure links different elements of the economic system and enables the movement of factors of production, goods and information across agents and markets. The availability and quality of infrastructure affect the decisions of firms and individuals to invest. As such, infrastructure is important in determining the location of an economic activity and the kinds of activities or sectors that can develop. For example, well-maintained transportation networks in rural areas connect agricultural products to markets, while information and communication technologies (ICTs) connect farmers and rural populations to information and knowledge networks. ICTs have a distinct role in enhancing innovation by speeding up the diffusion of information, facilitating networking, reducing geographic limitations and improving efficiency in communication.

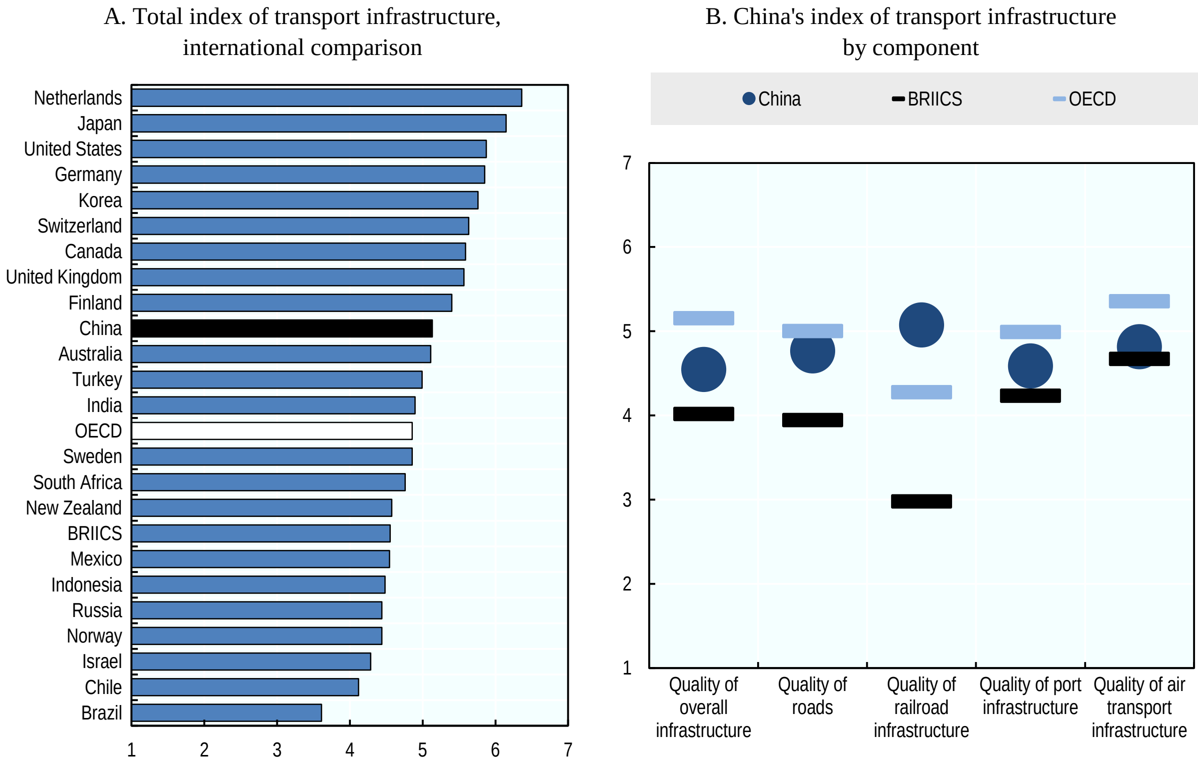
Within the central government of China, infrastructure policy and planning is provided by key agencies under the State Council, including the National Development and Reform Commission (NDRC), the Ministry of Finance (MOF), the People's Bank of China (PBC) and the sector-level ministries that implement projects. In 2000, the Central Government made infrastructure and social development in rural areas a priority, including through the improvement of roads, electricity utilities, drinking water utilities and biogas supply. In 2006, agricultural tax was abolished to reduce the burden on farmers, consequently reducing local government's possibilities to generate funds for rural infrastructure projects and maintenance (OECD, 2009). Meanwhile, fiscal transfer payments to local governments have increased. Overall, the total investment in agricultural infrastructure increased at an annual rate of 20% on average during the 11th and the 12th Five-Year Plan periods (2006-15).

China defines four broad areas of infrastructure investment to achieve the goal of constructing a "new rural area". The first is agricultural production infrastructure, including farmland improvement and irrigation. The second is rural life infrastructure investment, which includes ensuring water safety, rural roads and rural electricity. Access to basic infrastructure in rural areas has improved significantly over the last decades. The entire rural population had obtained access to electricity by 2012. The proportion of the rural population with access to improved water sources increased from 56% to 93% between 1990 and 2015 (World Bank, 2015). Similarly, access to improved sanitation facilities among the rural population increased from 41% to 64% between 1990 and 2015. Investment in ecological environment is the third area of rural infrastructure investment, which includes forest protection, construction of natural protection areas and other investments in protecting the natural environment. Finally, the fourth investment area is in rural social development infrastructure, which includes investment in rural education, health and cultural infrastructure.

China drastically improved its transport infrastructure, with almost all administrative villages gaining access to the public road system by the end of 2006 (OECD, 2009). The World Economic Forum's Global Competitiveness Index shows that China has developed an overall higher quality transport infrastructure than the OECD average (Figure 4.1). In particular, the quality of the railroad system in China is scored highly, while the quality of other transport infrastructure (roads, ports and airports) is more favourable than in other BRIICS countries but below the OECD average.

Figure 4.1. Global Competitiveness Index: Quality of transport infrastructure, 2016-17

Scale 1 to 7 (best)



Notes: Indices for BRIICS and OECD are the simple average of member-country indices. The OECD aggregates do not include Lithuania.
Source: World Economic Forum (2016), The Global Competitiveness Report 2016-2017: Full data Edition, www.weforum.org/reports/the-global-competitiveness-report-2016-2017-1.

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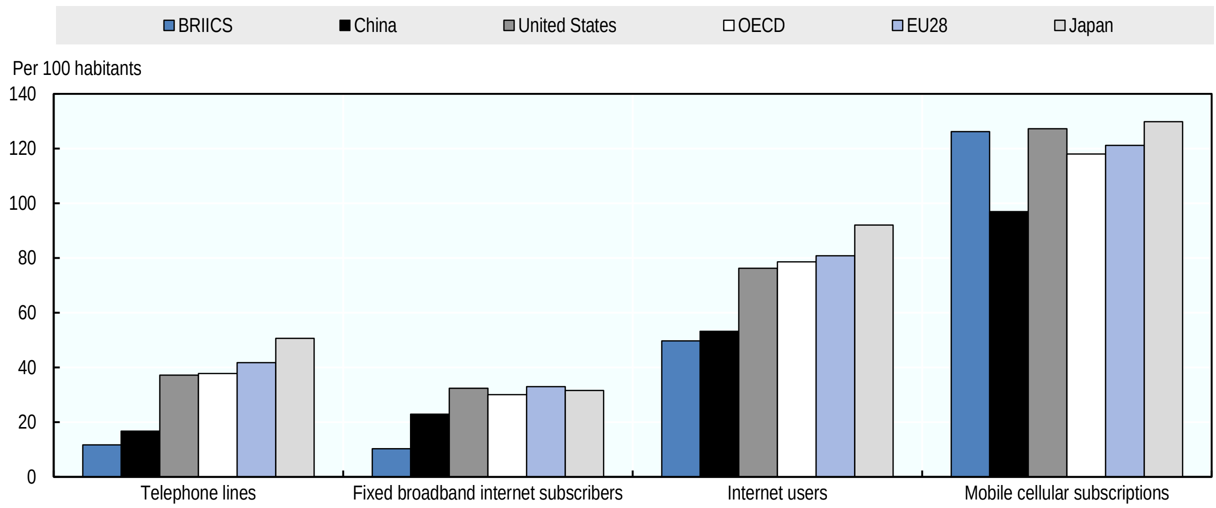
Whereas development and maintenance of remote networks of road and rail carry larger costs than in urban areas, telecommunications and Internet technologies offer connection at decreasing marginal costs. ICT use is essential in developing a knowledge-based economy, as it provides opportunities for better education and training for general skills that promote innovative thinking and facilitate knowledge transfer for farmers. China's 13th Five-Year Plan also aims to integrate agriculture and ICT to improve agricultural productivity. The government is encouraging ICT companies to establish a service platform to connect producers and consumers to accelerate the development of agriculture-related e-commerce. An international comparison shows that China has higher ICT penetration than BRIICS countries except for mobile cellular subscriptions, but lower penetration than the OECD average (Figure 4.2).

Figure 4.2. ICT penetration, 2016



Note: The OECD aggregates do not include Lithuania.
Source: World Bank (2017), World Development Indicators (database), http://data.worldbank.org/indicator.

StatLink http://dx.doi.org/10.1787/888933829227

China has developed a range of specific policies to promote greater adoption of ICT and development of the ICT industry. The State Informatization Development Strategy (2006-2020) includes long-term objectives to establish, promote and expand wider use of ICT across sectors and at the household level. Access to ICT infrastructure varies in China: while three fifths of urban Chinese use the Internet, a 2012 household survey revealed that less than a quarter of the rural population has access to it (Minges et al., 2014), though government investment in ICT readiness in rural regions has accelerated in recent years (Wan et al., 2008). To reduce the urban-rural digital divide, the government has set high-speed Internet connectivity as a strategic public infrastructure programme through its 2013 Broadband China Strategy. The strategy aims to equip 98% of villages with Internet access and provide high-speed connections by 2020 for all rural households.

According to the rural household survey of 2012, almost all villages had electricity and received a mobile signal, but only 20% of the households had a personal computer or accessed the Internet. Few rural public Internet facilities, notably village libraries, offer training on Internet use, and farmers lack knowledge on how to access resources, training and networks on farming online (Minges et al., 2014). The penetration rate of the Internet increased to 33% as of December 2016, which is still below the rate among the urban population (69%) (CNNIC, 2016). The National Agricultural Modernization Plan (2016-20) aims to increase the share of Internet use among the rural population to 52% by 2020.

The National Plan for Education Informatization (2011-20) also aims to equip all rural schools with Internet access. Most teachers even in the rural setting receive information technology training formally through MOE or informally. Students are exposed to information technology but there are limited computers available in rural schools (Minges et al., 2014). In rural communities, one-to-one computing for children would expand the reach to families, providing access and informal training to farming families.

Despite growing investment in rural areas, overall rural infrastructure still lags that of urban areas. Farms benefit significantly from basic infrastructure investment in roads, electricity, water and telecommunication networks as well as knowledge transfer and learning through ICT. Efforts to enhance the penetration of ICT in rural areas should continue, including the use of ICT in agricultural production and marketing.

4.2. Land policies

Protection of land use rights

In China, the rural reform in 1978 initiated the household responsibility system, which allocated land contract rights to households and gave farmers freedom in agricultural operations. This institutional reform stimulated households to improve productivity and profitability. Under the current household responsibility system, land-use rights include property, contract and operation rights. Land property rights belong to village collectives and the sale of land ownership is prohibited (Kung, 2000; Yao, 2000). The village collectively owns land and retains rights to contract, adjust, supervise and take back contracted land to ensure an effective use of collective land.

Securing land use rights is fundamental to the encouragement of investment and the sustainable use of farmland. China has implemented a number of institutional reforms to secure land use rights, which protect farmers' right to use, transfer, pledge land and return contract land (Box 4.1). In 1984, the central government ordered local governments to grant more than 15 years of contract rights. However, most of the villages continued to reallocate land frequently (Brandt et al., 2002). Local leaders reallocated land mainly to maintain egalitarianism rather than to achieve efficient land allocation (Deng et al., 2006). In 1998, the revision of the 1986 Land Management Law granted all farmers 30-year written contract rights and limited administrative land reallocation by village leaders to exceptional occasions. The Rural Land Contract Law in 2002 further strengthened farmer's contract rights by guaranteeing 30 years of security and the freedom of transaction of land operation rights as well as providing dispute settlement rules on land rental contracts.

China is also strengthening the security of contract rights by registering the owners of those rights and issuing certificates to promote investment and sustainable use of land as well as to facilitate transaction of operational rights of land. Pilot work to determine, register and certify contracted rural land-use rights have proceeded across the entire area of 12 provinces and 2 160 counties. As of June 2015, 350 million mu (23.3 million hectares) of land have been measured and the rights to 260 million mu (17.3 million hectares) of land have been verified. The 2016 No. 1 Document targeted the completion of registration and certification of all contracted land by 2020.

Box 4.1. China's Land Administration Law

The Land Administration Law, which entered into force on 1 January 1999, is China's main land use regulation. The Land Law states that land collectively owned by farmers belongs to a village. The collectively owned land is registered by county governments, who issue certificate of the ownership. The use rights of other agricultural land such as grassland and woodland are defined in other laws such as the Forest Law, Grassland Law, and Fisheries Law. Article 14 stipulates that land owned by farmers' collective economic organisations (villages) is to be contracted to members of the organisations for purposes of farming, forestry, animal husbandry and fishery activities for 30 years.

Other government documents including the No. 1 Documents regarding agricultural and rural affairs propose concrete measures to implement the Land Law. For example, the No. 1 Document of 2013 emphasised the importance of promoting transfers of land operational rights, particularly to specialised large farms, family farms, and farmers' co-operatives. The No. 1 Document of 2014 clarified that farmers are allowed to collateralise the land contract rights as a tool to finance investments in farming. The 2015 No. 1 Document put emphasis on the strict implementation of the clarification, registration, and certification of land rental contracts to facilitate the smooth transaction of land operation rights.

The Land Administration Law also protects productive cultivated land and controls non-agricultural use of cultivated land. When cultivated land is converted to other purposes, the same area of cultivated land has to be reclaimed to compensate for the loss. "Basic agricultural land" is defined as particularly protected areas of land; this includes arable land within the production base of grains, cotton and oil seeds, arable land with good water conservancy and water and soil conservation facilities, land within the vegetable production base, and agricultural experimental and education land. This basic agricultural land has to make up more than 80% of total cultivated land at the provincial level.

In addition to maintaining the area of basic agricultural land, the Land Administration Law also protects the productivity and environmental quality of land. It mandates governments to preserve irrigation and drainage facilities, improve soil quality and fertility, prevent desertification, salinisation, soil erosion and land pollution. The conversion of unutilised land is allowed under the overall land use plan, subject to scientific assessment. The Law also prohibits the conversion of forest, grassland, and lakes to cultivated land, but allows cultivated land to return to forest, grassland and lakes. These elements of the Law provide the legal bases for the "returning land to forest" (Grain for Green project) and "returning land to grassland" projects. Regulations on land conversion to construction land include protection of the holder of land contract rights. For instance, the Law sets out the compensation principle, including subsidies for relocation, as well as compensation for properties and crops.

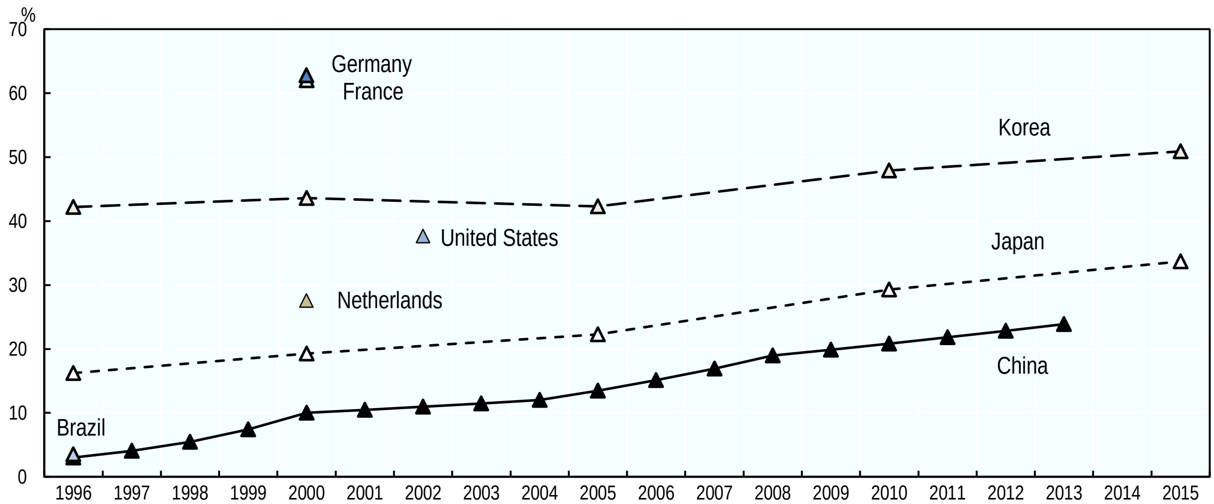
Promoting land consolidation

In pursuing improved farm-level productivity, the introduction of the household responsibility system generated small scale family farms and led to land fragmentation and dispersion. This farm structure has been a major constraint to further improving productivity and competitiveness, particularly in land-intensive agriculture. China took a number of steps to promote more efficient allocation of land resources, while strengthening the security of land contract rights. A reform to separate operational rights from contract rights stimulated land rental. The 2002 Rural Land Contract Law specifically defined the scope of transferability of land and mandated the transfer of land operational rights based on a written contract.

These institutional reforms in land regulation helped to accelerate the transfer of land operational rights (land rental) from the late 2000s, and by the end of 2015, the operational rights of 443 million mu (29.5 million hectares) had been transferred. The share of land whose operational land was transferred increased quickly, from 12.4% to 33.3% between 2009 and 2015 (Han Changfu, 2015). However, the share of rented land in China is still lower than in many OECD countries, where typically more than half of farmland is rented, e.g. Korea, France and Germany (Figure 4.3). While the transfer of land operational rights among relatives and friends within the same village was dominant in China, land transfer to new types of farm operators has been increasing in recent years (Huang, Gao and Rozelle, 2012). For example, of rented-out land in 2013, about 20% was transferred to the Farmer Professional Co-operatives, more than 9% to firms or companies, and the rest to individual households (MOA, 2014).[1]

Figure 4.3. Proportion of rented farmland, 1996 to 2015

Share of total cultivated land rented



Notes: The figure shows that the share of rented cultivated farmland in China increased from 3% in 1996 to around 24% in 2013. Estimates from the World Census of Agriculture highlight that China's share of rented farmland by 2013 remained below point estimates for many developed economies taken around 2000. These included France (taken in 2000), Germany (2000), the United States (2002) and the Netherlands (2000).
Source: FAO (2013), 2000 World Census of Agriculture: Analysis and International Comparison of the Results (1996-2005), FAO Statistic Development Series; Gao, L., J. Huang and S. Rozelle (2012), "Rental markets for cultivated land agricultural investments in China", Agricultural Economics 43(4), pp. 391-403.; State Council of the People's Republic of China.

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Given the dominance of small-scale farms, transaction costs associated with farm size expansion through the transfer of land operational rights is likely to be high, particularly for a large operation. To facilitate the transaction of land operational rights, the local government recently set up land transfer service centres (LTSC) or platforms. Most of these LTSCs were established at township level and, in some cases, larger networking platforms pooling rental information across townships have been set up at county level. Major mandates of these LTSCs are: 1) conducting land rental market surveys and collecting information on who is willing to transfer the operational rights of their land; 2) facilitating land operational rights transfer by providing clients with information on location, area, major characteristics of land plot, and suggested rental prices for each plot of land; 3) preparing and recording formal land transfer contracts; and 4) being responsible for land transfer contract dispute mediation. By 2014, more than 13 000 towns in around 800 counties had established the LTSCs (China Development Press, 2015).

Besides formalising the transfer of land operational rights, China is encouraging various ways of consolidating farm management to explore more effective forms of land operation. One innovative organisational development in response to the agricultural structure dominated by small-scale family farms is the growing consolidation of farm operation to farmers' co-operatives and corporate farms through the transfer of land operational rights or farm machine service contracts. Diverse formats of farm consolidation into these new farm management units have developed in China. For example, land equity and land trusts have emerged, whereby individual farmers can lease farmland or machinery to co-operatives in return for shares in their large-scale farm operations.

These formats of farm consolidation are likely to be a more efficient way to facilitate structural change towards a desirable agricultural production structure than conventional land rental transactions between family farms. This organisational experience of China provides an important lesson for countries dominated by small-scale producers in how organisational innovation can facilitate structural change and allow farmers to integrate with food supply chains.

Conservation of farmland

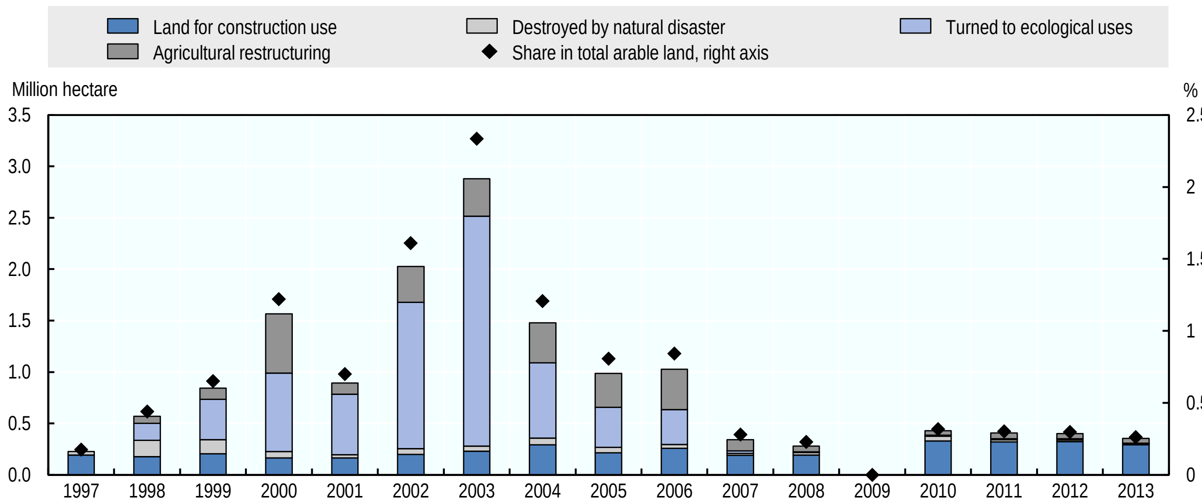
Land is a scarce resource in China and the country's rapid economic growth has increased competition between agricultural and other land use. Arable land area declined an average of 500 000 hectares per year between 1997 and 2013; in the early 2000s, the area of converted arable land exceeded 1% of the total area, but the majority of this was converted to ecological use such as forests and grasslands (Figure 4.4). However, Kong (2014) finds that around 3 million hectares of high-quality arable land and 1 million hectares of paddy land were converted to urban use in just over a decade, and more than 3 million hectares of farmland suffered from environmental degradation. It is often the case that arable land plots favourable for agricultural production are also suitable for construction use because of their good road access, and the flat and square shape of the plot.

China places the preservation of high-quality arable land high on its policy agenda. It has also set a "red line" for the protection of certain areas of farmland (permanent basic farmland) as a result of national food security concerns. The Outline of the National Overall Planning on Land Use (2006-2020) aims to preserve 1.805 billion mu (120 million hectares) of arable land, including 1.546 billion mu (104 million hectares) of basic agricultural land. It also limits the conversion of arable land to construction land to 45 million mu (3 million hectares) in total by 2020. The Outline also includes the target of preserving ecological land. Alongside the protection of arable land, "basic ecological land" is strictly protected to ensure that cultivated land, orchards, forests, pastureland, water areas, and certain unutilised land that have ecological functions have to exceed 75% of the total national land area. The Outline strengthens the ecological function of land, including maintenance of the retirement of certain cultivated land, the ecological rehabilitation and reclamation of wasteland from mining activities, and the prevention and treatment of degraded land.

Given the scarcity of land in China and the higher return on industrial or residential use of land, the conversion of agricultural land to non-agricultural use is inevitable. The conversion of land use may contribute to the diversification of economic activity in rural areas. The land use policy should prioritise the conservation of high-quality farmland and concentrates agricultural investment to such area. They should also guide the conversion of farmland to other purposes based on a clear land use plan at the local level.

The geographical distribution of agricultural production has been rationalised over the past three decades, reflecting the production conditions of different regions. For example, rice production has been concentrating in northern China, mainly in Northeast China. The 2017 No. 1 Document proposed to establish functional zones for production of rice, wheat and corn, and production protection zones for soybean, cotton, rapeseed, sugar cane, and rubber, which concentrate infrastructure investment and subsidy programmes. In April 2017, the State Council issued a guideline establishing these functional and protection zones.

Figure 4.4. Area of arable land converted to other use in China, 1997 to 2013



Source: MLR (2015).

StatLink http://dx.doi.org/10.1787/888933829265

Farmland improvement

In addition to the institutional reform of land markets, China recently started to emphasise the promotion of construction of high-standard farmland. The 2016 No. 1 Document urged the government to speed up the investment in farmland improvement so that China develops 800 million mu (53 million hectares) of concentrated and contiguous, drought proofed, consistently high-yield, eco-friendly farmland by 2020. The government prioritised investment in the main grain producing regions. The construction of high-standard farmland will be one of the assessment criteria for the performance of local governments.

The high-standard farmland thus achieved will be maintained as permanent basic farmland. The public investment in farmland is expected to improve productivity and environmental performance of crop farms by improving the efficiency of farm machine use, mitigating the weather risk for production and reducing water use.

4.3. Water policy

China faces multiple water challenges, including an uneven distribution of resources, large water consumption from agriculture and increased water demand from other sectors, and growing water quality issues (Jiang, 2009, see Annex 4.A). These concerns are expected to last: water shortages are projected to increase, particularly in the North China Plain, adding to the tensions of projected large increases in water demand (2030 Water Resources Group, 2009; Fang et al., 2010; Hijoka, et al., 2014).

Sustainable productivity growth in agriculture requires a sufficient and stable quantity of usable freshwater for crops and livestock, and minimised impacts of agriculture activities on water resources. Irrigation is particularly critical to agriculture productivity in China (Khan, Hunjra and Mu, 2009); for example, crop productivity directly relies on irrigation in the North China Plain (Wang et al., 2001). Fulfilling these conditions depends on the effectiveness and direction of i) quantitative water resource management policies; ii) water quality oversight; iii) water risk mitigation policies; and iv) the financing and management of infrastructures supporting these functions.

This section reviews current and planned water policies in these areas, drawing on examples from key agricultural regions. The analysis draws on recent policies (listed in Annex 4.B) and available publications.

China's water governance

As in many other large countries, multiple institutions manage water resources in China, at different levels, separating responsibility both horizontally and vertically through the combination of regional management and watershed management (Box 4.2). But the existing fragmentation is affecting the effective management of water due to a lack of co-ordination and co-operation across agencies (Jiang, 2009). For instance, in the case of drinking water, the lack of a co-ordination mechanism associated with unclearly defined responsibilities creates gaps and overlaps in management (Liu, 2006).

Furthermore, river basin agencies are often superseded by regional political authorities, impeding the objective of integrated water resource management (Jiang, 2009). The unclear delineation of authorities among administrative levels creates transaction costs and inefficiencies. The fragmentation of authorities also leads to ineffective application of management objectives, with water use exceeding quotas in some regions (ibid.). Moreover, different objectives across regional and national authorities have contributed to the mismanagement of water pollution (Moore, 2013).[2] In some cases, diverging regional priorities has generated inter-jurisdictional conflicts (ibid.).

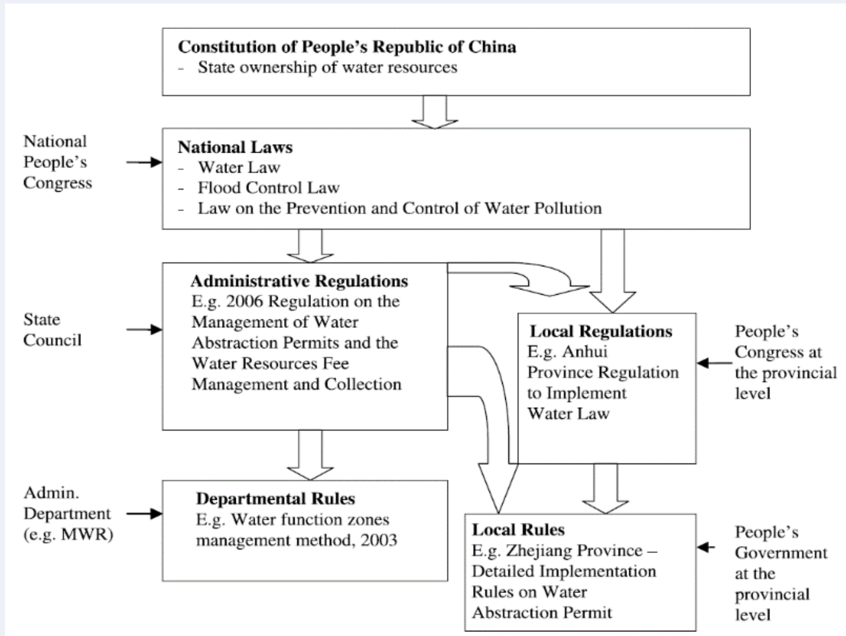
For these reasons, the governance of water in China appears to be below the standards defined by the OECD Principles on Water Governance (OECD, 2015c, Annex 4.C). This is particularly the case when considering the lack of co-ordination, unclear allocation of responsibility, and lack of stakeholder participation (Gleick, 2009). Still, efforts at the regional level have been conducted to cope with some of these issues and to increase co-ordination, information and stakeholder participation, for instance, in the Hai river basin (Wijnen et al, 2012).

Box 4.2. Legal framework and governance of water in China

China's water management relies primarily on three key pieces of legislation: the 1988 Water Law (revised in 2002, 2009 and 2016), which frames water rights and allocation systems; the 1997 Flood Control Law, which focuses on floods; and the Law on the Prevention and Control of Water Pollution of 1984 (amended in 1996 and 2008), which focuses on water quality. These laws were used in the development of regulations and rules for departments and provinces (Figure 4.5).

Water governance is covered by multiple administrative departments under the oversight of the State Council. The major administrative body responsible for water management is the Ministry of Water Resources (MWR). Two layers of lower-level management co-exist under the MWR. First, the Provincial Water Resources Departments, which oversee multiple levels of Water Resource Bureaus or, increasingly, integrated "Water Affairs Bureaus" (or "water authorities"). These local bureaus' responsibility can cover water resources management, but also water supply, urban water savings, flood control and management, and wastewater treatment. In practice, these Bureaus often respond more to provincial authorities than to the MWR. Second, the seven National River Basin Commissions are charged with implementing the MWR activities along river basins.

Figure 4.5. China's legal framework on water



Multiple functions are devolved to other ministries: the Ministry of Environmental Protection (MEP) enforces environmental laws; the Ministry of Agriculture (MoA) focus on agriculture conservation through resources including engineering facilities, agricultural technologies, machinery and biotechnology to develop water-saving agriculture; the Ministry of Land and Resources (MLR) oversees groundwater resource management; and the NDRC administers pricing of water. In the case of drinking water, the MWR, MEP and MoA share responsibilities with the Ministry of Housing and Urban-Rural Development (urban water supply), the Land Department (groundwater quality), and the National Health and Family Planning Commission (water quality monitoring).

Source: Liu, B., and R. Speed (2009), "Water Resources Management in the People's Republic of China", *International Journal of Water Resources Development*, Vol.25, No. 2, pp.193-208; Liu, B. (2006), "China's Agricultural Water Policy Reforms", in *Water and Agriculture: Sustainability, Markets and Policies*, OECD Publishing, Paris; Lohmar, B. et al. (2003), "China's Agricultural Water Policy Reforms: Increasing Investment, Resolving Conflicts, and Revising Incentives", *Agriculture Information Bulletin* No. (AIB-782), Economic Research Service, United States Department of Agriculture.

Sustaining sufficient water resources

Several policy alternatives have been pursued to cope with the growing water quantity challenges associated largely with growing use and uneven distribution of resources. Significant investments have first been made on supply-side engineering approaches, with the goal of relieving the constraints (Jiang, 2009; Barnett et al., 2015). More than 87 000 reservoirs have been built to store a capacity of over 7 000 km^3 of runoffs and precipitation in the last 65 years (Xiao-jun et al., 2012). A number of large dams have increased hydropower capacity but were often accompanied by significant social and environmental problems (Box 4.3). Large water transfers have progressively moved water from agriculture to municipal and industrial sector use, at the risk of social tensions and conflicts (Gleick, 2009). The latest development has been the South to North Water Diversion (SNWD) project, shifting up to 9.5 billion m^3/year from the upper reaches of the Yangtze River to the Yellow River, to help lessen droughts and water shortages in parts of

North China. Despite its immense scale, reports suggest that this project will not be sufficient to cope with the expected increased demand (Barnett et al., 2015).

Box 4.3. Major infrastructure investment in the Three Gorges Dam and the South to North Water Diversion

The Three Gorges Dam is the largest but also most controversial dam in China. Built in 12 years and finished in 2005, it sits on the Yangtze River in Hubei Province and has a capacity of 39.3 million m^3. The dam regulates flow downstream (reducing Shanghai's flooding), provides 22.4 GW of hydropower and facilitates trade on the river. However, its building was accompanied by significant problems: it required the resettling of over 1 million people and was associated with water quality and broader environmental damage. Concerns remain regarding sedimentation of the dam, its stability in an active seismic zone and periodic salinisation of the Yangtze River.

The South to North Water Diversion (SNWD) is the largest inter-basin transfer scheme of the world. It is expected to have the capacity to extract up to 9.5 billion m3 per year from the Yangtze River basin in the south to the drier north China, feeding megacities and provinces. The Central and Eastern routes, each transferring water over 1 000 km, started to operate in 2014; the project includes a possible Western route, shorter but requiring the drilling of hundreds of kilometres of tunnels in hard rocks. Construction of the SNWD has cost about USD 80 billion, resulted in the displacement of 300 000 people due to rising water, and created new water quality and environmental challenges. Originally seen as an important instrument to relieve the water shortages in north China, the transfer is now seen as providing "temporary" relief to overall water stress, particularly when considering the North China Plain Aquifer depletion.

Source: Barnett et al. (2015), "Transfer project cannot meet China's water needs", *Nature*, Vol. 527, pp. 295-297; Jiao, L. (2010), "Water Shortages Loom as Northern China's Aquifers Are Sucked Dry", *Science*, Vol. 328, pp. 1462-1463; Tan et al. (2015), "Towards a water and energy secure China: Tough choices ahead in power expansion with limited water resources", China Water Risk.

The government progressively increased its emphasis on water demand management. Water rights systems were introduced in the 1988 Water Law, and then strengthened in 2002 (Liu and Speed, 2009; OECD, 2015d). Water is publicly owned by the state and allocated via both basin and regional multi-annual plans. Priority is given to urban users over agriculture and industry (Lohmar et al., 2003). Water users have to use a permit (right) to abstract water for a specified fee set at the regional level. The framework also allows for the trading of water rights, but it was primarily used by the government to support transfer initiatives. Water pricing measures have been initiated and applied particularly in cities. The 2002 Water Law aimed for charges at cost recovery levels (Lohmar et al., 2003). Water efficiency measures were also introduced in the 2002 Water Law. Public campaigns were launched to raise public awareness of the need to conserve freshwater (Zheng et al., 2010). Regarding groundwater, the 2002 Water Law allocated all groundwater property rights to the state and forbade unsustainable groundwater use (Wang et al., 2009). This was accompanied by policy measures to regulate drilling of wells, well spacing and adding a fee for groundwater collection (Shen, 2015). In 2005, groundwater zoning was also introduced for allocation and planning purposes (Shen, 2015).

While China made progress in increasing water use conservation, leading to minimal increase in demand compared to GDP growth, unsolved challenges remain, including gaps in policy and insufficient implementation, particularly in rural areas. The Yellow River achieved partial success in its comprehensive allocation of water, but the water rights system remained unclearly defined, incomplete, unmonitored, and partially enforced (Jiang, 2009; Liu and Speed, 2009). For instance, abstractions in the largest irrigation districts were not monitored. Pricing was incompletely applied, and limited if at all applied for agriculture (Liu, 2006; Khan, Hunjra and Mu, 2009). A large number of provinces implemented water efficiency measures and quantitative restrictions, but not fully in rural areas (Liu and Speed, 2009; Blanke et al., 2007). Groundwater laws were not effectively implemented; instead, local farmers and rural institutions actively responded to shortages (Wang et al., 2007).

The latest policies, initiated by Document No 1 of 2011 and most recently reiterated by Document No 1 of 2017, emphasise a higher control on water use, its more effective allocation and increased water efficiency. The water conservation objective centres on the "red line for controlling total water use", which caps total water use to 670 billion m^3 in 2020 and 700 billion m^3 in 2030. The plan is meant to be applied at the provincial level, with sub-totals for cities and counties. The system relies first on the introduction of water quotas for water users from river basin level to irrigation districts and village levels. It is supported by withdrawal permission and water fee collections for all water users. Second, socio-economic planning and project construction is required to adapt to local water resource conditions, with limits for regions close to their water caps. Third, groundwater resource management has been strengthened. Provinces have to determine the status of groundwater resources. Exploitation should be gradually reduced in regions with groundwater overdraft, and quasi-forbidden for deep confined aquifers.

The government also introduced measures to improve water resource allocation. They include an integrated water allocation set at the river basin level, superseding other allocation plans. A continued effort is directed towards the water supply side, involving both improved transfer and the promotion of reuse of treated wastewater and desalination. Based on the water quota system, the government also aims to introduce water rights institutions to encourage water markets and transactions across sectors, regions, and/or specific users.[3]

These initiatives are complemented by efforts on water efficiency improvements under the "red line for water use efficiency", with a set of goals for 2020. In particular, water use per GDP should decline by 23% between 2015 and 2020, while irrigation efficiency should reach 55% by 2020 for a total irrigated area exceeding 1 billion mu (66 million ha). These targets are supported by investments in upgrading irrigational infrastructure in large districts, and a stricter control of new constructions in regions suffering from water shortages. Water saving facility should be included in new investment projects. In 2015, the central government invested in pilot projects for controlling over-exploitation of surface water and groundwater. Where efficient water-saving irrigation was adopted based on local conditions, the planting area of crops with high water consumption was reduced and groundwater wells were filled so as to improve agricultural and aquatic environments. Lastly, a stronger water pricing policy is being introduced, gradually increasing water prices for urban and industrial water uses.

Agriculture water price is also subject to a comprehensive reform. In particular, in January 2016, the State Council announced that China will establish a new agricultural water price mechanism within ten years. The policy is aimed at adjusting agricultural water prices to cover the cost of operation and maintenance. According to the proposed system, water prices would increase when water use exceeds a certain level and would also reflect seasonal differences in water use (OECD, 2017a).

Preserving water quality: water sanitation and pollution control policies

The government's main policy responses to the degradation of water quality have included setting regional objectives, approving standards, and strengthening the monitoring and enforcement of regulations. Under the 2002 Water Law, water quality protection is applied by zones, classified by MWR basin commissions and local departments (Liu and Speed, 2009). Each zone is defined by the specific intended functions of the water body. Discharge caps are set in each zone, and permits can be acquired depending on this cap and other regulations. The 2008 Water Pollution Prevention and Control Law strengthened monitoring and enforcement, setting up regional supervision centres and water quality bureaus under the Water Basin Commissions (Moore, 2013).

There has been measurable but insufficient progress in water quality since the 2002 Water Law. Water pollution remained very serious in multiple areas (OECD, 2007), and sewage treatment rates have increased dramatically, but insufficiently to avoid having large amounts of untreated wastewater dumped in the environment (Jiang, 2009). Toxic discharge from industry were reduced by 60-70% from 1998 to 2006 (Liu and Speed, 2009), but continued to be too high in many locations. Municipal waste discharges were decoupled from economic growth but remained high (OECD, 2007).

More recent policies emphasised even stronger monitoring and control on water quality sources. They first introduced the "red line to strictly control the total discharge of sewage into rivers and lakes", with goals on increasing the share of total water of good quality (class III or higher) in major river basins (higher than 70% by 2020, and 75% by 2030) and the proportion of high quality drinking water in cities (above 93% in 2020 and 95% in 2030), but also reducing the share of water areas with low quality (under class V) to below 15% by 2020. These goals are supported by the reinforcement of early warning and monitoring systems on water quality at the regional level, and special treatment plans to control discharge from ten key polluting industries (including paper, printing and dyeing and agriculture). For agriculture, the government's 2020 Zero-Growth Action Plan for Chemical Fertilizers and Pesticides introduced targets and means to reduce pollution. The government also introduced pollution discharge fees, above set minimal levels, for industries on selected key pollutants including ammonia, nitrogen, heavy metals, nitrogen oxide and sulphur dioxides.

Special attention has also been devoted to the improvement of groundwater quality. First, the government launched a comprehensive survey of groundwater pollution (completed in 2015) and a national monitoring and management system devoted specifically to groundwater. It has also established a risk prevention mechanism for groundwater used for drinking purposes. This includes strict monitoring and control of groundwater pollution from key industries and urban uses. In agriculture, efforts have been made to encourage farmers to reduce fertiliser and pesticide use, and to promote organic agriculture. Groundwater remediation actions have also been planned.

Protection of water resources is the responsibility of the MWR and MEP. In collaboration with the NDRC, the MOA and the Ministry of Industry and Information Technology (MIIT), the MWR and MEP developed a Water Pollution Prevention and Control Action Plan in 2015. In this plan, various references and measures have been made to water pollution deriving from agricultural activities.

First, to reduce pollution from intensive livestock and poultry farming, strict zoning regulations are in place to keep certain areas free from these activities; existing large scale operations and specialised farm households are to be closed or reallocated. This measure is to be first implemented by the end of 2017 in the Beijing-Hebei-Tianjin area, the Yangtze River Delta, and the Pearl River Delta. Permitted large-scale operations must build complementary manure and waste-water storage, processing, and reutilisation facilities, whereas areas with intensive backyard livestock and poultry activities need to implement a system of individual manure and waste-water collection and of collective treatment and reutilisation. From 2016, newly built, expanded, and remodelled large-scale livestock and poultry farms must implement separate treatments of rain and waste water, and provide processing and utilisation of manure and waste water. These requirements are to be coordinated by the MOA with participation from the MEP.

Second, concrete measures are initiated to control agricultural non-point pollution from the use of fertilisers and pesticides. Aside from government programmes for supporting the use of low-toxicity pesticides and the application of formula fertilisation by soil testing, environmental requirements are also imposed on the construction of high-standard farmland and on land consolidation and exploitation. In particular, in sensitive areas and large- and medium-scale irrigation areas, existing ditches and ponds are to be utilised for growing water biomes and for installing permeable dams and other installations, for purposes of purifying farmland drainage and surface runoff. These measures are to be implemented by the MOA, with participations from NDRC, MLR, MEP, MWR, and others.

Third, adjustments are to be made to the nationwide structure and spatial distribution of the crop sectors. In water-shortage regions, pilot projects are to be implemented on retirement of land for reduction of water use. In areas where ground water is susceptible to pollution, priority should be given to the cultivation of crops requiring less fertiliser and pesticide. In areas where surface water and underground water has already been over-drafted and where agricultural water withdrawal is high, such as Gansu, Xinjiang, Hebei, Shandong, and Henan, appropriate adjustments are to be made on reducing the cultivated areas of crops that are intensive in water use. By the end of 2018, it is planned that comprehensive adjustments are to be made on 33 million mu (2.2 million hectare) of irrigated farmland to achieve water saving amounting to more than 3.7 billion cubic meters. These projects are to be led by the MOA and MWR, with participations from the NDRC and MLR.

Other measures relevant for the agriculture sectors in the Water Pollution Prevention and Control Action Plan are: the development of water-saving technology and constructing of water-conservancy infrastructure to meet the target of having 700 million mu of farm land covered by water-saving irrigation technology; the implementation of comprehensive reforms of the agricultural water pricing schemes; and the inclusion of agriculture pollutants in the national survey and monitoring system of pollutants, especially via the inclusion of nitrogen and phosphorus in the binding targets of total pollutant discharges.

China issued *Administrative Measures for the Collection and Use of Compensation Fees for Water and Soil Conservation* in 2014, clearly stipulating the requirements for the collection, payment into the treasury, use and administration of compensation fees for soil and water conservation, and considering compensation for water and soil conservation. In May 2014, China implemented the trial charging standard for water and soil conservation.

Managing climate-related water risks

Several policies have been introduced to address water risks. A target was set for 2020 to improve flood control and drought resistance capacity, which includes improvement of river reaches and reservoirs. In parallel, the government strengthened the monitoring and early-warning information systems. It also reinforced the emergency management system for water risks that clarifies responsibilities across departments to ensure co-ordinated action. Emergency rescue teams were established and charged with efforts to set up emergency plans and to improve flood control and drought relief services in counties and townships.

Other actions have been undertaken gradually to respond to drought, combining water reservoir and demand management (Xiao-jun et al., 2012). Most recently, the government has encouraged the construction of a limited number of approved drought-resistant water projects, specifically designed to store and release water in case of emergencies. The government has also explored the use of artificial rainfall, notably by using climate engineering solutions to trigger precipitation.

In the case of flood management, policies have shifted from engineering supply-side approaches to more institutional management resolutions (Liu and Speed, 2009). Very large efforts have been made by governmental authorities to ensure better information, preparation and mitigation infrastructure, but damage remains high in large flooding events (ibid.).

Sustaining finances for management and infrastructures for water conservation

The government has pushed to increase investment in water conservation. Under the 2011 No. 1 Policy Document, “efforts should be made [by the government and other stakeholders] to increase investment in water conservation so that the annual average investment of the whole society on water conservation in the next 10 years is two times as much as the level in 2010”. In particular, the government supports a central water conservation construction fund (CNY 4 billion - USD 600 million - in recent years) to support projects, maintain or repair water infrastructure and fund emergency flood activities.

At the local level, the fund can be allocated to a wider range of programmes, covering improvement of river breaches and reservoirs, erosion and flood control, and emergency flood control. An additional special subsidy fund is dedicated to the operation and maintenance of water conservation projects in central and western China (amounting to CNY 1 billion - USD 150 million - in 2011). In addition, the State Development Bank, Agricultural Bank, Rural Credit Cooperatives, Postal Saving Bank and other financial institutions are encouraged to further increase the provision of bank loans to rural water conservancy projects.

Water policy and the future agriculture productivity growth

The above overview shows that the government of China has increased its efforts, investments and policies to address the multiple major water challenges it faces. Recent policies, prompted especially by Document No. 1 of 2011 (the first to focus specifically on water security instead of agriculture) has led to ambitious plans to increase water conservation, water use efficiency and quality improvements. In particular, groundwater investments have been bolstered and are increasingly becoming a priority for action.

Given the scope and complexity of China’s water challenges, prioritising future policy efforts to agriculture production regions identified as facing the most water risks – using a water risk “hotspot approach” – could help accelerate progress at a lower cost (OECD, 2017b). This may involve upscaling and continuing to support successful pilot programmes, and extending those in high risk regions.

Examples from the past have shown that implementation remains the key challenge for water management improvements. The co-ordination of action across the multiple agencies and implementation levels will need to be closely monitored to see if progress can effectively be achieved. In particular, the proposal to strengthen agriculture water prices should be carried out progressively.

Whether agriculture can achieve sustainable productivity growth will critically depend on the ability of water policies to fulfil the set goals effectively; however, both the agriculture sector and the policies to which it directly responds also have a key role to play in increasing efficiency, reducing pollution, and adapting to water risks.

4.4. Labour market and social security policy

Labour market policy influences employment composition and can play an important role in facilitating structural adjustment. Flexibility in labour mobility and social security help provide the conditions for innovation and skills training. It also facilitates the transition of labour from agriculture to other sectors and retirement of aged farmers from the sector. Labour regulations affect the cost and conditions of employing labour, and thus production choice by firms and their incentives to invest in new products and processes. Innovative enterprises engaged in changing technologies, processes, or business organisations are likely to be particularly sensitive to adequate conditions for hiring and dismissing people, complemented by a good unemployment insurance system and support for job placement, skills training and continuous learning. Labour market policies play an important role not only for the general economy, but for bringing innovation into the agricultural sector through improved opportunities for rural employment overall.

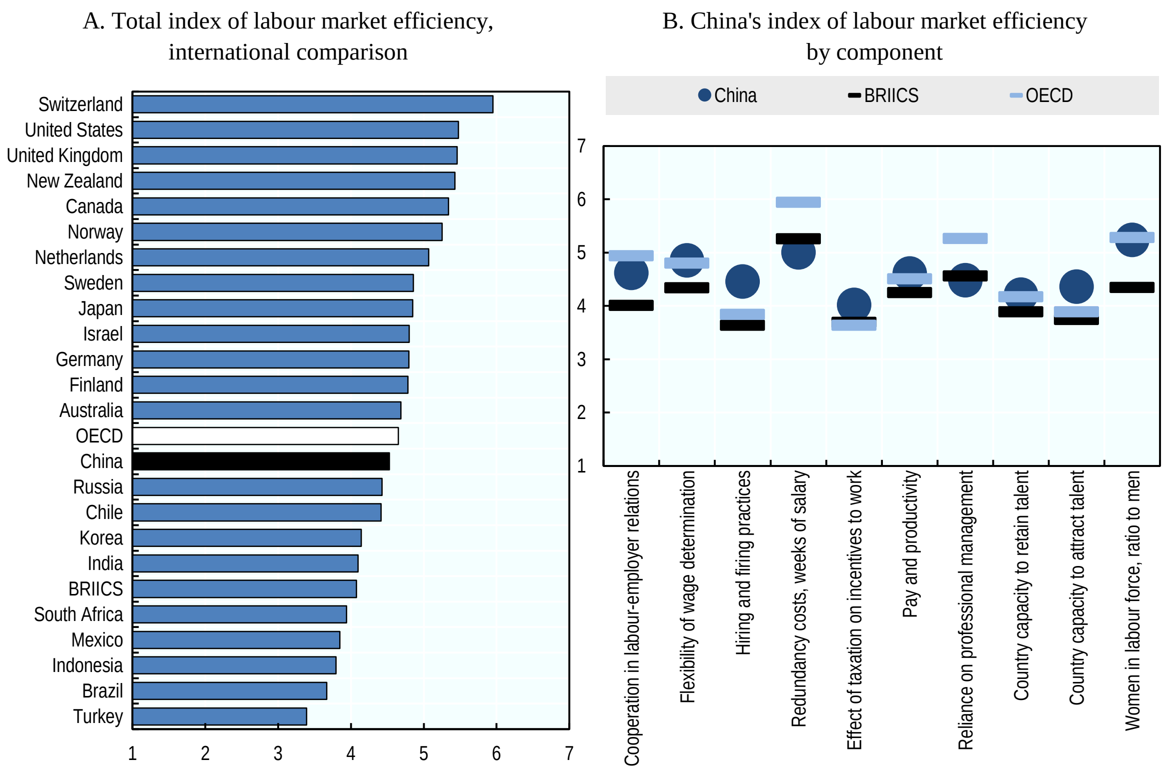
General features of the labour market

The 2008 labour laws provide the legal basis to regulate labour contract and working conditions, and provide a framework for dispute settlement, employment services, unemployment insurance and training programmes. While the labour laws are particularly strict in the procedure to change working conditions or terminate indefinite employment contracts, the regulation on fixed-term contracts are more liberal compared to other countries (Herd, Koen and Reutersward, 2010).

The World Economic Forum’s Global Competitive Index ranks China slightly below the OECD average in overall labour market efficiency (Figure 4.6). The database ranks China particularly high in flexibility of wage determination, the hiring and firing process, pay and productivity, and female participation.

Figure 4.6. Global Competitiveness Index: Labour market efficiency, 2016-17

Scale 1 to 7 (best)



Note: Indices for BRIICS and OECD are the simple average of member-country indices. The OECD aggregates do not include Lithuania.

Source: World Economic Forum (2016), *The Global Competitiveness Report 2016-2017: Full data Edition*, www.weforum.org/reports/the-global-competitiveness-report-2016-2017-1.

StatLink http://dx.doi.org/10.1787/888933829284

Facilitating rural to urban migration

China's economic growth can be largely attributed to the massive movement of migrant workers from rural to urban areas (Taylor and Martin, 2001). In 2014, more than 168.2 million migrant workers lived and worked in China's cities (NBSC, 2015). Outmigration improves productivity in both agriculture and non-agricultural sectors through more efficient allocation of labour (De Haan, 2000). China's Household Registration (*hukou*) System differentiates rural and urban registration, and this is linked to different social services. Rural residents are entitled to the allocation of farmland from villages, but do not qualify to receive most urban public services, including education and health care, when they reside in China's cities (Chan and Zhang, 1999). The *hukou* system has been a barrier to integrating rural and urban labour markets.

China has taken steps to improve the *hukou* system and social security system for rural residents (Table 4.1). A New Rural Cooperative Medical Scheme (NCMS) in 2002 extended coverage to the majority of the rural population, leading to a significant improvement in the quality of health care (Blumenthal and Hsiao, 2005). However, children and the elderly with rural *hukou* who had migrated to suburban or urban areas were hardly covered by the urban health care system, which was targeted to residents with urban *hukou*. In 2016, China implemented a reform combining the NCMS with the Urban Resident Basic Medical Insurance without the constraints of rural registration. This was an important achievement in equalising the social security system for urban and rural residents and in facilitating the integration of rural and urban labour markets.

Table 4.1. Evolution of China's hukou system

1956-1957	Started restricting the migration of the farmers with rural *hukou* to cities.
1958	Differentiated the urban and rural *hukou* registration system, abandoning the freedom of migration under 1954 Constitution.
1984	Allowed the farmers to settle in township
1985	Set quota for converting the rural to urban *hukou* as 0.02% every year. Started the resident ID card system. Rural residents are allowed to migrate to urban cities for non-farm employment.
2002	Started the reform of *hukou* system. For example, Promoting the migrants to relocate in the cities; In rural area, government started the trials of the New Cooperative Medical System (NCMS) and up to 2008 NCMS covers all of the rural areas; Started to reform on the education of migrants' children in urban or suburban area.
2006	Started free compulsory education for nine years in rural area.
2009	Started the trials of the new rural social pension insurance system, covering all rural residents by 2012.
2014	Single national registration system (*jumin hukou*) was established for both urban and rural residents.
2015	Unified basic standard of old age pension for urban and rural residents.
2016	Integration of New Rural Cooperative Medical Scheme with Urban Resident Basic Medical Insurance.

In the absence of a public pension system, the elderly in rural areas typically work until they are unable to do so. Pang, de Brauw and Rozelle (2004) reported that only a very small percentage of healthy individuals over the age 60 stop working. Almost all people in the 50-60 age group, and over two-thirds of those between 60 and 70 years old are working. The analysis from a nationwide random survey of 2 000 households in 100 villages located in five provinces showed that until 2011, roughly two-thirds of the cohort over 60 years old still worked on or off the farm. The share for those between 60 and 70 years old was even higher – as much as three quarters.

Developing a pension system for farmers could facilitate the retirement of elderly farmers and assist young farmers to enter the sector. The pension system can be linked to agricultural policies. For example, in Switzerland eligibility for the direct payment system terminates as farmer reaches the pension age. Japan used to have a farmers' pension system that paid an extra premium when aged farmers transferred farm assets to a full-time successor, to promote early retirement of elderly farmers.

China has recently started to develop a pension system for rural residents. In 2009, the government issued "Guidance regarding the development of the new rural social pension insurance pilot", and gradually extended its coverage to all rural areas by 2012. The new rural social pension system combines individual contributions and government subsidies. The basic standard was set at CNY 55 (USD 8) per month for people over 60 years old, but allowed local government to change the payment rate. This system aligns with land entitlement, social assistance and other social security policies in its aim to guarantee a basic quality of life for elderly rural residents. In 2015, China announced unified standards of the basic pension, whereby both urban and rural residents over 60 years old can get at least CNY 70 (USD 11.15) per month. Central government covers the full cost of the subsidy for central and western regions, while supporting half of the budget in eastern regions. Although the benefit from this pension is relatively small, it is likely to assist the retirement of elderly farmers.

4.5. Education and skills policy

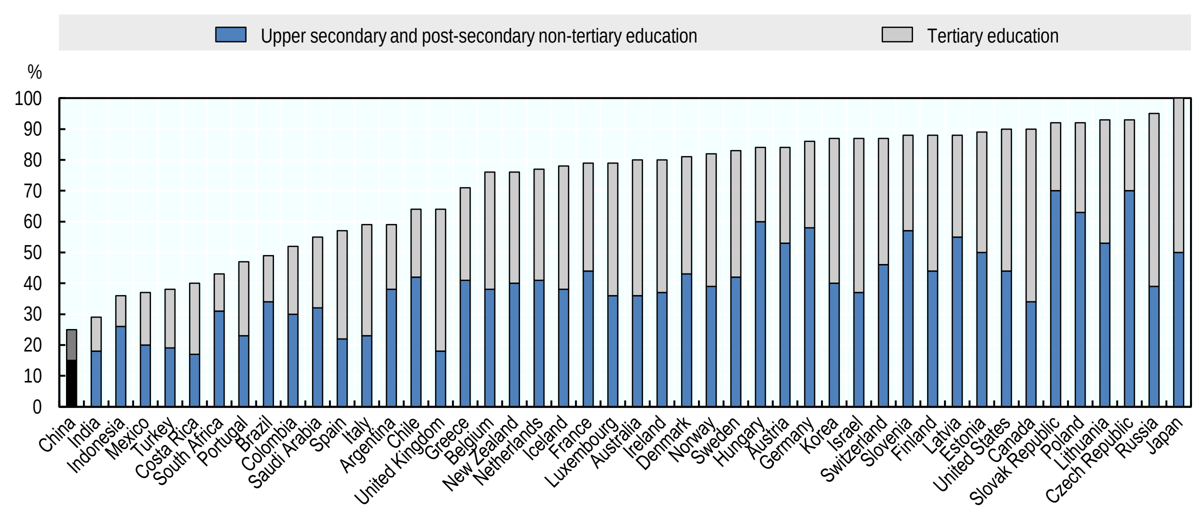
Education policy has strong and diverse links to innovation. A high level of general and scientific education across the population facilitates acceptance of innovations by society in general. Effective innovation systems require well-educated researchers, teachers, extension officers and business owners. Producers with a good general, technical and business education will generally be more willing and better skilled in fostering and adopting innovations. Ensuring the equity of access to quality education is a key factor to improve the skill level of human capital in rural areas, including in agriculture.

Overall education status

China has made considerable progress in improving the educational attainment of the population. Currently, most of the working age population has completed lower- and upper-secondary education. However, the proportion of the adult population who completed tertiary level education in China remains 10%, which is significantly lower than OECD counties (Figure 4.7). International surveys of business leaders evaluating the overall quality of higher education and training for market competitiveness also ranked China below the OECD average both in terms of quantity and quality of higher education and training (World Economic Forum, 2015). Increasing the level of attainment of higher education and training in a broader skill set would be particularly impactful in building the capacity needed to adapt and innovate in the agricultural sector.

Figure 4.7. Education attainment, 2016

Percentage of the population aged 25-64 years old



Note: Data for Brazil, Chile, Indonesia, Ireland, Russian Federation and South Africa refer to year 2015, for Argentina and Saudi Arabia to 2014, for India to 2011 and for China to 2010.
Source: OECD (2017c), Education at a Glance 2017: OECD Indicators, http://dx.doi.org/10.1787/edu-data-en.

StatLink http://dx.doi.org/10.1787/888933829303

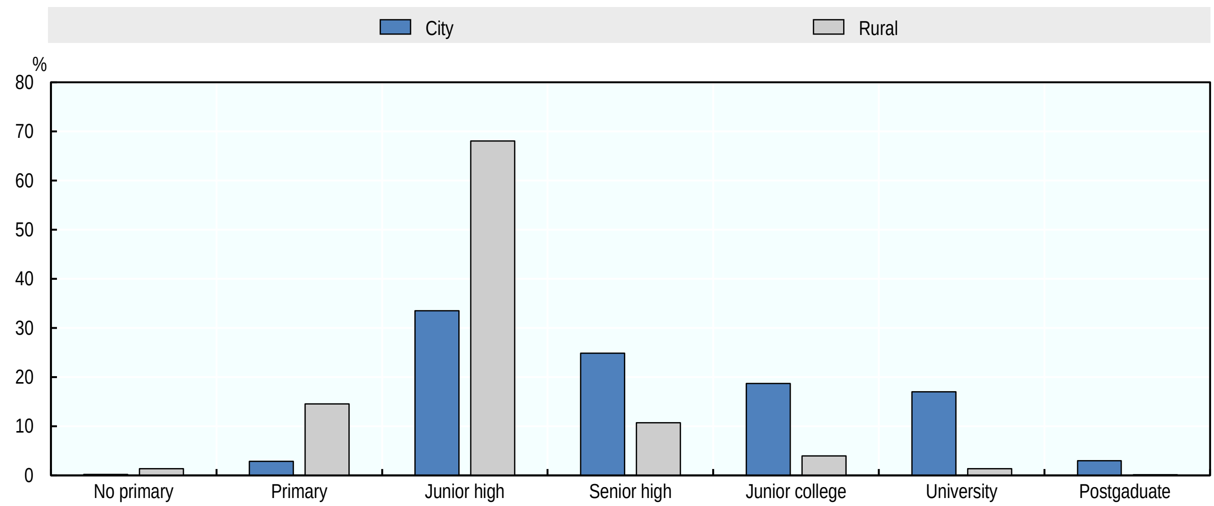
Improving the rural and urban disparity in education

The urban-rural divide in the household registration (*hukou*) system also plays a large role in educational opportunities. Rural students have lower access to higher education

(Figure 4.8). This is partly because lower quality in education in rural area reduces chances to succeed in entrance exams for higher education. The educational regulations still require university admission examinations to be taken in the locality of the student's registration and to follow the local syllabus (Herd, Koen and Reutersward, 2010).

Figure 4.8. Disparity of education attainment between urban and rural youth in China

Proportion of 25 to 29-year-olds with a given maximum level of education in 2010



Source: OECD (2015a), "All on Board: Making Inclusive Growth Happen". Tabulations of the 2010 Chinese Census.

StatLink http://dx.doi.org/10.1787/888933829322

With more than 168.2 million migrant workers living and working in China's cities as of 2014, the children of migrant workers are particularly vulnerable in terms of access to quality education. Migrants' children are often not allowed to enrol in urban schools for primary and secondary education or they have to pay an admission fee (so called "*zan zhu fei*") which is often unaffordable (Liu et al., 2011). Even though private schools can accept the children of migrant workers, the tuition is found to be high; moreover, these schools are often equipped with poor facilities and staff are under-qualified (Chen and Feng, 2013). Some teachers lack a teaching certificate, while some of the schools are not certified by the government and run the risk of being shut down. Access to high-school education is even more limited for children of migrants. In China, high-school education is not free, and the cost of tuition is known to be one of the most expensive in the world (Liu et al., 2011). Moreover, to attend high-school it is necessary to take an entrance examination, and this must be taken in the locality of registration rather than the locality of residence.

Without access to public education in urban areas, migrants often leave their children at home to attend the local rural public school. The children in this situation are called left-behind children (LBCs). According to the All China Women's Federation's report based on the 2010 Population Census (ACWF, 2013), there are more than 61.02 million LBCs aged 17 years or under in China. These left-behind children accounted for 21.9% of all children and 37.7% of rural children.

The negative impact of migration on the quantity and quality of the human capital of migrants' children could constrain China's sustainable economic growth in the future. Liang and Chen (2007) indicate that temporary parental migration into the cities or the suburban areas in Guangdong province can significantly increase the dropout rate of children. Based on survey data in western provinces, Zhao et al. (2014) also implies that even though migration has short-term financial benefits to a family it has a significantly negative impact on the human capital accumulation of the children in the long run.

China has established a course of reforms which includes targets for enrolment, expansion of compulsory education, improving the quality of the education system, and reducing regional disparities in education (OECD, 2015b)[4] Since 2000, the Central Government has implemented policies to improve the access to education in rural areas such as reducing fees for compulsory education, distributing free textbooks and providing stipends for poor families (Chen, 2010). The government encourages young teachers to teach in rural and poor regions through financing their salaries for an initial three years. The government also provides free vocational education for rural students and all students pursuing agriculture-related subjects (OECD, 2015b). However, urban areas still receive greater allocations of per-pupil spending than rural areas (MOE, 2012).

Recent policy documents emphasise the importance of human resource development. In particular, the No. 1 Document of 2016 recognised that five-year basic training is necessary for the managers of new professional farms, and urged that the development of new professional farmers become part of the national education and training development plan. Secondary-level agricultural vocational education is expected to receive national funding, and the government encourages farmers to participate in vocational education on a part-time basis.

Overall, China has made significant progress in educational attainment. However, the enrolment rate in higher education is lower and the capacity and skills for innovation is considered lower than in most OECD countries. Moreover, reducing the rural-urban disparity in access to a quality education service is crucial to ensuring sustainable productivity growth in agriculture. For example, the government could ensure access to pre-education for all students and provide free education for all subjects. Monitoring and evaluation of skills across the country would improve the evidence base for education reforms, particularly in improving equity in access and quality of education in poor, rural and agricultural regions. While the proposed *hukou* reform allows rural *hukou* holders access to urban social services and better school education, further improvement in education in rural regions will reduce the urban-rural divide in educational opportunity.

4.6. Summary

China has developed a competitive transport and electricity infrastructure network which is comparable with most OECD countries. Economic activities benefit from a well-developed national transportation infrastructure network. On the other hand, the penetration of Information and Communication Technology (ICT) among the rural population still lags that among the urban population. The effort to increase the penetration of ICT in rural areas should continue, including the promotion of ICT in agricultural production and marketing, as stated in 13th Five-Year Plan.

The institutional reform in the late 1970s to allocate land contract rights to individual family farms contributed significantly to the productivity growth in agriculture in the early 1980s. Since then, China has taken a number of steps to secure land contract rights and to activate the transaction of land operational rights between farms. However, the operational size of farms is small and the share of rented land remains lower than many OECD countries. The consolidation of small and fragmented farm operations to large-scale units is one of the most important pathways of productivity growth in Chinese agriculture. The consolidation of land use to large farms can also have a sustainability benefit, as small farmers who engage in off-farm activity have an incentive to apply fertiliser and chemicals more intensively to reduce labour input in agriculture. The local government should play a proactive role in providing information on potential lenders of land and reduce the costs related to land transactions. Securing land contract and operational rights is also important to providing incentives for holders of such rights to commit to long-term investment in land. Promoting the entry of new and diverse types of entities to agriculture (including agri-business ventures and migrants from urban to rural areas) by allowing them to obtain land operational rights would bring fresh capital to the agricultural sector.

China's policy approach to promote consolidation of farm operations through various organisational formats (e.g. transaction of operational rights, farmers' co-operatives, land trust and farm operational services) is effective in adapting to local conditions. A traditional approach to promote land consolidation through transactions of land ownership and tenancy faces high transaction costs under the country's small and fragmented farm structure. China's approach provides a policy lesson for other counties who wish to promote consolidation of small and fragmented farm operations.

The recent policy to establish geographical zoning for grains and other crops targets government support to designated areas. The zoning policy would facilitate a structural change of agriculture and more sustainable agricultural production though rationalising the geographical distribution of agricultural production to reflect natural and environmental conditions. It is also expected to promote the consolidation of farm operation to large-size units and improve the efficiency of government infrastructure investment.

Saving labour inputs through farm mechanisation is an important driver of agricultural productivity growth in China, considering the rising costs of labour in rural areas. Mechanisation allows farmers to operate larger farms or to engage more time in off-farm activities. The development of farm machinery services in China made a significant contribution to a rapid increase in the use of modern farm machinery, including on small farms. Indeed, outsourcing major farming operations (e.g., ploughing, planting and harvesting) of small farms to farm service providers allows small farms to benefit from economies of scale in farm operation and reduce the cost of capital inputs. However, fragmented land structure and lack of farm access roads limit the efficient use of farm machinery. China's recent policy emphasis on increasing investment in high-standard farmland would address this constraint to productivity improvement through mechanisation.

China's household registration (*hukou*) system limits access for households registered in rural areas to social security and education systems in urban areas, despite the introduction of a single national resident registration system in 2014. While China is improving medical insurance, pension and public education for rural residents, unequal access to social security systems remains between urban and rural residents. For example, the children of rural households living in cities have difficulty accessing the public school education system in urban areas. Meanwhile, only the members of rural collective economic organisations (villages) can have an allocation of land contract rights.

Ensuring more equal access to social services would facilitate the migration of rural residents to urban areas and allow aged farmers to transfer farm resources to efficient and productive farmers. This would reduce an existing large income disparity between urban and rural populations and improve productivity in agriculture. The allocation of farmland contract rights should also be decoupled from rural household registration to allow the entry of diverse types of farm operators, including individuals and corporations migrating from urban to rural areas.

While most of the working age population obtained lower- and upper-secondary education, China currently has the lowest proportion of the adult population with tertiary level education compared to other OECD and BRIICS countries. The education attainment of rural residents is largely limited to lower-secondary level. Increasing the attainment of education and training in a broad skill set would be particularly impactful in rural regions as it would improve the competence and capacity to adapt and innovate in the agriculture sector. Public support to vocational education in agriculture should be increased.

Notes

[1] Box 2.2 describes the role of Farmer Professional Co-operatives in expanding the operational size of farms.

[2] This phenomenon has also been observed more broadly for policies pertaining to environmental protection (Zhang and Cao, 2015).

[3] There are several pilot projects implementing water rights transaction, such as Dongyang-yiwu water rights transaction (between two cities), water rights transaction in the Inner Mongolia and Ningxia Provinces (between agricultural and industrial water users), and water rights transaction among individual farmers in the Shiyang River Basin.

[4] For example, China's National Plan for Medium and Long-term Education Reform and Development 2010-2020, the State Councils' Medium and Long-term National Plan for Science and Technology 2006-2020 and the National Medium-and Long-term Talent Development Plan (2010-2020).

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Annex 4.A. Current and future water demand

Annex Table 4.A.1. Spatial distribution of water resources in China

	Mean annual surface runoff		Groundwater		Total annual water resources[1]		Population		Arable land		Annual per capita water resources
Basin	km³	%	km³	%	km³	%	million	%	million hectares	%	m³
North	334.3	12.3	168.9	20.3	405.4	14.4	520.5	44.4	57.4	59.5	778.9
Song-Liao	165.3	6.1	62.5	7.5	192.8	6.9	113.2	9.6	19.5	20.2	1 703.2
Hai-Luan	28.8	1.1	26.5	3.2	42.1	1.5	117.6	10.0	10.8	11.2	358.0
Huai	74.1	2.7	39.3	4.7	96.1	3.4	190.5	16.2	14.7	15.2	504.5
Huang	66.1	2.4	40.6	4.9	74.4	2.6	99.2	8.4	12.4	12.9	750.0
South	2 260.8	83.4	591.7	69.3	2 276.6	80.9	327.4	53.5	33.5	34.8	3 628.6
Yangtze	951.3	35.1	246.4	29.7	961.3	34.2	402.5	34.3	22.9	23.8	2 388.3
Peral	468.5	17.3	111.6	13.5	470.8	16.7	141.5	12.1	6.5	6.7	3 327.2
Southeastern	255.7	9.4	61.3	7.4	259.2	9.2	65.1	5.6	2.4	2.5	3 981.6
Southwestern	585.3	21.6	154.4	18.6	585.3	20.8	18.3	1.6	1.7	1.8	31 983.6
Inland	116.4	4.3	89.2	10.4	130.4	4.6	24.7	2.1	5.4	5.6	5 279.4
Total	2 711.5	100.0	828.8	100.0	2 812.4	100.0	1 172.6	100.0	96.4	100.0	2 398.4

Note: The sum of water resources from surface water and groundwater may exceed the total water resources by the amount of overlap between them, since surface water interacts with groundwater, with the river base flow formed by groundwater and part of groundwater *recharge coming from percolation of surface water.*
Sources: World Bank (2009).

StatLink http://dx.doi.org/10.1787/888933829949

Annex Table 4.A.2. Projected water demand in China, 2000 and 2030

	Total demand (km3)			Per capita demand (m3)		Share by sectors					
						2000			2030		
	2000	2030	Increase	2000	2030	Municipal	Industry	Agriculture	Municipal	Industry	Agriculture
River basins											
Songhuajiang	35.2	51.7	16.5	559	689	9	22	69	9	20	71
Liao	16.6	22.7	3.1	356	355	13	18	69	20	25	55
Hai	40.2	42.9	2.7	312	262	13	17	70	21	21	58
Huang	43.7	48.1	4.4	397	364	7	14	79	13	19	68
Huai	65.1	71.6	6.5	332	320	10	16	74	18	20	62
Yangtze	193.9	223.9	30.0	454	451	10	29	61	15	33	52
Southeast Rivers	33.9	33.8	-0.1	471	367	12	26	62	20	34	46
Pearl	79.2	81.0	1.8	492	5	13	20	67	20	29	51
Southwest Rivers	10.6	13.6	3.0	530	544	8	3	89	14	6	80
Northwest Rivers	59.8	64.2	4.4	2 062	1 646	2	3	95	4	3	93
Regions											
6 Northern regions	263.6	301.2	37.6	453	432	8	14	78	13	17	70
4 Southern regions	317.6	352.3	34.7	467	433	12	25	63	17	31	52
Nationwide	581.2	653.5	72.3	461	432	10	20	70	16	24	60

Source: World Bank (2009).

StatLink http://dx.doi.org/10.1787/888933829968

Annex 4.B. Recent water policies referred to in section 3

Policies relevant to managing water quantity

The General Office of the State Council issued "Notice on promoting the reform of water price to promote water conservation and protection of water resources" On 19 April 2004 (No. 36 document in 2004).

The "Outline of China's Water Saving Technology Policy" was made by the National Development and Reform Commission in conjunction with the Ministry of Science and Technology, the Ministry of Water Resources, the Ministry of Construction and the Ministry of Agriculture made on 21 April 2005.

"Management Regulations for Water Withdrawal Permission and Water Resources Fee Collection" was issued by the State Council on 21 February 2006.

The National Development and Reform Commission, the Ministry of Water Resources and the Ministry of Construction issued No. 236 document on "Water-Saving Society Construction of the Eleventh Five-Years Plan" on 14 February 2007.

The "Decision of the CPC Central Committee and State Council on Accelerating the Development of Water Conservancy Reform" was promulgated as the No. 1 Document of 2011.

The State Council promulgated the "Opinions on the implementation of the strictest water resources management system" in January 2012.

The General Office of the State Council issued the "National Agricultural Water Conservation Program (2012-2020)" in November 2012.

The Ministry of Water Resources issued the "Opinions on Accelerating the Construction of Water Ecological Civilization" in January 2013.

The State Council issued the "Water Pollution Prevention and Control Action Plan" on 16 April 2015.

Policies relevant to managing water quality

The Ministry of Environmental Protection issued "National Groundwater Pollution Prevention and Control Planning (2011-2020)" on 28 October 2011.

The State Council formally approved the "Planning of water pollution prevention and control in key river basins (2011-2015)" proposed by the Ministry of Environmental Protection, the National Development and Reform Commission, the Ministry of Finance and the Ministry of Water Resources on 16 May 2012.

The State Council promulgated the "Opinions on the implementation of the strictest water resources management system" in January 2012.

The Ministry of Environmental Protection issued the "Twelfth Five Year Development Plan for National Standard of Environmental Protection" on 17 February 2013.

The Ministry of Water Resources issued "Opinions on Accelerating the Construction of Water Ecological Civilization" in January 2013.

The Ministry of Water Resources issued "Opinions on Accelerating the Construction of Water Ecological Civilization" in January 2013.

The National Development and Reform Commission, the Ministry of Finance and the Ministry of Environmental Protection jointly issued the "Notice on the Adjustment of Sewage Charges and Other Relevant Issues" on 1 September 2014.

The State Council issued the "Water Pollution Prevention and Control Action Plan" on 16 April 2015.

Policies relevant to managing water risk

"The Law of the People's Republic of China on Emergency Responses" was issued on 30 August 2007.

The State Council issued the "Regulations of the People's Republic of China on Drought Resistance" on 26 February 2009.

The State Council made the second amendment of the "Regulations of the People's Republic of China on Flood Control" on 8 January 2011.

The General Office of the State Council issued "Opinions on Strengthening the Work of Meteorological Disaster Monitoring, Early Warning and Information Dissemination" on 11 July 2011.

Policies relevant to investment on water conservancy projects

The "Management Measures for the Collection and Use of Fund for Water Conservancy Construction" was issued by the Ministry of Finance, the National Development and Reform Commission and the Ministry of Water Resources on 10 January 2011.

The Ministry of Finance and the Ministry of Water Resources issued "Notice on Provision of Funds for Farmland Water Conservancy Construction from the Land Transfer Income" on 4 July 2011.

The Ministry of Finance issued "Opinions on the Implementation of the Spirit of the Conference on Water Conservancy Work of Central Government", 2011, No. 265.

In 2011, the Ministry of Finance and the Ministry of Water Resources issued the "Interim Measures for the Administration of the Use of the Maintenance Funds from Financial Subsidy of the Central Government for Public Welfare Water Conservancy Engineering in Central and Western Areas and Poverty-Stricken Areas".

In 2012, the Ministry of Finance and the State Administration of Taxation issued "Notice on Tax Policy for Supporting the Construction and Operation of the Rural Drinking Water Safety Projects".

The Ministry of Finance and the Ministry of Water Resources issued "Administrative Regulations on Overall Funds of Central Finance for Farmland Water Conservancy Construction Provided from the Land Transfer Income" on 8 April 2013.

Annex 4.C. OECD principles of water governance

OECD (2015c) defines 12 core principles for a better governance of water under three main goals: effectiveness, efficiency and trust and engagement. These principles are aimed to apply to any country's water system, OECD and non-OECD countries.

- **Principle 1**. Clearly allocate and distinguish roles and responsibilities for water policymaking, policy implementation, operational management and regulation, and foster co-ordination across these responsible authorities.
- **Principle 2.** Manage water at the appropriate scale(s) within integrated basin governance systems to reflect local conditions, and foster co-ordination between the different scales.
- **Principle 3.** Encourage policy coherence through effective cross-sectoral co-ordination, especially between policies for water and the environment, health, energy, agriculture, industry, spatial planning and land use.
- **Principle 4.** Adapt the level of *capacity* of responsible authorities to the complexity of water challenges to be met, and to the set of competencies required to carry out their duties.
- **Principle 5**. Produce, update, and share timely, consistent, comparable and policy-relevant water and water-related *data and information*, and use it to guide, assess and improve water policy.
- **Principle 6.** Ensure that governance arrangements help mobilise water finance and allocate *financial resources* in an efficient, transparent and timely manner.
- **Principle 7.** Ensure that sound water management *regulatory frameworks* are effectively implemented and enforced in pursuit of the public interest.
- **Principle 8.** Promote the adoption and implementation of *innovative water governance practices* across responsible authorities, levels of government and relevant stakeholders.
- **Principle 9.** Mainstream *integrity and transparency* practices across water policies, water institutions and water governance frameworks for greater accountability and trust in decision-making.
- **Principle 10.** *Promote stakeholder engagement* for informed and outcome-oriented contributions to water policy design and implementation.
- **Principle 11**. Encourage water governance frameworks that help manage *trade-offs* across water users, rural and urban areas, and generations.
- **Principle 12.** Promote regular *monitoring and evaluation* of water policy and governance where appropriate, share the results with the public and make adjustments when needed.

Chapter 5. Agricultural policy in China

This chapter provides an overview of developments in agricultural policies in China. It also reports on trends in the level and compositions of support and discusses the likely impacts of agricultural policy measures on structural change, environmental performance and innovation in the sector.

Agricultural policy includes measures that are specifically designed for and applied to the agricultural sector, which create a direct incentive for investment in agriculture and innovation, including technological adoption and structural change. Some agricultural policies are specifically targeted to improving environmental performance at the farm level. This chapter first reviews agricultural policy objectives in the People's Republic of China (hereafter "China"), then domestic agricultural policy and agricultural trade policy. The structure of agricultural policy is assessed using OECD indicators of support. The section concludes with a summary of findings regarding extent to which agricultural policies in China are oriented towards innovation for improving productivity growth and sustainability.

5.1. Agricultural policy objectives

China's agricultural policy objectives have evolved over the last three decades, reflecting the changing role of agriculture at different stages of economic development. The objective of agricultural policy initially focused on a quantitative increase of food production to satisfy a growing population, but has evolved to ensure food safety, increase farmers' income, boost competitiveness and improve the environmental performance of agriculture (Box 5.1).

Box 5.1. Evolution of agricultural policy objectives in China

Since the foundation of the People's Republic of China in 1949, China exploited the agricultural sector to promote industrial development, through such policies as agricultural tax and maintaining low prices of agricultural products relative to industrial ones. Through over 30 years of reform and opening-up, China has adjusted the goals of its agricultural policies to the different stages of economic development. Since the 1990s, China's agricultural policies shifted fundamentally, from exploiting agriculture to promoting and subsidising the sector. The development of agricultural policies since reform and opening-up in the late1970s can be divided into three stages, based on the changes of their priorities and goals.

The first stage was between the beginning of reform and opening-up in the late 1970s and the mid- to late 1990s. The primary policy goal in this period was to increase food production and ensure food security. The policy was designed to ensure a steady supply of grain and other agricultural products and to stabilise food prices. At the beginning of reform and opening-up in 1978, China's central policy documents emphasised increasing food production to feed its population of nine hundred million, and clarified that it must depend on domestic resources to do so (CCCPC, 1979, 1983). China began the negotiation on its accession into WTO before 1990, with a major policy goal of increasing the competitiveness of its agriculture (OECD, 2005).

The second stage was from the late 1990s up to the first decade of this century. At this stage, while food self-sufficiency remained the policy focus, increasing farmers' income was included as the most important policy goal among topics included in the No. 1 Documents of 2004, 2008, 2009 and some other years. The No. 1 Documents in many years began to emphasise other policy goals, such as ensuring the quality of agricultural products and food safety, enhancing agricultural competitiveness, and protecting the agricultural ecosystem.

The third stage started in 2010, when achieving sustainable agricultural development became a primary policy objective. In particular, the 2014 No. 1 Document emphasised food quality and safety in addition to quantity, placing greater importance on sustainable agricultural development in the long term (while ensuring sufficient food supply). Ensuring food security and increasing farmers' income remain top policy priorities.

In this stage, non-agricultural sectors support agriculture and an institutional framework and a policy system are being built to support agriculture (Cheng, 2011).This is reflected in policies such as the minimum purchase price; temporary purchasing and storage; the target price and direct food subsidies; subsidies for agricultural materials, superior crop varieties and for the agricultural insurance premium; and the abolition of the agricultural tax.

1. The No. 1 Central Document is the most important policy document in China jointly issued by the Central Committee of the Communist Party (CCCPC) and the State Council. This document determines the most important issues and focus of the year. The issues related to agriculture, farmers and rural area (the Three Nongs) have been selected as the topic of this document consecutively since 2004.

Food security has long been a central objective of China's agricultural policy. A number of policy documents issued during the past years set the basic goal of increasing food production and achieving food self-sufficiency with domestic resources. The goal is to ensure basic supply of grain and other major agricultural products, and access to food by urban and rural residents. The white paper of *The Grain Issue in China* in 1996 put forward the goal of raising food self-sufficiency level to 95%.

The Chinese government has long stressed the significance for China's economic and social development of realising self-sufficiency of grains with domestic resources and of ensuring food security. This involved ensuring food production, protecting basic farmland, determining permanent farmland, improving productivity, and achieving self-sufficiency of grain (State Council, 2014). However, in recognition of the economic and environmental cost of maintaining self-sufficiency policy, China announced a new food security strategy in 2014, aiming to ensure food security by making use of both domestic and international resources, and promoting sustainable agricultural development (Box 5.2). This is an important step in changing the nature of food security policy in China.

Box 5.2. New Food Security Strategy in China

China has introduced a series of policies and measures to ensure food security, including a system of protecting basic farmland, strengthening the capacity of food production, and establishing systems of price support and direct payment, food storage, and food regulation. Rapid industrialisation and urbanisation caused structural problems in satisfying domestic food demand with available domestic agricultural resources, increasing environmental pressure. In 2014, China introduced a new food security strategy to ensure food production with available domestic resources, importing moderately and utilising science and technology (State Council, 2014).

The new strategy emphasises the importance of basing food supply on domestic resources, which is determined by the nature of food and China's domestic circumstances. China's large population makes it the world's largest food producer and consumer. Due to concerns regarding risks arising from over-reliance on imports, food self-sufficiency is still seen as central to China's ability to maintain its food security and control its economic and social development.

However, policy makers recognise that China is not fully capable of maintaining self-sufficiency of all agri-food products, and that the economic and environmental costs of maintaining self-sufficiency is high. The new food security strategy requires proper allocation and conservation of domestic resources to meet the basic demand for grain, supported by "moderate import" to ensure food security. China has been importing international agricultural resources to complement domestic agricultural production and balance seasonal fluctuation of production in different areas. China's economic growth proves that moderately importing agricultural products and properly utilising agricultural resources overseas can, to a certain extent, complement the shortage of domestic agricultural resources and contribute to realising grain self-sufficiency, thereby ensuring food security. The new food security strategy calls for more efforts to use international markets of agricultural products and agricultural resources, and to effectively adjust and supplement domestic food supply as a strategic choice.

Finally, the new strategy gives more weight to sustainable agricultural development, recognising that increasing domestic production cannot be achieved without paying the price of a degraded environment. For a long time, China has given excessive weight to the increase of total food production. For example, the National Medium- and Long-Term Outline Plan for Food Security (2008-2020) sets clear binding requirements for domestic food production, i.e. “the self-sufficiency level for food should be over 95%, and that for cereal should reach 100%”. This policy emphasis on self-sufficiency neglects economic, social and environmental costs: for example, farmland is overused, the use of pesticide and fertiliser exceeds safety standards, and farmland and water resources suffer serious pollution and degradation. Such circumstances and practices cause potential problems for food security and sustainable agricultural development in the medium- and long term. The new food security strategy focuses on not only food quantity and current food supply, but food quality and safety and sustainable agricultural development. Based on the need to ensure sustainable agricultural development and long-term food security, and on concerns about the negative externality of increasing the quantity of food production. China has decided to transform its food production strategy from yield growth to sound and sustainable development (Cheng, 2015).

During the late 1990s, China’s rural economy experienced structural problems such as falling prices of agricultural products, declining profit of township enterprises, lower income growth for farmers, and widening income disparity between urban and rural residents.[1] The 2004 No. 1 Document gave priority to **increasing farmers’ income** as the goal of its agricultural policy for the first time, calling for comprehensive policies to accelerate the rapid growth of farmers’ income and to reverse the trend of widening income disparity (State Council, 2004). In 2012, China set the goal of building a moderately prosperous society, doubling its gross domestic product (GDP) and per capita income of urban and rural residents compared with 2010 levels, and alleviating poverty for all rural residents based on the current poverty line by 2020. The 2016 No. 1 Document pointed out that a moderately prosperous society cannot be built unless farmers attain a moderately high standard of living (State Council, 2016).

Since WTO accession in 2001, China has opened up its agricultural market, thereby increasing the challenges arising from international competition. China considers **competitiveness of its agricultural sector** as an important policy objective, together with developing multiple roles of agriculture and promoting integrated growth of rural and urban areas; these objectives have been included in China’s No. 1 Documents since 2004.

By increasing its grain output for 12 consecutive years since 2004, China has increased the pressure on natural resources and the environment, including extensive use of agricultural resources, severe pollution of farmland and its functional degradation, waste of water resources, water pollution, groundwater over-exploitation, grassland and wetland degradation and deterioration of the ecological environment (Cheng, 2013). The 2014 No. 1 Document was the first to propose establishing a long-term framework of **sustainable agricultural development**: to develop eco-friendly agriculture, to implement pilot projects of temporary retirement of agricultural resources, and to strengthen ecological protection (State Council, 2014).

In 2015, the State Council authorised the Ministry of Agriculture (MOA) and other government agencies to issue the Agricultural Sustainable Development Plan (2015-2030), which sets the goals and paths of sustainable agricultural development (MOA, et.al. 2015). This plan requires that China accelerates its development of resource-saving, environment-friendly and ecosystem-protecting agriculture, and that it takes effective measures to change the mode of agricultural development from extensive management — which consumes resources and damages environment — to intensive farming focusing on quality and efficiency. Considering factors such as capacity of agricultural production resources, environmental capacity and ecological types, the plan divides China into optimised, moderate and protected development areas. Based on a principle of adjusting measures to local conditions, different priorities for achieving sustainable agricultural development were set in different areas.[2] The strategy of differentiating policy priorities regionally and locally would support the locational adjustment of agricultural production to reflect resource availability (Box 5.3).

Box 5.3. Zero-Growth Action Plan for Chemical Fertilizers and Pesticides

In 2015, China announced the Zero-Growth Action Plan for Chemical Fertilizers and Pesticides. This initiative is designed to realise zero growth of the usage of fertilisers and pesticides by 2020. The goal of the action plan is to restrict the annual growth of chemical fertiliser use to below 1% during 2015-2019 and to achieve zero-growth by 2020 for major agricultural crops, relative to the annual growth rate of nitrogen and phosphorus uses at 3.9% and 2.5% during 2000-2013, respectively. The target on pesticides limits the average use per unit of land falls below that of the last three years.

In the Action Plan for chemical fertilisers, issues related to current practices are highlighted: excess application of fertiliser of 21.9 kg/mu (328.5 kg/ha) as compared the worldwide average of 8 kg/mu (120 kg/ha); uneven fertiliser use across regions and products, with excessive use observed in eastern China, the lower Yangtze River area, as well as for cash and horticulture products; low utilisation rate of organic fertilisers at around 40% of overall fertiliser use; and the unbalanced structure of fertiliser uses.

The Action Plan proposes soil testing to encourage farmers to use organic fertiliser and support the development of effective fertiliser. However, implementation details will vary across Chinese regions due to uneven regional practices in fertiliser application. For instance, in regions where fertilisers are currently used excessively, such as Northeast China, the North China Plain, and the mid- and lower Yangtze River area, nitrogen and phosphorus inputs will be regulated whereas the use of potassium will be capped. In Southwestern China, nitrogen use will be capped, use of phosphorus fertilisers will be adjusted, and potassium use will be increased; in Northwest China, the focus is to match the use of fertilisers and water resources, while capping the use of both nitrogen and phosphorus.

The initial steps of the Zero-Growth Action Plans include several pilot projects. In 2014, the central government started to support the demonstration project of more efficient slow-release fertilisation on maize production in five provinces. Another pilot project that started in 2011 provides subsidies to lower farmers' costs of applying low-toxicity biological pesticides. In 2014, this project was expanded to 42 major vegetable, fruits and tea production counties in 17 provinces. A third project is the government support for soil testing and formula fertilisation.

5.2. Domestic agricultural policy

Domestic agricultural and associated trade measures affect farmers' investment decisions and the choice of production practices. Several dimensions of agricultural policies are important: 1) the extent to which market-distorting instruments are used to support producers; 2) the extent to which policies facilitate structural adjustment; 3) the extent to which policies provide targeted support to promote the adoption of innovation and sustainable production practice at the farm level.

Level of support for agricultural producers

OECD indicators of producer support allow a quantitative evaluation of support to agriculture, including such measures as: 1) the share of farm revenue which can attributed to the government support, including both price support and budgetary transfer to individual producers (%PSE); 2) the extent to which the producer support is provided through most market-distorting measures such as Market Price Support (MPS) and input subsidies; and 3) the extent to which agriculture is supported through general service to the sector (General Service Support Estimate, GSSE) or support to individual producers (Producer Support Estimate, PSE). OECD classifies GSSE and PSE measures according to their purpose and implementation criteria, respectively. This information provides a comparison of producer support in China with OECD countries and major emerging economies in a consistent method since 1995. It also helps identify whether existing policy measures boost agricultural innovation, agricultural productivity and sustainability performance.

Box 5.4. OECD support indicators

The OECD indicators were developed to monitor and evaluate developments in agricultural policy, to establish a common base for policy dialogue among countries, and to provide economic data to assess the effectiveness and efficiency of policies. The support indicators are different ways to analyse agricultural policy transfers and measure their levels in relation to various key economic variables. The names, abbreviations and definitions of the selected indicators are listed below.

Producer Support Estimate (PSE): the annual monetary value of gross transfers from consumers and taxpayers to agricultural producers, measured at the farm-gate level, arising from policy measures that support agriculture, regardless of their nature, objectives or impacts on farm production or income.

Percentage PSE (%PSE): PSE transfers as a share of gross farm receipts (including support).

Producer Single Commodity Transfers (producer SCT): the annual monetary value of gross transfers from consumers and taxpayers to agricultural producers, measured at the farm gate level, arising from policy measures directly linked to the production of a single commodity such that the producer must produce the designated commodity in order to receive the transfer.

Producer Percentage Single Commodity Transfers (producer %SCT): the commodity SCT as a share of gross farm receipts for the specific commodity.

General Services Support Estimate (GSSE): the annual monetary value of gross transfers to general services provided to agricultural producers collectively (such as research, development, training, inspection, marketing and promotion), arising from policy measures that support agriculture regardless of their nature, objectives and impacts on farm production, income, or consumption. The GSSE does not include any transfers to individual producers.

Percentage GSSE (%GSSE): transfers to general services (GSSE) as a share of Total Support Estimate (TSE).

Total Support Estimate (TSE): the annual monetary value of all gross transfers from taxpayers and consumers arising from policy measures that support agriculture, net of associated budgetary receipts, regardless of their objectives and impacts on farm production and income, or consumption of farm products.

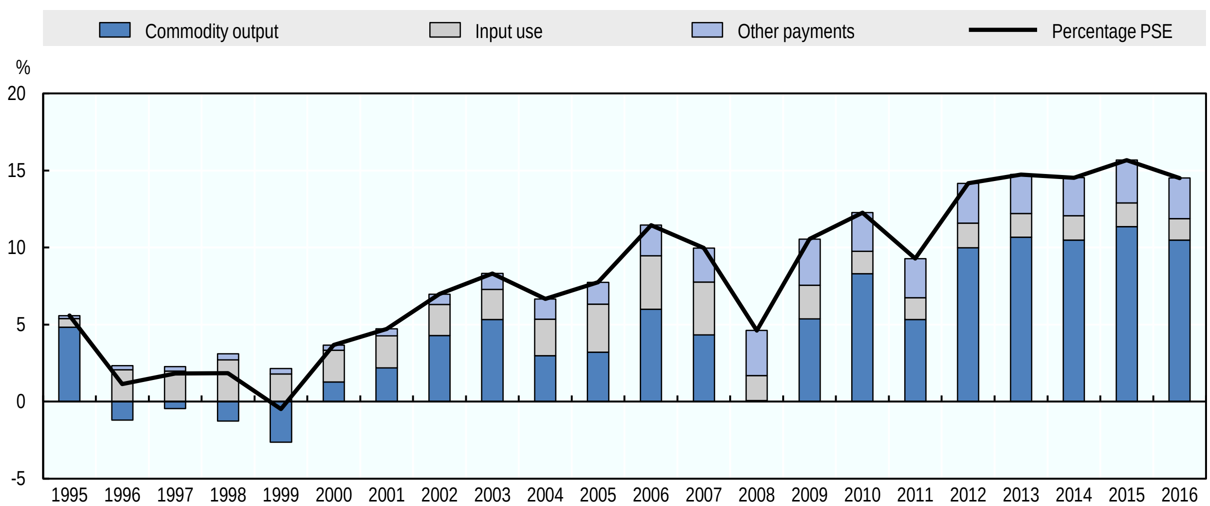
Percentage TSE (%TSE): TSE as a share of GDP.

Source: OECD (2016).

China's Producer Support Estimate (PSE) shows a drastic evolution of producer support policy in the last two decades (Figure 5.1). Between 1996 and 1999, the MPS was negative, and the budgetary payments were dominated by input payments such as fertiliser subsidy. MPS became positive in 2000-01 but the payments based on agricultural inputs still dominated the producer support. Since 2002, MPS has increased at a faster pace than budgetary payment and has become the main instrument for supporting agricultural producers. In 2008, domestic prices in China remained stable in spite of a price spike of agricultural products in international markets, leading to negative market price support.

Figure 5.1. Evolution of support for China's agricultural producers, 1995 to 2016

As a percentage of gross farm receipts



Source: OECD (2017), "Producer and Consumer Support Estimates", OECD Agriculture statistics (database), http://dx.doi.org/10.1787/agr-pcse-data-en.

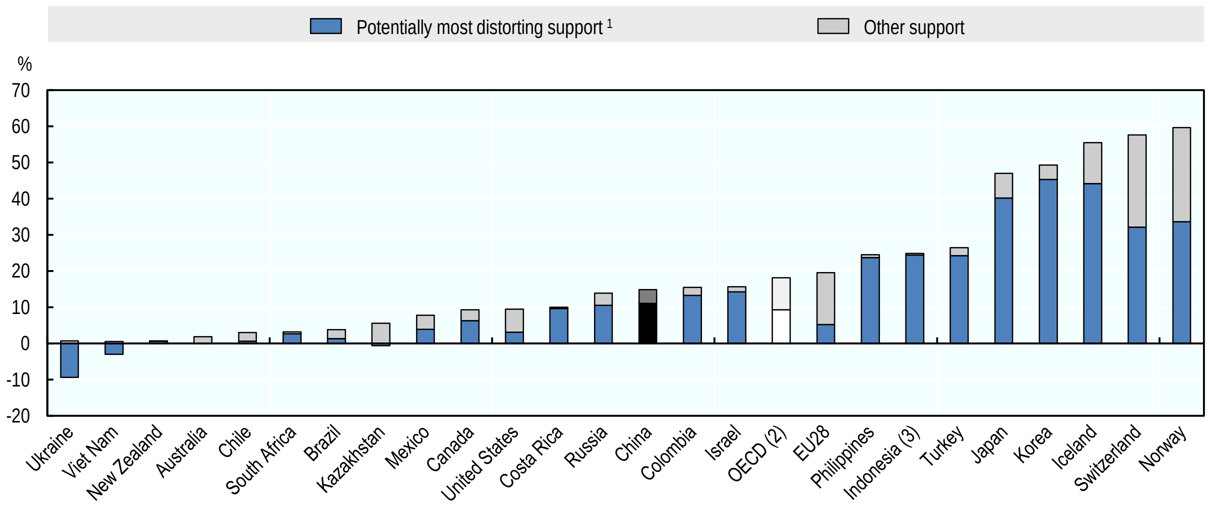
StatLink http://dx.doi.org/10.1787/888933829341

Despite yearly fluctuations, %PSE in China shows an increasing trend. China's level of producer support in 2014-16 is close to the average of OECD members and higher than that of Russia, Canada, the United States, Brazil, South Africa, and Australia, but lower than that of Norway, Switzerland, Japan, Korea, and the European Union (Figure 5.2).

MPS accounts for 72% of China's PSE in 2014-16. The payments based on current land area account for more than half of the budgetary payment since 2011, exceeding the share of input subsidy since 2008. The majority of the payments based on inputs support the farmer's investment and technological adoption, such as subsidies for farm mechanisation, and farm extension and advisory services. However, the most distortive forms of support — based on commodity output and variable input use — accounted for 74% of total producer support in 2014-16, which is higher than the OECD average of 51%.

Figure 5.2. Composition of the Producer Support Estimate, 2014-16

As a percentage of gross farm receipts



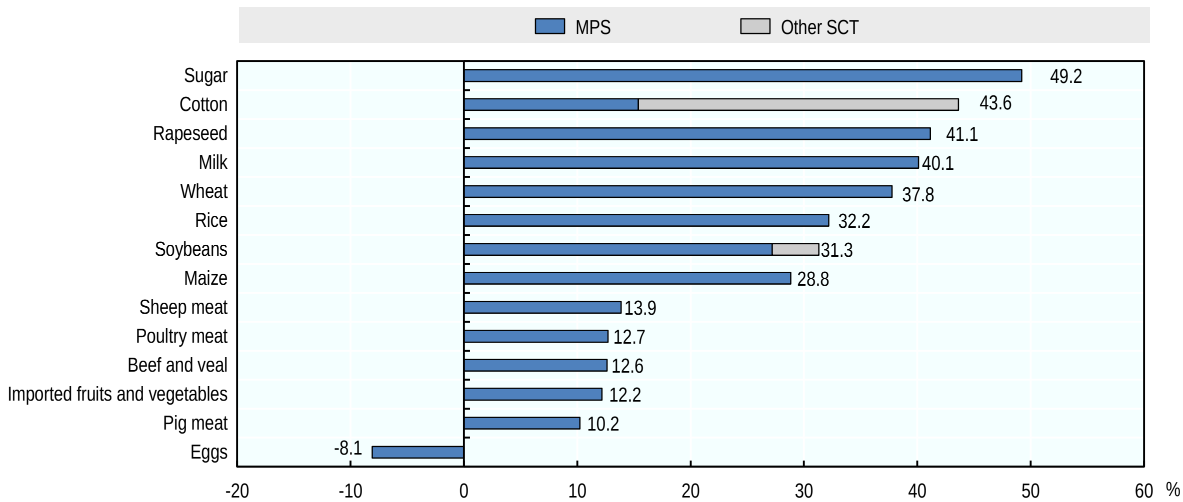
1. Support based on output (including market price support and output payments) and on the unconstrained use of variable inputs.
2. The OECD aggregate does not include Lithuania.
3. For Indonesia, data refer to 2013-15 average.
Source: OECD (2017), "Producer and Consumer Support Estimates", OECD Agriculture statistics (database), http://dx.doi.org/10.1787/545b3853-en.

StatLink http://dx.doi.org/10.1787/888933829360

With a low average tariff on agricultural products, domestic prices of many agricultural commodities have been aligned with prices on international markets. However, certain commodities which are covered by the minimum price system or by temporary purchasing and storage (such as rice and wheat) are priced at higher levels than on international markets. In particular, China increased minimum purchase prices and enlarged the scope of commodities covered by the temporary purchase and storage system between 2008 and 2013, resulting in large increase in MPS of these commodities (which is a part of support based on commodity output in Figure 5.1).[3] Among the commodities covered, the top five in terms of the amount of MPS are rice, pork, corn, wheat and milk. Meanwhile, sugar, cotton and rapeseed received the highest level of single commodity transfer, in terms of share in gross farm receipts of each commodity (Figure 5.3). The level of single commodity transfer of rice and wheat increased from 6% and -9% in 1995-97 to 38% and 32% in 2014-16, respectively.

Figure 5.3. Support to specific commodities in China: Single Commodity Transfer, 2014-16

As a percentage of gross farm receipts for each commodity



Source: OECD (2017), "Producer and Consumer Support Estimates", OECD Agriculture statistics (database), http://dx.doi.org/10.1787/545b3853-en.

StatLink http://dx.doi.org/10.1787/888933829379

Price support policies remain the main instrument of domestic agricultural policy in China. The price support policies are composed of a minimum purchase price policy, and a temporary purchasing and storage system. The **minimum purchase price policy** was implemented in 2004, mainly for rice and wheat in major grain producing regions. The National Development and Reform Commission (NDRC) sets the minimum purchase price in consultation with the Ministry of Agriculture and other government institutions, considering various factors including prices of agricultural inputs, cost of production, reasonable profit, and market supply and demand.

Minimum purchase prices are announced before sowing season to help farmers make production decisions. The central government authorises the state-owned China Grain Reserves Corporation (Sinograin) and other state-owned companies to openly purchase at the minimum purchase price in the main grain-producing regions in cases where the market price is continuously below the minimum price.[4]

China raised minimum purchase prices of rice and wheat continuously between 2008 and 2014, which boosted grain output throughout this period (Table 5.1). This policy contributed to the maintenance of food self-sufficiency, but gradually pushed up domestic food prices above international prices, leading to a significant rise in policy-based stocks of rice and wheat. Considering high domestic prices as well as large domestic grain stock, the government maintained the minimum purchase price of grain in 2015 at the same level as 2014. However, the government reduced the minimum purchase price of early indica rice in 2016 and 2017 as well as the minimum price of middle and late rice and japonica rice in 2017.

With a sharp decline in food prices in 2008 after the price hike in world markets, China implemented a **temporary purchase and storage policy** primarily to stabilise market prices and to ensure adequate supplies of corn, soybeans, canola, cotton, sugar, meat and other agricultural products.[5] While the policy for corn and soybeans is applied in northeast

China and Inner Mongolia, the policy for rapeseed is implemented in 17 rapeseed-producing areas including Jiangsu, Hubei, and Anhui. The temporary purchase and storage policy was extended to frozen pork in 2009 and to cotton in 2011. With the introduction of a pilot programme for the target price system, the temporary purchase and storage policy was scaled down to corn and frozen pork in 2015.

Table 5.1. China's Minimum Purchase Price (MPP) and Temporary Purchase and Storage Price (TPSP) for grain, 2004 to 2016

Yuan per tonne

	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
Minimum Purchase Price (MPP)													
Rice													
Early indica	1 400	1 400	1 400	1 400	1 540	1 800	1 860	2 040	2 400	2 640	2 700	2 700	2 660
Medium and late indica	1 440	1 440	1 440	1 440	1 580	1 840	1 940	2 140	2 500	2 700	2 760	2 760	2 760
Japonica	1 500	1 500	1 500	1 500	1 640	1 900	2 100	2 560	2 800	3 000	3 100	3 100	3 100
Wheat													
White wheat			1 440	1 440	1 540	1 740	1 800	1 900	2 040	2 240	2 360	2 360	2 360
Red wheat			1 380	1 380	1 440	1 660	1 720	1 860	2 040	2 240	2 360	2 360	2 360
Mixed wheat			1 380	1 380	1 440	1 660	1 720	1 860	2 040	2 240	2 360	2 360	2 360
Temporary Purchase and Storage Price (TPSP)													
Corn					1 500	1 500	1 800	1 980	2 120	2 240	2 240	2 000	..
Soybean					3 700	3 740	3 800	4 000	4 600	4 600	..	..	..
Oil seed					4 400	3 700	3 900	4 600	5 000	5 100	5 100	..	..
Cotton								19 800	20 400	20 400	..	..	..

1. The minimum purchase price and temporary purchase and storage price are applicable to Grade-3 products of the national quality standard with a price difference of 40 yuan per tonne between each grade.
2. The temporary purchase and storage price in 2008 are also applicable to medium and late indica rice and japonica, with 1 880 yuan per tonne and 1 840 yuan per tonne respectively.
3. The temporary purchase and storage price for corn varies in the major grain producing areas in the Northeast. It was 2 260 yuan per tonne for Inner Mongolia and Liaoning, 2 240 yuan per tonne for Jilin, and 2 220 yuan per tonne for Heilongjiang.
4. The temporary purchase and storage prices for soybean and cotton were cancelled in 2014, and replaced with the experimental target price subsidy system; the temporary purchase and storage price for oilseed was terminated in 2015.
Source: NDRC.

StatLink http://dx.doi.org/10.1787/888933829987

In contrast to its minimum price purchase policy, the government announces temporary purchase prices only during the harvest season. The state-owned companies purchase at the temporary purchase price if the market price is lower. However, intervention prices may differ across provinces, and purchases are not undertaken systematically every year (OECD, 2013). The temporary purchase prices of corn, soybean and rapeseed were continuously raised between 2008 and 2012.

The amounts of crops purchased by state-owned companies at minimum price or temporary purchase and storage price change from one year to the next, depending on the relative levels of market prices and those offered by the government. In some years, the government becomes the dominant buyer of grains. In 2015, the government purchased a record amount of 175 million tonnes of grains, out of which just 18.5 million tonnes had been auctioned (Renmin Daily, 2016) due to high prices and inconsistent quality (GAIN-CH15058, 2015). As international prices fell, the price gaps continued to increase, with the exception of cotton, for which the price gap declined quite strongly. As a result, the value of overall market price support in 2015 reached the highest level since 1993, when the OECD started to apply the PSE methodology for China (OECD, 2017).

Overall, price support is still a dominant instrument to support producers, accounting for 80% of the Producer Support Estimate in 2013-15. This policy succeeded in boosting domestic food production and maintaining the target level of food self-sufficiency. However, it raised domestic prices above international prices, increasing the cost to consumers and to the government, who were forced to cover high costs of storage. Previous OECD studies find that these policy instruments, in general, reduce the competitiveness of the sector by preventing farmers from responding to market signals and are unable to target specific policy objectives such as the environmental performance of agriculture (van Tongeren, 2008).

Payments to support farm income or reduce cost

Recognising the distortive effects of price support policies, China started to replace its price support system with a ***target price system for agricultural products*** (State Council, 2014). If the average market price of the product is below the pre-determined target price, farmers can receive direct payments covering the price difference.[6] In 2014, China initiated the pilot programmes of target price payment for soybeans in northeast and Inner Mongolia with the target price of soybeans at 4 800 yuan per tonne, and for cotton in Xinjiang Province with the target price of cotton at 19 800 yuan per tonne. In 2016, the target price of soybeans remained unchanged while that of cotton was lowered to 18 600 yuan per tonne. In addition, China introduced a direct payment to rapeseed producers in 2015, replacing the temporary purchase programme.

In 2015, China reduced the temporary purchase price of corn to 2 yuan per kg, 10.7% lower than that in 2014. In 2016, China abolished the temporary purchase and storage policy for corn, replacing it with a new mechanism of market-based storage acquisition that allows market supply and demand to determine prices, while farmers would receive direct payments. The reform was implemented in key maize producing areas: in Heilongjiang, Jilin, Liaoning and Inner Mongolia, where a temporary purchase and storage programme was in place. As a result, the domestic prices of soybeans, cotton, rapeseed and corn declined gradually close to international prices.

China has developed four main direct payment programmes since the early 2000s: direct payment for grain producers; payments to compensate farmers for an increase in prices of agricultural inputs, in particular for fertilisers and fuels; subsidies for improved seeds; and subsidies for purchases of agricultural machinery. ***Direct payment to grain producers*** was implemented in 2004 as a payment based on current area of production, in which provincial government decides which grains are eligible for this subsidy. In practice, the payment is given to farmers based on the actual taxed land area and taxed output,[7] rather than the actual planting area, which makes the subsidy more decoupled from current production in practice. The total amount of payment was CNY 11.6 billion (USD 1.4 billion) in 2004, up to CNY 15.1 billion (USD 1.98 billion) in 2007, and has remained at that level since then.

The ***agricultural input payments*** were implemented in 2006 to reduce farmers' input costs, given the rising prices of agricultural materials like diesel oil and fertiliser. The subsidy rose from CNY 12 billion (USD 1.51 billion) in 2006 to CNY 71.6 billion (USD 10.3 billion) in 2008 as a result of increases in input prices. The payment is made on current area production, but rate of the subsidy is calculated based on input price.[8] In practice, some local governments provide payments based on taxed land area, which resulted in a decline of production incentive. In 2008, China combined agricultural input payments and direct payment to grain producers into a comprehensive income subsidy, which targets subsidising farmers' income instead of promoting food production.

The ***subsidy for improved seeds*** was implemented on a pilot basis in 2002 to motivate farmers to plant high-oil soybean in the northeast in 2002. The variety of products receiving the subsidy increased from soybean to rice, wheat, corn, canola, cotton, potatoes, peanuts, barley, pigs, dairy cattle, and beef, but only a subsidy for rice, wheat, corn and cotton is available nationwide. The payment is made based on current area or animal number, and the rate of subsidy depends on the varieties. The subsidy rapidly increased to CNY 12.1 billion (USD 1.74 billion) in 2008 from CNY 100 million (USD 12.08 million) in 2002 and CNY 2.85 billion (USD 344.28 million) in 2004, and the amount of subsidy reached CNY 20.35 billion (USD 3.24 billion) in 2015. Subsidies in improved animal variety were launched in 2005, and rose to CNY 1.2 billion (USD 190 million) in 2014; these subsidies support farmers in purchasing semen of quality boars, dairy cows and beef cattle or in purchasing stud rams and male yaks.

These three subsidies have been the main instruments of China's direct payment policy. In 2015, the government applied a pilot programme to combine the three subsidies, all paid on a per unit of land basis, into a single payment, called the "***agricultural support and protection payment***", in the five provinces of Anhui, Hunan, Shandong, Sichuan and Zhejiang. The payments consist of two components. Under the new programme, all of the original expenditure for the direct payment for grain producers and the subsidy for improved seeds, and four-fifths of the original expenditure for the agricultural input payments was paid per unit of land directly to owners of land contract rights. This part is intended to protect arable land fertility and to preserve grain production capacity. One-fifth of original expenditure for the agricultural input payments and the future increase in expenditure for the agricultural support and protection payment are set aside for "new-style" farms that rent land, "family farms", co-operative farms, and farms run by agribusiness companies; it is disbursed in the form of credit guarantees, interest rate subsidies and technical advisory service rather than area based payment (MOA-MOF, 2016). This approach reflects a shift of agricultural policy orientation from boosting production to preserving production capacity and promoting structural adjustment towards large-scale operations. It is an important step to further decouple payments from production and input prices and give producers freedom over what they produce.

The ***subsidy for purchases of agricultural machinery*** is another major direct payment programme implemented since 2004. The programme, under which farmers receive a discounted price on new machinery with the price difference settled between the government and suppliers, aims to encourage farmers to use advanced and suitable farm machines (Ni, 2013). In 2004, the central government allocated CNY 70 million (USD 8.46 million) to purchase advanced farm machines in 66 counties, and the subsidy later became available nationwide. The subsidy increased to CNY 23.65 billion (USD 3.84 billion) in 2014. In 2016, buyers of 11 categories (including 43 sub-categories) of farm machinery can effectively receive a reimbursement of up to 30% of the purchase prices. This programme is implemented at the provincial level, and it is up to provincial governments to decide the models of machinery eligible for the subsidy. China also introduced a subsidy for scrapping and renewing agricultural machines in 2013 in Shanxi, Jiangsu, Xinjiang, and Heilongjiang provinces, i.e. providing a small amount of subsidy for tractors and combine-harvesters to be scrapped when purchasing new farm machines.

The introduction of this subsidy responds to Chinas rising cost of labour driven by a shrinking rural labour force and to the need to facilitate substitution of family labour input with machine services. It also facilitates consolidation of farms to large-scale operations (van den Berg et al., 2007). Zhang, Yang and Reardon (2015) argue that the machinery subsidies assisted the emergence of farm machine service providers which allow farmers to outsource some of the power-intensive steps of farm operations (Box 2.2). New types of farm organisation, such as Farmer Professional Co-operatives (FPCs), are increasingly becoming a major recipient of the subsidy. FPCs and other types of co-operatives received 30% of the national subsidy for the purchase of agricultural machinery in 2012 (Zhong, 2014).

The ***subsidy for agricultural insurance premium*** became one of the key support programmes for producers. The programme was launched in 2007 to enhance the farmer's capacity to manage risks and recovery of production after disaster. The central government subsidises insurance premiums for 15 products, including all the major crop and livestock commodities, at the rate of 40% of the premium in central and western provinces and 35% in the eastern provinces. Provincial and county governments provide additional subsidies, but as from 2016 the share covered by the central government subsidy was increased to 47.5% for the central and western provinces and to 42.5% for the eastern provinces (MOF, 2016).

The subsidy programme is implemented throughout China, and local governments can subsidise the insurance premium of special agricultural products. The central government steadily increased the subsidy from CNY 2.14 billion to CNY 24.47 billion (USD 0.29 billion to USD 3.97 billion) between 2007 and 2014. In addition to crop and livestock insurance programmes, the target price insurance for agricultural products was introduced in some provinces and autonomous regions in 2014. The 2016 No. 1 Central Document required the government to introduce experimentation of target price insurance, income insurance and weather index insurance programmes for major agricultural products, to improve the forest insurance system, and to support local governments in developing insurance for specialty agricultural products, fishery, and agricultural machinery.

In addition to these major programmes, China has also implemented subsidies to support the sowing of improved quality seeds and the extension of improved breeds of livestock via the New Variety Extension Payment. Other support policies include a subsidy for technologies key to preventing and mitigating agricultural disasters as well as increasing yield,[9] policies supporting standardised animal production, subsidies for animal epidemic prevention,[10] policies supporting the establishment of primary processing facilities in producing areas of agricultural products, and policies supporting the building of a traceability system for agricultural products.

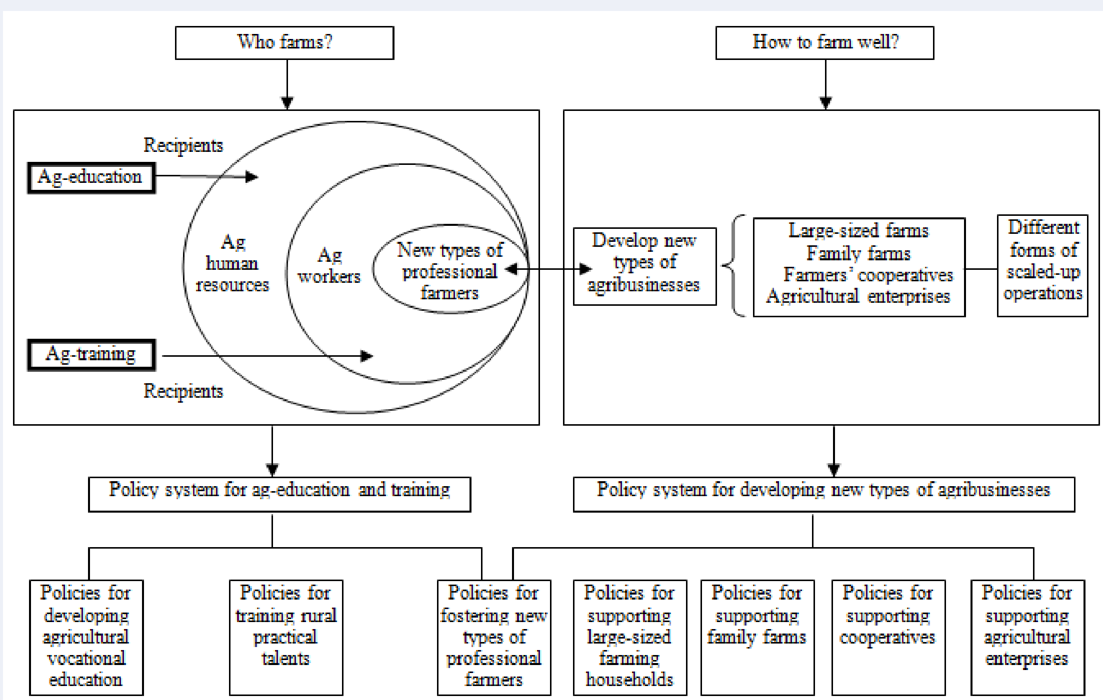
Besides supporting individual producers, the central government provides a financial incentive for recent years' major grain-, oilseed- or pig-producing counties, based on production records. Such counties have received CNY 35.5 billion (USD 5.35 billion) each year. The reward for major grain-producing counties is in the form of general transfer payment, while that for super grain-producing counties is used specifically to support food production and the food industry. The central government also awards the top five grain-producing areas. The rewards for major oil-producing and pig-producing counties must be used to support oil and pig production as well as related industry development. The goal is to enhance financial resources in these counties and motivate local governments to focus on food production and pig breeding.

Box 5.5. Policies supporting new types of professional farm operation in China

A series of policies have been released to encourage the development of new types of professional farm operations such as large family farms, co-operatives and corporate farms, with an expectation that such farms will dominate future agricultural production. First, the new type of agribusinesses like large grain producers and family farms have been given access to agricultural subsidies. For example, a part of new agricultural support and protection subsidy is reserved for those farmers in the form of credit guarantees, interest rate subsidies and technical advisory payments. The famers are allowed to pledge the operational rights of land to finance such farm investments as purchasing and renting machinery. An agricultural credit guarantee system is established to provide credit guarantee and risk compensation for the loans of large grain producers.

Second, local government has established a special fund for farmers' co-operatives to provide information, technology, training, quality standards and certification as well as marketing services. Moreover, specialised co-operative organisations and their processing and distribution businesses enjoy tax reductions and exemptions, and are given priority in applying for national agricultural projects. Certain agri-business enterprises are also subject to preferential policies in land use, taxation and credit loans. In addition, the Chinese government is enhancing agricultural vocational education to develop professional skills for new types of farmers, experienced farmers, large farming households, family farm owners, agricultural machinery operators, agricultural information collectors and staff in agricultural enterprises. Management training is arranged for managers of farmers' co-operatives, agri-business enterprises, farmer brokers, agricultural service providers, and grassroots leaders in rural areas.

Figure 5.4. Framework of supporting new types of professional farms



Agricultural policies targeted at environmental sustainability

The steady growth of the sector, especially for products with high self-sufficiency targets, has been aided partly by the intensive use of chemical inputs such as mineral fertilisers and pesticides, and the severe exploitation of land and water resources. Intensive use of chemical inputs in the crop sectors has led to soil degradation and pollution, water pollution, and damaged bio-diversity. Water resources have also been heavily exploited by agriculture, especially for irrigation, at the national scale, particularly in areas where irrigation is intensive or water resources scarce. Intensive use of inputs and natural resources are partly supported by the government subsidy based on output and input use, such as water and other purchased inputs. The development of the livestock sector has created serious stress on China's grassland areas. The release of animal manure and waste water from intensive livestock and aquaculture farms further pollutes the environment, especially water resources.

In response to growing environmental concerns, China started to implement agri-environmental policies, including soil and water protection, agricultural pollution control, and protection and restoration of the ecological environment. While the objective of agricultural policies has historically been largely oriented to increasing agricultural production, improving the environmental performance of agriculture recently became one of the major policy objectives (Box 5.2).

Agri-environmental payments

The **"grain for green project"** (officially called the "Returning Farmland to Forests Programme") has been in place since 1999 to retire cultivated lands in environmentally sensitive areas and convert them to pastureland or forest. While the grain for green project covered 27.7 million hectares of farmland in 25 provinces in 1999-2000, only 6.7 million hectares of farmland were converted in 2006-09, well below the original target of 15.7 million hectares, due to growing concerns over grain security (OECD, 2011). However, China started to scale up this programme in 2014.[11] In 2015, the central government allocated CNY 4.964 billion (USD 789.95 million), returning 10 million mu (0.7 million hectares) of farmland to forest and grassland. The subsidy for converting farmland to forest is to be provided at CNY 22 500/ha (USD 3 580/ha) and for converting farmland to grassland at CNY 15 000 (USD 2 387) (OECD, 2016b).

In 2003, China also began **projects to convert grazing land to grassland** to contain desertification of grassland and to protect the ecological environment. From 2011, new measures were implemented to improve the policy comprising the rational distribution of grassland fencing, the construction of stalls to support feeding and artificial forage land (Ni, 2013). In addition, the central government increased the subsidy rate and standard. The rate of subsidy was increased from CNY 17.5 to CNY 20 per mu (USD 31.7 to USD 46.42 per hectare) of fence built in Qinghai-Tibet Plateau area, and CNY 16 (USD 34.83) in other areas. Moreover, a subsidy to sow grass was doubled to CNY 20 per mu (USD 46.42 per hectare). The rate for artificial forage construction was CNY 160 per mu (USD 371.52 per hectare).

In addition, China introduced the **Grassland Ecological Protection Subsidy** for eight western provinces in 2011 and another five provinces in 2012, covering all pastoral and semi-pastoral counties. The subsidy aims to promote protection of grassland and to enhance incomes of animal herders. Since 2011, the rules have remained the same: payments are made for the suspension of grazing (CNY 6 per mu; USD 13.9 per hectare), as a reward for not exceeding the stock-carrying capacity of grassland (CNY 1.5 per *mu;* USD 3.48 per hectare), and as subsidies for improved breeds of animals, improved varieties of pasture grass and as a general input subsidy (CNY 500 per household; USD 77.36 per household) (OECD, 2015). The total budget allocated from the central government was CNY 15.77 billion (USD 2.56 billion) in 2014 and CNY 19 billion (USD 3.03 billion) in 2015.

The central government also launched **a subsidy for wetland protection** in 2010 to monitor and restore major wetlands, natural reserves and national wetland parks. In 2014, China started pilot projects for returning farmland to wetland and providing compensation for its protection and restoration. From 2009, the central government included a **subsidy for using agricultural machinery for sub-soiling and land preparation** in the newly added comprehensive subsidy fund. In 2013, China launched pilot projects of a subsidy for using agricultural machinery for sub-soiling and land preparation in autumn in suitable areas like the northeast and the Huanghuaihai Plain, to help farmers or farm machinery service providers these activities.

Box 5.6. Agricultural Resource Respite Pilot Policy

To deal with the pollution of key agricultural resources such as land and water, China initiated the Agricultural Resources Respite Pilot Policy. The first component of this policy carries out comprehensive prevention and control of heavy metal pollution to soil through conducting national surveys, surveillance and dynamic early warning of soil heavy metal pollution. Pilot projects of restoring farmland with heavy metal pollution aim to restore polluted farmland and enable the rice produced from heavily polluted land to meet required standards, or for other crops to be produced. In 2015, the central government invested CNY 2.79 billion (USD 444 million) in preventing and treating heavy metal pollution in 30 cities and regions. For moderately polluted arable land in those regions, demonstrative restoration of heavy metal polluted land is to be conducted without interrupting production activities, whereas for the heavily polluted arable land, production is to be stopped while restoration is undertaken. In the latter case, farm households in the demonstration projects are to be properly compensated.

The second component implements agricultural non-point pollution control and management, including the construction of a national agricultural non-point pollution monitoring and control network, with particular emphasis on building the prevention and control demonstration areas surrounding Tai Hu, E Hai, Chao Hu, and the Three Gorges Reservoir. In areas with particularly serious pollution from livestock and aquaculture operations, agricultural film residues and straw burning, this pilot policy also emphasises solutions such as pollution controls of large-scale livestock and poultry farms as well as aquaculture farms, adoption of decomposable biological agricultural films, recycling of residues of agricultural films, and comprehensive utilisation of crop residues.

The third component of the pilot policy is to explore and build the agricultural ecological compensation mechanism to provide subsidies to farm households for the reduction of chemical fertiliser and pesticide use and increased adoption of high efficiency, low toxicity and low residue pesticides. This compensation mechanism is to be strengthened in important watersheds where agricultural non-point pollution is particularly serious.

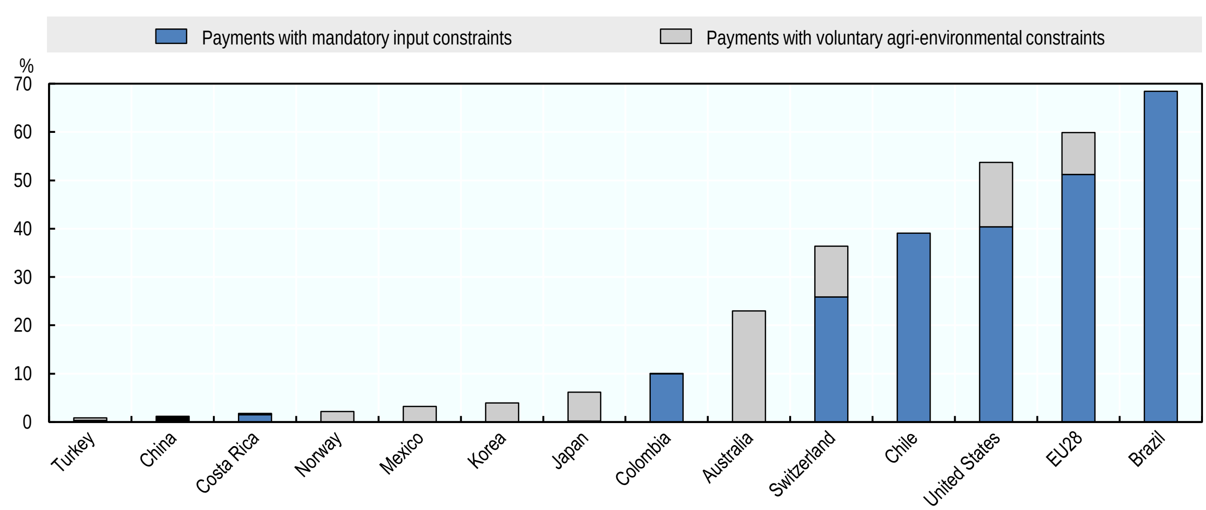
By the end of 2015, the central government had invested about CNY 4.8 billion (USD 763.85 million) through providing materials and funds to encourage farmers to apply soil improvement technology and to make better use of organic fertilisers like straws. From 2014, the “soil organic matter enhancement project” was renamed the **Farmland Protection and Quality Improvement Project**. The central government committed CNY 800 million (USD 127.39 million) in 2015 to support and encourage farmers to return crop residues to the fields, to better utilise green manure and organic fertiliser, and to improve soil and foster soil fertility.[12]

With increasing environmental issues related to **livestock waste**, China started to support large-scale livestock farms in having standardised renovation and construction, making better use of waste, and controlling the pollution discharge from livestock production. Since 2007, the central government has spent CNY 2.5 billion every year (about USD 330-400 million) supporting the construction of standardised large-scale pig farms. Moreover, to dispose of dead livestock and poultry in an environmentally-friendly way, the central and local governments have subsidised intensive pig farms for their pro-environment disposal of dead pigs at CNY 80 (USD 12.68) per head since 2012. In 2015, China also started a pilot project in nine provinces on the comprehensive treatment of livestock manure, including a subsidy for equipment and its use in the recycling process.

The announcement of the Agricultural Sustainable Development Plan (2015-30) was an important step in accelerating the development of resource-saving, environmentally-friendly and ecosystem-protecting agricultural policy in China. China has been increasing policy efforts to introduce a subsidy and reward mechanism for adopting more environmentally friendly practices, and restoring and protecting ecological environment as well as providing technical assistance. Nonetheless, policies to maintain self-sufficiency in grain production still account for a large part of producer support. The OECD indicator of producer support shows that China's payments conditional on the adoption of specific production practices was 1.2% of total producer support in 2014-16, whereas in the European Union and the United States the majority of support has such conditionality (Figure 5.5).[13]

Figure 5.5. Support conditional on the adoption of specific production practices, 2014-16

As a percentage of producer support



Source: OECD (2017), "Producer and Consumer Support Estimates", OECD Agriculture statistics (database), http://dx.doi.org/10.1787/545b3853-en.

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In this setting, China should also ensure that its ongoing policy programmes do not impede its sustainability objectives. Previous OECD work has demonstrated that input subsidies and market price support are particularly problematic (Van Tongeren, 2008). China should review its policies and strive to reduce environmentally harmful support; it should also ensure that it effectively meets its intention to move towards decoupled farm payments, which are much less likely to motivate farmers to misuse resources. It should also strive to ensure that its productivity and environmental objectives can support each other. China is shifting its agricultural policy orientation from boosting production to preserving production capacity and promoting structural adjustment. The reform to consolidate direct payments to producers and decouple them from input price movements is an important step in this policy direction.

Although monitoring of environmental performance at farm level is a challenge for many OECD governments, it is particularly challenging for China, which is dominated by a large number of small-scale farms. Scaling up soil testing at the field level will increase monitoring costs.[14] Making existing direct payments conditional on the recipient’s compliance with environmental standards could be an effective policy tool to reduce the cost of monitoring environmental regulation at the farm level. However, experience in OECD countries shows that such conditionality may not be effective unless it is adapted to the diversity of local farming practice and conditions.[15] The European Union’s experience in attaching cross-compliance requirements to direct payment programmes can be relevant for China (Box 5.7).

Box 5.7. Cross-compliance in the European Union

The EU approach to cross-compliance includes partial or full loss of payments if the farmer fails to comply with mandatory standards stemming from existing legislation and the maintenance of good agricultural and environmental conditions. Cross-compliance creates a link between several separate policies, amongst them income support and selected statutory standards or requirements. These relate to environment, animal and plant health, public health and animal welfare and identification and registration of animals, and are enshrined in existing laws. By introducing reduction of payments due to non-compliance, the effectiveness of enforcement of existing environmental laws could be expected to increase.

Primary legal enforcement of environmental legislation is carried out through European Union member states' sanctioning systems. Cross-compliance assists in reinforcing respect for the basic requirements and standards, avoiding support to farmers that do not abide by these rules.

The European Union uses a system in which both statutory requirements and voluntary commitments are complementary. Farmers receiving agri-environment payments for voluntary commitments must in any case respect the mandatory standards. In that sense, the European Union cross-compliance system already provides the baseline for calculation of payments for agri-environmental measures. EU member states and regional authorities define the cross-compliance standards on the basis of the EU framework, adapting them to local conditions in order to deal with heterogeneity in local circumstances.

Cross-compliance neither directly pursues an income support objective nor comprises the primary mechanism for enforcing environmental legislation. Rather, cross-compliance is a tool linking payment schemes to respect for a wide array of mandatory requirements and fostering adherence to them.

Source: OECD (2010a), Annex B.

5.3. Agricultural trade policies

Overall, China has had low tariffs on agricultural products for most commodities since its accession to the WTO. At present, the simple average applied tariff rate of China's agricultural imports is 15.6%. According to World Tariff Profiles 2015 (WTO, 2015), China's tariff rate on agricultural products is relatively low, with bound tariffs accounting for 64.4% and slightly high applied tariffs accounting for 66.3% for duties less than 15%. Imported agricultural products in the 15%-duty category account for 78.9% of total imports (Table 5.2). In addition, there is no tariff peak over 100%, and a very limited number of tariffs over the range of 50% to 100%.

Table 5.2. China's tariffs on agricultural products

Frequency distribution by duty ranges (in %)

		Duty-free	0<=5	5<=10	10<=15	15<=25	25<=50	50<=100	>100
Final bound		6.0	7.0	25.8	25.6	26.2	7.0	2.3	0.0
MFN applied	2014	7.5	9.1	25.7	24.0	24.7	6.4	2.6	0.0
Imports	2013	0.9	42.1	24.4	11.5	5.1	12.4	3.5	0.0

Source: World Trade Organization, International Trade Centre and UNCTAD (2015), *World Tariff Profile*, WTO Publications, Switzerland.

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By April 2016, China had endorsed twelve ***Free Trade Agreements*** (FTAs) with Australia, South Korea and other countries. The China-ASEAN FTA is to be upgraded after another round of negotiation. Eight FTAs are under negotiation and four are planned. In addition, the Asia-Pacific trade arrangements are preferential trade arrangements. According to relevant free trade area agreements, China is committed to opening up agricultural products to the outside world, except those on the negative list like grain (rice, corn and wheat), vegetable oil (soybean oil and palm oil, etc.), sugar, tobacco, and cotton.

Specifically, the Early Harvest programme of the China-ASEAN FTA covers products included in Chapter One to Eight of *Customs Tariff*. China protects such agricultural products as corn, rice, indica rice, wheat, sugar, tobacco, and combed cotton. The excluded products of the China-Chile FTA are grain, vegetable oil, sugar, tobacco, and cotton. The same applies to the China-Australia FTA and China-New Zealand FTA. The China-ASEAN FTA has opened markets of vegetables, fruits, and aquatic products, and the market of animal by-products is nearly open in the China-Australia FTA and China-New Zealand FTA.[16] China's agricultural markets are becoming more open to the outside world as China establishes more free trade areas with other countries.

China currently ***imposes import tariff quotas*** on wheat, corn, rice, sugar, cotton, wool and wool top. Based on regulations on tariff quotas of products, issued by NDRC and the Ministry of Commerce, the tariff quota of wheat is 9.636 million tonnes 10% of non-state trade; that of corn 7.2 million tonnes, 40% of non-state trade; and that of rice 5.32 million tonnes (half long-grain rice and half medium- and short-grain rice), 50% of non-state trade in 2016. The amount of sugar within the tariff quota is 1.945 million tonnes, 70% of which is state trade; the quantity of cotton is 894 000 tonnes, 33% of state trade; the amount of wool is 287 000 tonnes, and wool top 80 000 tonnes (Table 5.3).

The in-quota duty rate for wheat, corn, unhusked rice and rice is 1%, and the out-of-quota most favoured nation tariff is 65%; the in-quota duty rate of sugar is 15%, and the out-of-quota most favoured nation tariff is 50%; the in-quota duty rate of cotton is 1% and the maximum 40% of sliding duty rate is for the out-of-quota cotton; the in-quota duty rate of wool and of wool top is 1% and 3% respectively, and their out-of-quota duty rate is 38%.[17]

Table 5.3. China's agricultural products in tariff-quota management

	Quota (million tonnes)	State trade	In-quota duty (per cent)	MFN rate
Wheat	9.64	90	1	65
Rice	7.20	60	1	65
Unhusked	5.32	50	1	65
Sugar	1.95	70	15	50
Cotton	0.89	33	1	sliding tax
Wool	0.29		1	38
Wool top	0.08		3	38

Source: NDRC and MOC.

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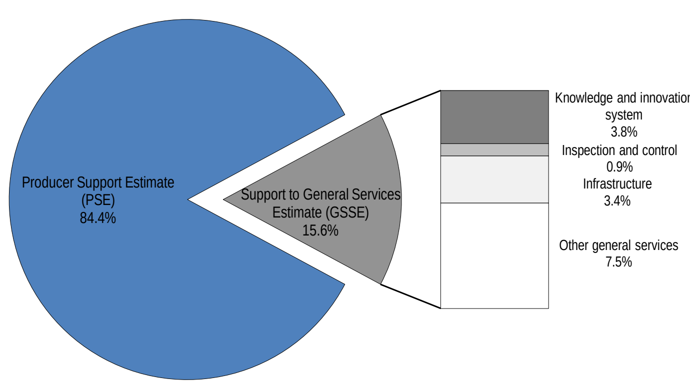
5.4. General support to the agricultural sector

The OECD producer indicator also provides a measurement of budgetary transfers on ***general service support to the agricultural sector***. It includes agricultural R&D, education and training, inspection and quarantine management, and infrastructure investment – all of which potentially have a positive long-term impact on China's agricultural innovation and productivity growth. China also provides marketing promotion and public stockholding as a part of general service to the sector. Their importance in total support to agriculture compared with support to individual producers reflects the policy emphasis on providing long-term investment to the sector.

China's expenditure for general services support has grown at a slower pace than support to individual producers, reducing the share of GSSE from 44% in 1995-97 to 16% in 2014-16 (Figure 5.6). The share of China's total support to agriculture including both GSSE and PSE as a share of gross domestic product (%TSE) was 2.4% in 2014-16. This indicator represents the burden of policies supporting agriculture on the whole economy. For China, this indicator is the fourth highest (Figure 5.7A).

Figure 5.6. Composition of support to agriculture in China, 2014-16



Source: OECD (2017), "Producer and Consumer Support Estimates", OECD Agriculture statistics (database), http://dx.doi.org/10.1787/545b3853-en.

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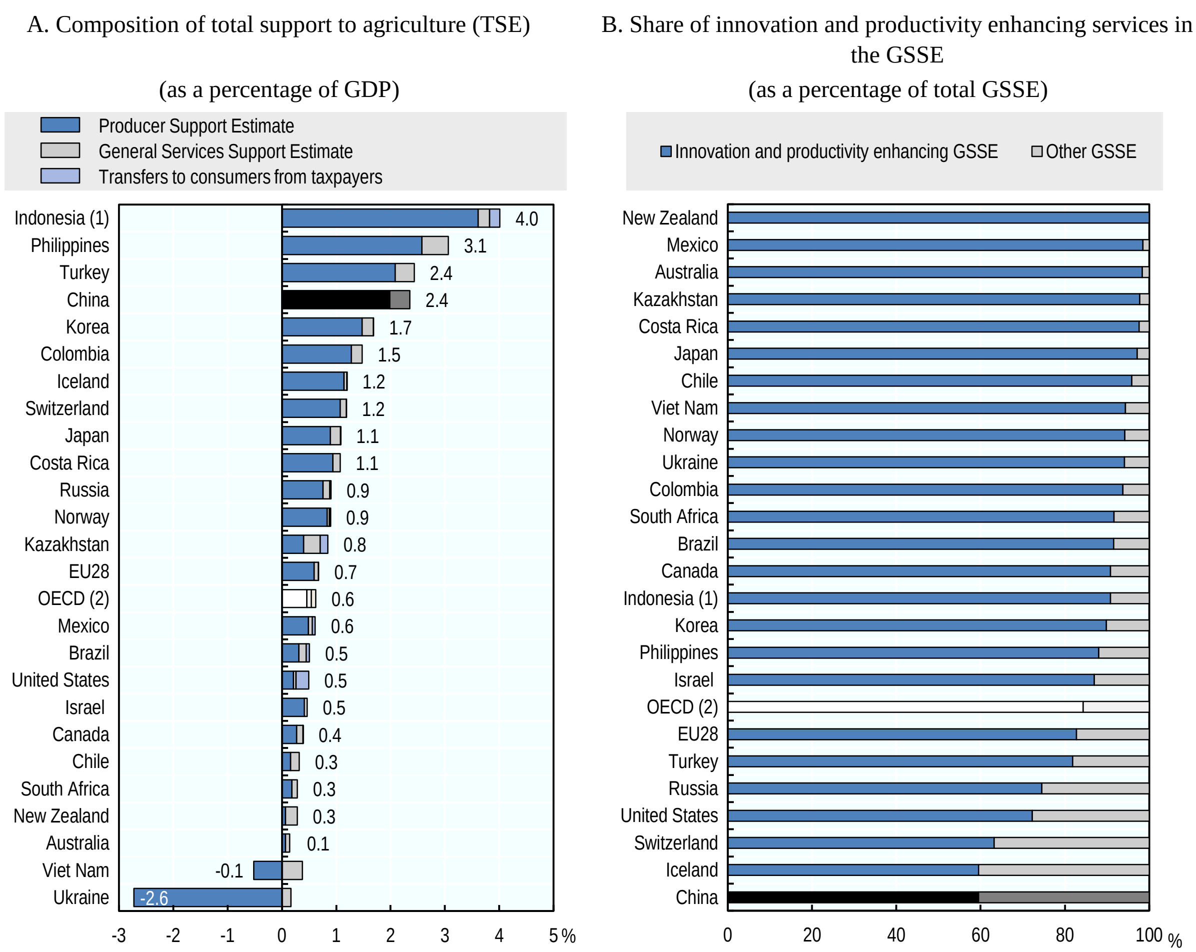
The cost of public stock holding has the largest share in GSSE in China, while its share declined from more than half until 2004 and 38% in 2014-16. China has gradually been increasing its innovation and productivity-enhancing service expenditures. As China attaches more importance to agricultural R&D, education and training, and technology extension, the share of support for the agricultural knowledge and innovation system has increased from 8% in 1995-97 to 25% in 2014-16. As a consequence, the share of innovation and productivity-enhancing services in GSSE, which also include the development and maintenance of infrastructure, was 59% in 2014-16 – lower than OECD average of 83% (Figure 5.7B).

Figure 5.7. Composition of support to agriculture, 2014-16



1. Data for Indonesia refer to 2013-15.
2. The OECD aggregates do not include Lithuania.
Source: OECD (2017), "Producer and Consumer Support Estimates", *OECD Agriculture statistics* (database). http://dx.doi.org/10.1787/545b3853-en.

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5.5. Summary

Over the last three decades, agricultural policy objectives in China evolved significantly, reflecting the different roles that agriculture plays at different stages of economic development. The policy objectives have been diversified from increasing the quantity of food production to ensuring food safety, increasing farmers' income, enhancing competitiveness and improving environmental performance.

Recently, the emphasis of food security policy shifted from boosting production towards using more international resources and markets while preserving domestic production capacity. This is a reasonable policy direction considering the cost of maintaining high self-sufficiency rate in grain production in China. Greater integration with international markets and decoupling of support from production would optimise the domestic agricultural structure and reduce the pressure on the environment and national resources. Recent reform to replace intervention prices by direct payments based partly on area planted is one step in this direction. Reform of the price support policy for rice and wheat is already underway, reducing or capping the minimum purchase prices. In the future, China should consider shifting the domestic price support to rice and wheat to a direct payment system.

China has been increasing public expenditure for the general service support to enhance innovation and productivity growth, such as public investment in R&D and infrastructure; however, the cost of public stockholding remains the largest part of the expenditure to general service support to agriculture. The portfolio of agricultural support could be further rebalanced to reflect the policy emphasis on long-term productivity growth and sustainability.

China developed area-based direct payment programmes such as direct payments for grain producers, agricultural input payments and an improved seed variety subsidy. Recent policy reform consolidated these payments into a single payment supporting the maintenance of grain production capacity rather than boosting production itself. It also focuses more on larger farms. However, the policy should not interfere with farm management decisions, including what to produce and what size of operation farmers choose. The payments targeted to large-scale farms could be counter-productive. Moreover, the income support through direct payment only has a transitory role to support the farmer's adjustment to a new policy and market environment. The payments should be decoupled from commodity production and introduced as a transitional measure which is time-bound. Such payments would enhance production diversification to higher value crops and allow producers to set aside farmland while maintaining production capacity.

The subsidy for agricultural insurance premiums launched in 2007 became one of the key programmes to support producers. However, it is not a cost-efficient programme for increasing farm income as these instruments generate high transaction costs and rent-seeking behaviour by farmers and insurance companies. Insurance subsidies may lead to unsustainable choices of production and farm practices in the short term. They may also crowd out on-farm diversification strategies as well as the development of agricultural insurance markets. In general, insurance subsidies risk crowding out market-based solutions and own-farm risk management strategies, and may transfer to taxpayers a part of the risks that should be borne by farmers.

Improving the environmental performance of agriculture has recently become a major objective of agricultural policy. China has been increasing policy efforts through strengthening regulations as well as introducing incentive measures. However, existing agricultural policy instruments are still largely focused on maintaining grain self-sufficiency. Price support policies induce intensive production, leading to an excessive use of inputs. Existing agricultural policy instruments should be reviewed to improve their coherence with environmental objectives.

Designing agri-environmental policies requires the definition of environmental quality reference levels and environmental targets, which play a crucial role in choosing policy instruments. While the reference level is the minimum level of environmental quality that famers are required to provide at their own expense, environmental targets represent a voluntary (desired) level of environmental quality. To establish a solid framework of agri-environmental policies, China should further clarify reference environmental quality levels and targets which are well adapted to local ecological conditions.

China has built a regulatory framework of environmental protection, but effectively enforcing environmental regulations and increasing producer's awareness remains a major challenge. The compliance to environmental regulation can be enforced more effectively with complementary incentive measures. For example, making direct payments conditional on the recipient's compliance with environmental standards could increase the farmer's incentive to comply with environmental regulations and reduce the cost of monitoring environmental regulations at the farm level, given that the farm structure in China is dominated by small-scale producers. However, experience in OECD countries shows that such conditionality would not be effective unless it is adapted to the diversity of local farming practices and conditions.

In addition to strengthening the enforcement of environmental regulations to ensure compliance, agricultural policy can introduce mechanisms to encourage the adoption of environmentally friendly production practices. For example, while payments for long-term resource retirements and for restoring environmental condition have been introduced in China, payments linked to specific environmental actions by producers account for only 1.2% of total producer support and 4.2% of budgetary transfer to producers in 2014-16. In contrast, the majority of payments in the European Union and the United States have such conditionality. Voluntary targeted payments rewarding better practices in key environmental areas are one potential tool to compensate for the additional costs associated with improving environmental performance beyond the reference level. Such payments can be introduced by reorganising the existing area-based direct payments so that some part of the payments is conditional on famer's additional adoption of environmentally friendly production practices. Considering China's small and fragmented farm structure, community-based policy which supports groups of farmers in localities such as watershed areas in setting up voluntary co-operative arrangements among themselves to collectively address common problems such as water pollution and soil erosion may also reduce the monitoring cost of small farms and may increase the policy impacts on environmental conservation.

Notes

[1] Both a widening income gap between farmers in developed areas and underdeveloped areas and between farmers in major grain-producing areas and other areas.

[2] The priorities include protecting farmland, promoting sustainability of farmland; saving and efficiently using water, ensuring agricultural water availability; controlling environmental pollution, improving agricultural and rural environment; restoring agricultural ecological environment; improving ecological functions; protecting soil and water resources; optimising agricultural and rural environment, protecting and restoring agricultural ecological environment.

[3] In 2014-16, the domestic price of rice exceeded the international price by 48%; and wheat and corn prices were 62% and 41% higher than international prices, respectively. Although a target price subsidy was implemented for soybeans and cotton in 2014, their domestic prices remained higher than international prices by 27% and 41% in 2014-16, respectively. However, it is foreseen that prices of soybeans and cotton will be gradually brought into line with the international market, as China reduces the direct market intervention through minimum price purchases and replaces them with deficiency payments for these products.

[4] Major producing areas of early indica rice comprise five provinces (Anhui, Jiangxi, Hubei, Hunan, and Guangxi); those of late rice (including medium and late indica rice and japonica) comprise eleven provinces (Jilin, Heilongjiang, Anhui, Jiangxi, Hubei, Hunan, Sichuan, Liaoning, Jiangsu, Henan, Guangxi); those of wheat comprise six provinces (Hebei, Jiangsu, Anhui, Shandong, Henan and Hubei).

[5] In 2008, rice was subject to temporary purchase and storage policy, while no minimum purchase price policy applied to rice.

[6] Special sites are set up to monitor the average market purchase price in a certain period. Subsidies are granted based on actual planting area, yield or trading volume.

[7] It is an average output when agricultural tax was levied in the 1980s and 1990s.

[8] To adjust the overall spending on this programme, the central government followed a "dynamic adjustment system" that ties projected levels in fertiliser, diesel and other agricultural input prices to the amount of the subsidy.

[9] Examples include spray-prevention technology for wheat, agricultural film covering technology for dry crops, and comprehensive use of fertiliser to promote early ripening of rice.

[10] Such as subsidies for compulsory immunisation to prevent major animal diseases, stamping-out animal diseases, grass-root animal disease prevention and control, pro-environment disposal of pig carcasses in breeding farms.

[11] See Figure 4.4for the composition of the area of arable land converted to other uses including ecological use supported by the government programme.

[12] The project particularly emphasises three initiatives: promoting comprehensive technology to return crop residues to the fields, particularly straws from rice cultivation in the south and maize straws in the Northern China Plain; intensifying the adoption of the technology of soil fertility through utilisation of straw, organic fertilisers and organic fertiliser crops, and soil conditioner; and construction of green manure demonstration zones. These efforts were planned in 2015 for selected counties to improve the fertility of the black soil in Heilongjiang, Liaoning, Jilin, and Inner Mongolia

[13] In China, four payments based on non-commodity criteria related to long-term resource retirement are conditional on the adoption of specific production practices: the Returning Grazing Land to

Grassland Project, Grain for Green Programme/Return Farmland to Forest Programme, Returning Farmland to Grassland Project and payments for grassland vegetation recovery.

[14] Community-based measures may also reduce the monitoring cost of small farms and may increase the policy impacts on environmental conservation. Financial support based on their environmental performance at the community level utilises the social capital of the community, facilitating monitoring by community members and reducing the cost to the government. For example, Japan introduced a direct payment programme for environmentally-friendly farming. It is based on two tiers: one tier provides payments to the joint activity of the community on environmental preservation, and another tier provides additional payments to individual producers adopting higher environmental standards.

[15] Comparing different cross-compliance approaches or cross-compliance and other approaches and policy mixes (such as agricultural support payments with no environmental conditions attached or with targeted agri-environmental payments) to achieve farm income and environmental objectives is an empirical question and is dependent on the baseline chosen for making such comparisons. OECD (2010b) provides a "checklist" of the criteria to weigh up the advantages or disadvantages of cross compliance approaches.

[16] Special safeguard measures were included in both the China-Australia FTA (on beef and dairy products) and the China-New Zealand FTA (on dairy products) based on import quantity.

[17] In line with Foreign Trade Law of the People's Republic of China, the Ministry of Commerce issued the following "List of State-owned Trading Enterprises". Food: China National Cereals, Oils and Foodstuffs Corporation. Sugar: China National Cereals, Oils and Foodstuffs Corporation, China Export Commodity Base Construction Corporation; China National Sugar & Alcohol Group Corporation; China Commerce & Foreign Trade Corporation. Cotton: China National Textiles Import and Export Corporation; Beijing Jiuda Textile Group; Tianjin Textile Supply and Marketing Company; Shanghai Textile Raw Materials Corporation.

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Chapter 6. The agricultural innovation system in China

This chapter describes the Agricultural Innovation System in China and outlines the recent changes it has undergone. It first provides an overview of the general innovation system; presents agricultural innovation actors and their roles in the system; outlines changes in roles and themes of R&D; and presents the main policy instruments and monitoring efforts. It also reviews the main trends in public and private investments in R&D, the funding mechanism and the means used to foster knowledge markets and networks. This is followed by an overview of policy incentives for the adoption of agriculture innovation, with an emphasis on the role of training and advisory services at farm level.

6.1. General innovation profile

Innovation is regarded as the most important engine to promote the sustainable growth of agricultural productivity in the People's Republic of China (hereafter "China"). Agricultural innovation includes technological advances which enable agricultural development to be decoupled from material inputs. It also includes innovation in business operation systems and management which enable the creation of a modern agricultural business sector based on household operations, interconnected via co-operation and alliances, and supported by services from other sectors in the economy. China's innovation-driven development strategy also defines innovation as a broad concept including scientific and technological innovation, management innovation, institutional innovation, business model innovation, organisational innovation, and cultural innovation.

The fundamental objective of agricultural innovation in China has been the enhancement of the supply capability of major agricultural products like grains to ensure food security. Recent policy documents in China such as the 2016 No. 1 Document of the State Council establish innovation as one of the most important policy agendas in agriculture. Its primary goals are the fostering of engines for healthy and sustainable agricultural growth and the promotion of sustainable agricultural development which is innovative, coordinated, green, open and shared.

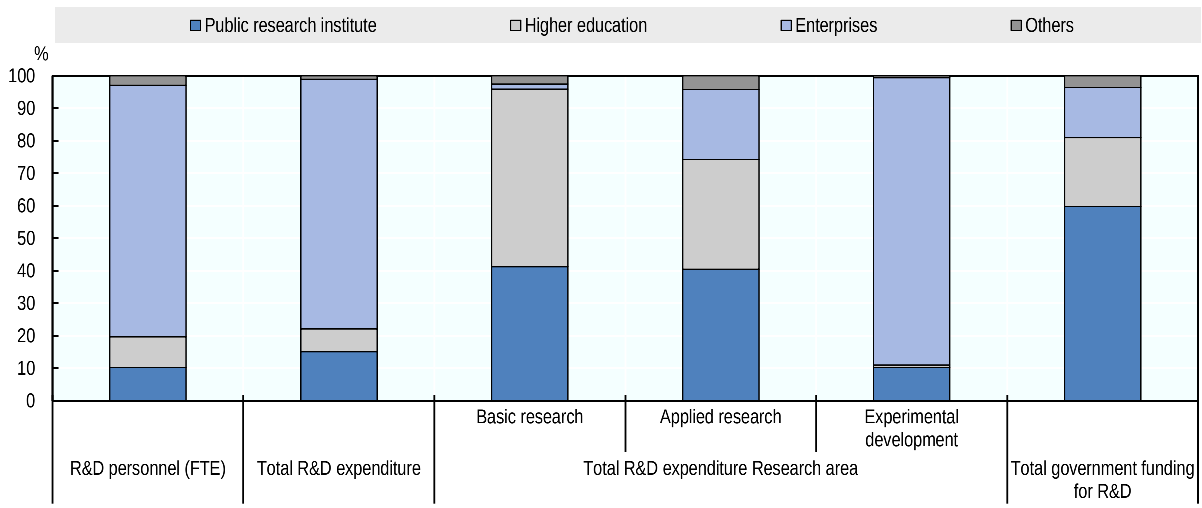
The No. 1 Document of 2017 emphasised strengthening basic research in agricultural R&D and enhancing innovation capacity through constructing national agricultural high-technology development zones and promoting public and private partnerships. It also strengthens the extension system of agricultural R&D, stressing the importance of public support to allow diverse actors to participate in extending agricultural science and technology. The Document urged improvement in the incentive mechanism for innovation in agricultural science and technology through: allowing researchers in public research institutions to work in the private sector; introducing an outcome-based compensation system; enhancing public support to basic research; establishing a differentiated technology evaluation system; and strengthening agricultural intellectual property rights.

Innovation in agriculture depends on innovation in the broader economy, for example through developments in ICT, biotechnology and nanotechnology, but also through marketing and non-sector-specific innovations. A thriving innovation system will ensure that general knowledge and specific knowledge in other fields (which are needed to develop and implement agriculture innovations) are available, and that economic actors and society in general share an innovation culture (OECD, 2015).

Gross expenditures in research and development (GERD) as a percentage of GDP are slightly lower in China than the OECD average. According to OECD statistics, China spent about 2.1% of GDP on overall research and development (R&D) in 2015, which is close to the EU15 average, and slightly lower than OECD average of 2.4%. The gap with the OECD average has been narrowing compared to the early 2000s, when the GDP share of gross R&D expenditure was less than half of the OECD average. In China, the government financed 21% of GERD, which is lower than the OECD average of 26% in 2015. The private sector has become the largest R&D performer in China, accounting for 74% of total R&D personnel and expenditure in 2015 (Figure 6.1).

The private sector in China contributed R&D outlays equivalent to 1.5% of GDP in 2015, exceeding the level as the OECD average. The intensity of private R&D investment increased more than three times since 2000, indicating the increasing role of the private sector in R&D in China Self-financing accounts for more than 90% of R&D expenditure in the private sector. By contrast, the share of the government funds in R&D expenditure in government research institutions and higher education was 84% and 64% in 2015, respectively.

Figure 6.1. Share of R&D by performers in China, 2015



Source: National Bureau of Statistics and Ministry of Science and Technology (2016), China Statistical Yearbook on Science and Technology 2016.

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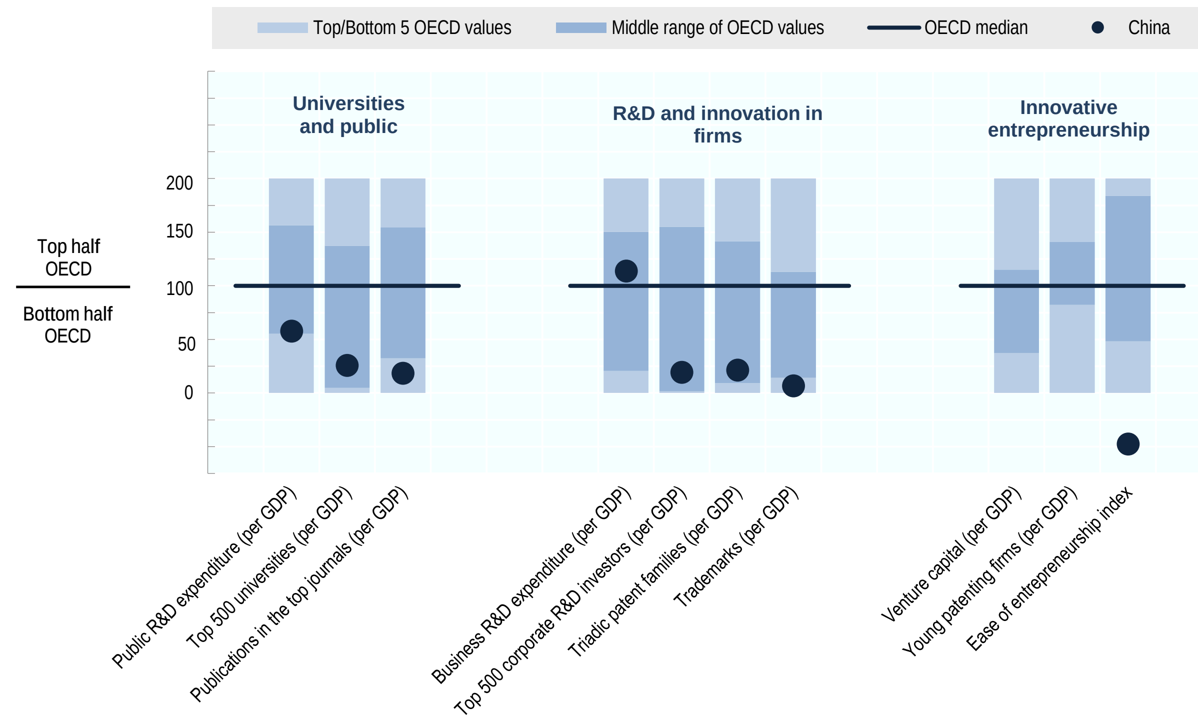
Overall, 5% of total R&D expenditure goes to basic research, while applied research and experimental development account for 84% and 11% of total R&D expenditure in 2015, respectively. The share of basic research is considerably lower than in most OECD countries spending more than 10% of GERD on basic research (e.g. 17% in the United States and 12% in Japan in 2015). Among the performers of R&D, nearly all the private R&D expenditure is experimental development, accounting for 88% of China's R&D on experimental development in 2015.[1] On the other hand, higher education concentrates more on basic research, accounting for the majority of China's R&D expenditure for basic research. Public research institutes account for approximately 41% of basic and applied research, but they allocate 57% of total R&D expenditure for experimental development.

While the financial input to China's innovation system is now comparable to most OECD countries, the system's output still lags OECD countries (Figure 6.2). China has fewer top 500 University and top 500 corporate R&D investors than expected, considering the size of its GDP. Similarly, publications in the top journals, triadic patent families (a set of patents registered in various countries) and trademarks are increasing in China, but remain below OECD medians if compared on a per GDP basis.

Figure 6.2. Science and innovation in China, 2016



Notes: Normalised index of performance relative to the median values in the OECD area (Index median = 100). The OECD aggregates do not include Lithuania.

Source: OECD (2017a), "China", in *OECD Science, Technology and Innovation Outlook 2016*, OECD Publishing, Paris, http://dx.doi.org/10.1787/sti_in_outlook-2016-58-en.

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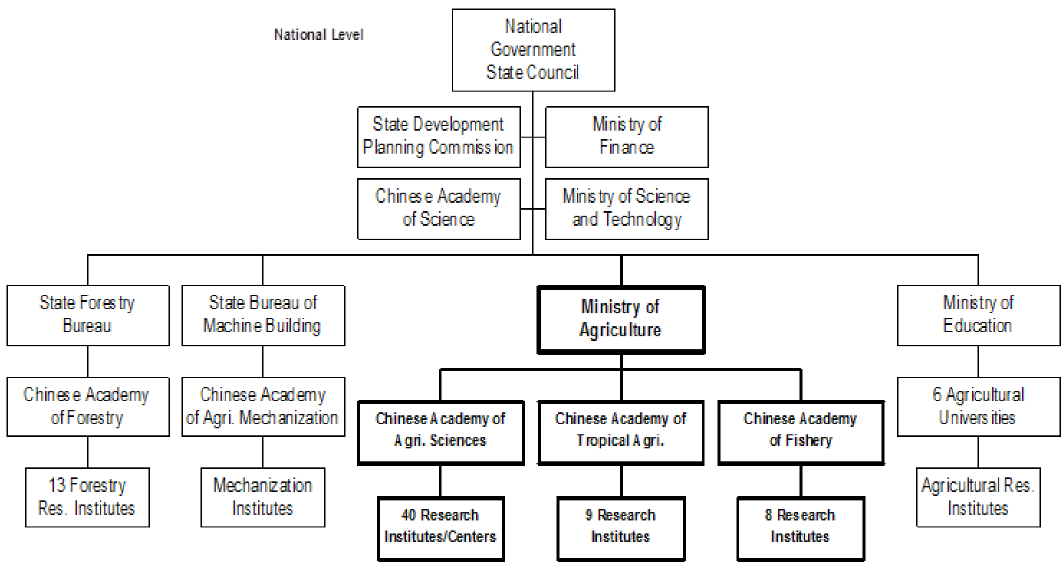
6.2. Actors, institutions and their roles in agricultural innovation system

The agricultural innovation system (AIS) in China functions as a part of the overall national science, technology and innovation system. The AIS is composed of a broad range of actors who enable, guide, fund, perform, implement, inform and facilitate innovation. The key players include government, public research institutions, industry, academia and other organisations (OECD, 2015). The main actors in AIS in China also include government, public research institutes, colleges and universities, enterprises and intermediate organisations. Family farms, farmer co-operatives, agricultural enterprises and other agribusinesses are important actors in the AIS (Table 6.1).

Both central and local governments are responsible for formulating, implementing and managing the policies related to agricultural innovation, developing the institutions and infrastructure to support agricultural innovation, and making investments. These governments are also directly involved in R&D and extension activities. For example, they fund agricultural R&D; provide education and training to human resources engaging in AIS; and are involved in extension and application of agricultural innovations through public and private agricultural extension services.

The government structure at the provincial and municipal level resembles that of the central government. The local governments are important actors in the innovation governance structure. Provincial counterparts exist for all the central government ministries and agencies. Science and Technology Commissions are established in each province, minority autonomous region and municipality. Provincial governments play a major role in policy making, implementation and financing R&D and innovation. However, OECD (2008) finds that the lack of a co-ordination mechanism between the central and provincial governments may reduce the efficiency of China's innovation system as a whole and delay the creation of a truly national system of innovation which makes optimal use of regional R&D and innovation resources and strengths.

Figure 6.3. China's public agricultural R&D system



Source: Huang, Hu and Rozelle, 2003.

Higher education institutions including colleges and universities undertake more basic areas of agricultural R&D and develop human resources for the AIS. Additionally, enterprises in the same industry or industry chain often form associations or alliances to implement joint R&D programmes and to learn from each other, complementing the resources available to each enterprise. Intermediary agents such as industry associations and farmers' co-operatives function as a bridge between farmers and other actors of AIS, including public research institutions, colleges and universities, and enterprises. Given the nature of China's agricultural structure, these intermediate agents play an important role in promoting the flow of knowledge, capital, information and talents, and matching the supply and demand of agricultural innovation.

Table 6.1. Major actors in the agricultural innovation system in China

Type	Participant	Role
Government	Central government Provincial government Municipal and county government	Designing rules and measures for supervising and stimulating innovation; providing basic knowledge, industrial generic technologies and infrastructure for technology innovation; providing capital and necessary conditions for innovation.
Public research institutions	Research institutes	Playing a leading role in basic research, applicable research and strategic technical development; undertaking high-risk research.
Colleges and universities	Universities Independent colleges	Incubators of talents and knowledge; central pillar bridging industry and scientific basic research
Enterprises	Trans-national corporations Large- and medium-sized enterprises Small-sized enterprises	Sponsoring and innovating new technologies and products; promoting the commercialization of science and technology achievements by applying their results.
Intermediary organisations	Industrial alliances Industrial associations Farmers' co-operatives	Functioning as a bridge between farmers, industries, R&D institutions to promote technology innovation.

AIS governance and coordination mechanisms

The governance of the AIS should ensure that national priorities are coordinated and communicated clearly, that progress is monitored, and policy outcomes and impacts are evaluated against the defined objectives. The integration of the AIS into the overall governance of the innovation system ensures a better use of public funds and increased efficiency through the pooling of different types of expertise.

In China, the leading group of science and technology education of the State Council oversees the innovation system and plays a key role in the decision-making for major innovation plans, including coordinating related ministries and agencies at the national level. The Ministry of Science and Technology (MOST) and the State Intellectual Property Office develop R & D innovation policy, including for agriculture. The Ministry of Agriculture (MOA), Ministry of Water Resources (MWR) and the State Forestry Administration then implement the agricultural R&D policy, together with the attached public R&D institutions. The National Development and Reform Commission (NDRC) and the Ministry of Finance (MOF) allocate public funding for innovation and the technological upgrading of various economic sectors, while the National Natural Science Foundation of China plays an important role in allocating resources for scientific research (OECD, 2008).[2]

China defines different responsibilities for the actors in AIS, including public agricultural R&D institutions at national, provincial and municipality level, experimental stations and enterprises' technology research and development centres (Table 6.2). The national agricultural R&D institutions perform research on key technologies, high- and new technologies with strategic significance, basic and applied agricultural research, as well as general basic scientific and technological work. Regional agricultural research centres are responsible for developing key technologies that have a broad application for regional industrial development. These centres also engage in applied basic and frontier research where China boasts strengths and specialty. They are also involved in integrating and transferring key technologies.

Agricultural science and technology experimental stations apply achievements of research in typical agricultural areas and agricultural ecological areas of different types, integrate such achievements, demonstrate experiments and spread technologies. The agricultural R&D divisions of enterprises conduct, on a commercial basis, independent research or combine production, learning and research to promote R&D and process improvement of agricultural inputs, and major agricultural and forestry processed products.

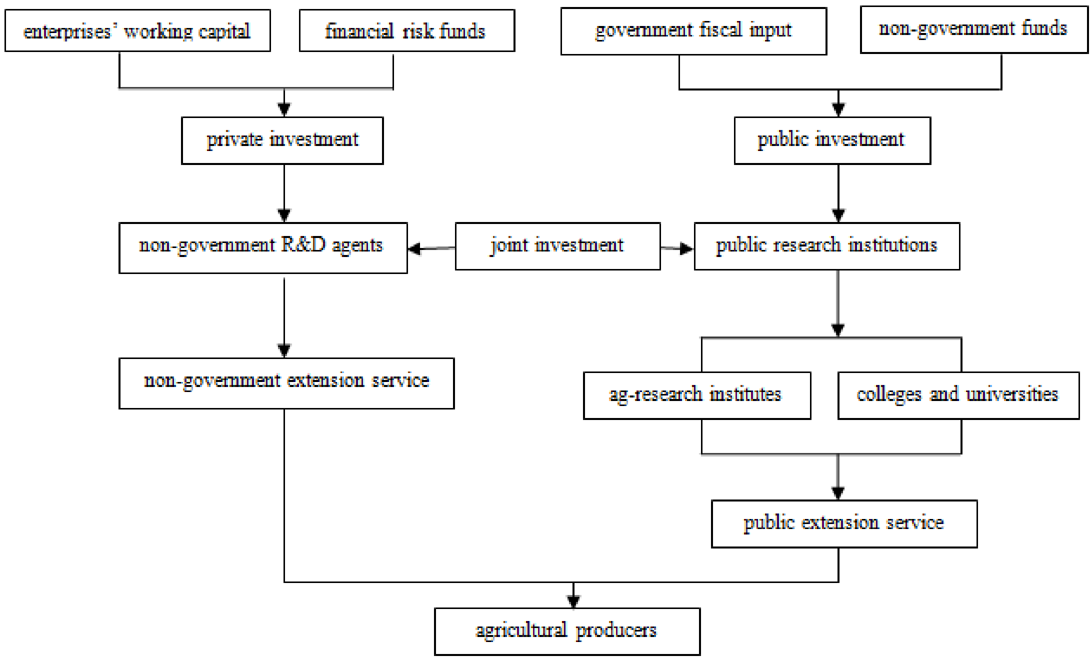
Table 6.2. Responsibilities of major participants in agricultural innovation system

	Basic research	Applied research	Experiment and development	Extension and application of results
Government	√	√	√	√
Public research institutions	√	√	√	√
Colleges and universities	√	√	√	√
Enterprises		√	√	√
Intermediary organisations				√
Agribusinesses				√

The government often plays a major role in investing in agricultural innovation, as certain agricultural knowledge and technologies have a public goods nature and it often takes time to get returns from the investment. The benefits of R&D often have a spill-over effect to other firms and consumers, justifying government investment in R&D. The market failure argument was originally formulated to bolster public support for basic research, but a recent economic study finds that large gaps in the social and private rate of returns apply for a wide range of industries, including agriculture (Pardey, Alston and Ruttan, 2010). However, the public sector could crowd out private investment in agricultural R&D if it competes with private investors in the development of new technologies. This is not the case if public sector focuses on the areas where a large gap between social and private returns on investment exist (OECD, 2016).

In China, there are two sources of public investment in agricultural R&D. The first is investment from government departments, which have different focuses at different administrative levels (i.e. national, provincial and municipal level), or are sourced from different projects, such as from the National Natural Science Foundation, the Major National Science and Technology Projects, the National Key Research and Development Plans, the Guiding Projects for Technology Innovation, or the Innovation Base Projects and Talent Projects (State Council, 2014). The second form, not as common in China, is non-government funds coming from various donors, which is more likely to finance basic and non-profit agricultural research (Figure 6.4).

Figure 6.4. Investment in Agricultural R&D and innovation



In China, private investment in agriculture R&D takes the form of investment by enterprises, financial institutions and venture capital. The private sector mainly invests in agricultural R&D activities that have a high market return on investment. They tend to concentrate on applied and development research and on areas that protect their returns through the protection of their intellectual property rights. For example, private investors favour sectors such as food processing, agricultural chemical inputs, farming machinery, hybrid seeds and genetically modified crops breeding (Zhao, Liu and Yang, 2015). In general, good performance of the agricultural innovation system hinges on strong investment over the long term, and tripartite collaboration between education, research and industry to explore complementarities.

Several forms of joint investment in agriculture R&D between public and private funds exist in China. Private enterprises compete for public agricultural R&D projects. Alternatively, the government sometimes funds private R&D activity directly. The private sector may also participate in application of new technologies developed by government research institutions. Collaboration in R&D activities between public agricultural R&D institutions and the private sector is a common format of public-private partnership in agricultural R&D (Box 6.1). Agricultural producers and other agribusinesses adopt technologies based on scientific results and communicate their needs to agricultural R&D institutions and extension staffs. This encourages problem-oriented decision making for public R&D activity.

Box 6.1. Collaboration between public agricultural R&D institutions and private sector

In China, public R&D institutions have been collaborating with the private sector for the last decade to complement research funding and to apply R&D outcomes in practice. This allows public R&D institutions to share risk, deepen cooperation, and share research and development responsibility.

In general, five categories of collaboration exist. First, research staff in public R&D institutions engages in R&D activity in private enterprise on a part-time basis. This is one of the most simple and feasible modes of cooperation. Second, joint development of new technology has become a common model of cooperation: public R&D institutions, higher educational institutions and enterprises work together to develop new materials, new products, new technology, new equipment. The third model involves indirect cooperation between public R&D institutions and the private sector through intermediaries such as brokers, consulting firms, industry associations, federations and government agencies and departments. These intermediary institutions play a major role in bridging, monitoring and coordinating the cooperation. Fourth, public R&D institutions and the private sector sometimes establish a joint research institution. This model of cooperation can clarify the direction of R&D and reduce waste of resources, thus shortening the research cycle. It also can share the responsibility between researchers and the private sector, thus shortening the industrialisation cycle of R&D outcomes. Finally, public R&D institutions and the private sector could set up an enterprise. In the current legal framework, three types of companies are the most practical: a limited liability company; a joint stock limited company; a cooperative organisation.

The key objectives and priorities in overall science and technology development in China are set by the National Plan for Long- and Medium-Term Scientific and Technological Development (2006-2020) (State Council, 2006). The Plan aims to make innovation the driver of future economic growth and to build up an indigenous innovation capability in China. Based on this objective, the Plan has set the specific goal that science and technology development should contribute to 60% of economic growth and the intensity of R&D investment increase to 2.5% of GDP by 2020.[3] The National Plan for Science and Technology Talent Development (2010-20) addresses the business sector's need for innovative human resources through supporting the mobility of highly skilled personnel and investing in innovation platforms and key national laboratories to foster talented and leading R&D personnel.

The most recent 13th Five-Year Plan (2016-2020) called for an innovation-driven development strategy. Based on the Outline of the National Innovation-Driven Development Strategy published in May 2016, the State Council issued its 13th Five-Year Plan for National Science and Technology Innovation in August 2016. This Plan set the basic principles of science and technology innovation and announced 12 major targets; these targets included raising the national innovation capacity ranking to the top 15 in the world, and increasing the GDP share of the knowledge-intensive service industry to 20%. Additionally, development of productive, safe and ecological modern agricultural technology is included as one of the top ten strategic research areas. Following the 13th Five-Year Plan for National Science and Technology Innovation, the MOA issued the 13th Five-Year Plan for Agricultural Science and Technology Development in February 2017. This Plan lays out the objectives and targets of agricultural R&D up to 2020 (Box 6.2).

Box 6.2. 13th Five-Year Plan for Agricultural Science and Technology Development

The Plan announced three stages in the long-term objective of agricultural science and technology development: catching up to advanced country level in agricultural science and technology innovation capacity by 2020, becoming one of the leading countries by 2030, and being the leader of world agricultural science and technology innovation by 2050. The plan set three basic principles of agricultural R&D: 1) demand and problem-solution orientation; 2) following the basic principles of public, basic, socially-oriented and market mechanisms; and 3) independence and originality of innovation.

Based on the overall objectives and basic principles, the Plan identifies specific targets and indicators of outcomes for its reference period in 11 fields. For example, in the area of seed modernisation, the Plan aims to achieve 97% self-sufficiency of main crops and a contribution of more than 50% of grain yield growth from new variety through a breakthrough in the identification of genetic resources and developing high quality and more efficient seeds more suitable to farm mechanisation. The area of efficient use of agricultural resource sets a target of reducing agricultural non-point source pollution of nitrogen and phosphorus emissions by more than 30% through developing non-point source pollution control technology.

To achieve the targets, an action plan covering all the stages of agricultural innovation system includes: 1) development of agricultural science technology; 2) extension of technology; 3) human resource development; and 4) institutional innovation. In the area of science and technology development, priority is put on comprehensive solutions for regional agricultural problems, reducing chemical fertiliser and pesticide, farmland conservation, improvement of water use efficiency, livestock breeding, comprehensive mechanisation, waste recycling, safety and quality, and management of agricultural non-point source pollution.

The plan also proposes institutional reform to strengthen co-ordination between AIS actors, such as the establishment of an inter-ministerial coordination mechanism, improving the linkage between ministries and provincial government, and strengthening public and private collaboration. The reform of the organisation and management of innovation includes the establishment of a network model of science and technology innovation, a national innovation platform, comprehensive human resource development, and an effective monitoring and evaluation mechanism.

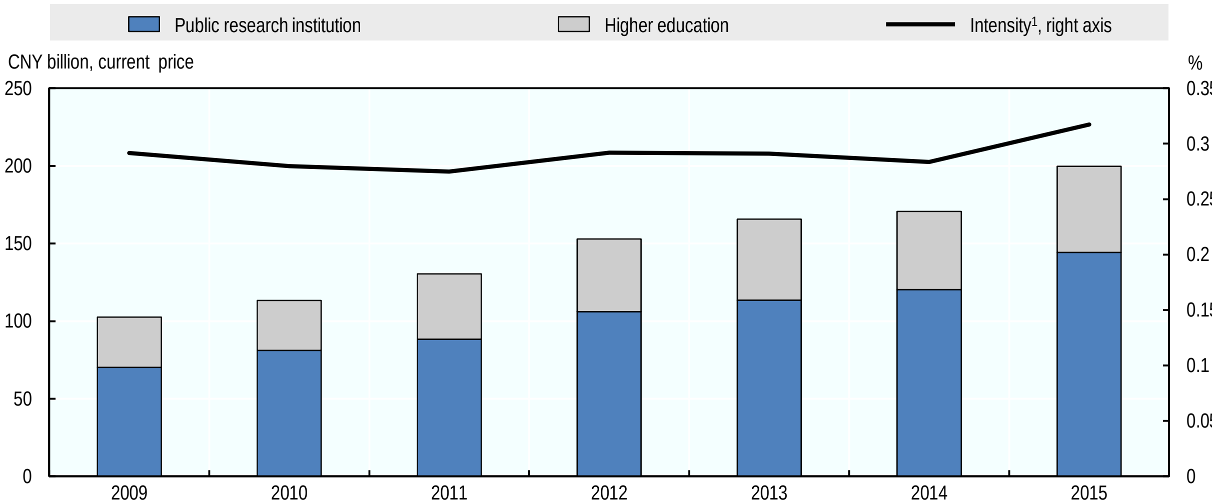
6.3. Investments in agriculture R&D

Trends in public agricultural R&D spending

In China, the majority of agricultural R&D spending is made by the government. Although information on private R&D expenditure in agriculture is not available in China's official statistics, Chen (2009) estimates that it accounts for only 10-20% of the overall investment in agricultural R&D. Public research institutions are the main performers of agricultural R&D activities, which account for 60-70% of the total public agricultural R&D expenditure in China. The public agricultural R&D spending by public research institutions and higher education account for around 0.3% of value added in agriculture, forestry and fisheries in recent years (Figure 6.5).

Public agricultural R&D expenditures in China more than doubled between 2002 and 2010, when measured in purchasing-power-parity (PPP) dollars (Figure 6.6). By contrast, public expenditure in the United States declined by 10% in the same period, overtaken by investment by the private sector. The rapid increase in the size of public expenditure for agricultural R&D in China in the last decade made China one of the largest investors in public agricultural research in the world.

Figure 6.5. Expenditures for public agricultural R&D in China, 2009 to 2015



Notes: R&D expenditure in public agricultural R&D institutions is defined as intramural expenditure on R&D in agriculture, forestry, animal husbandry, fishery and related service activities. Intramural expenditure on R&D in agriculture, forestry, livestock and fishery in higher education is estimated based on the share of expenditure for these disciplines.

1. Share in agriculture, forestry and fisheries value added.

Source: NBSC and MOST (2016), China Statistical Yearbook on Science and Technology 2016.

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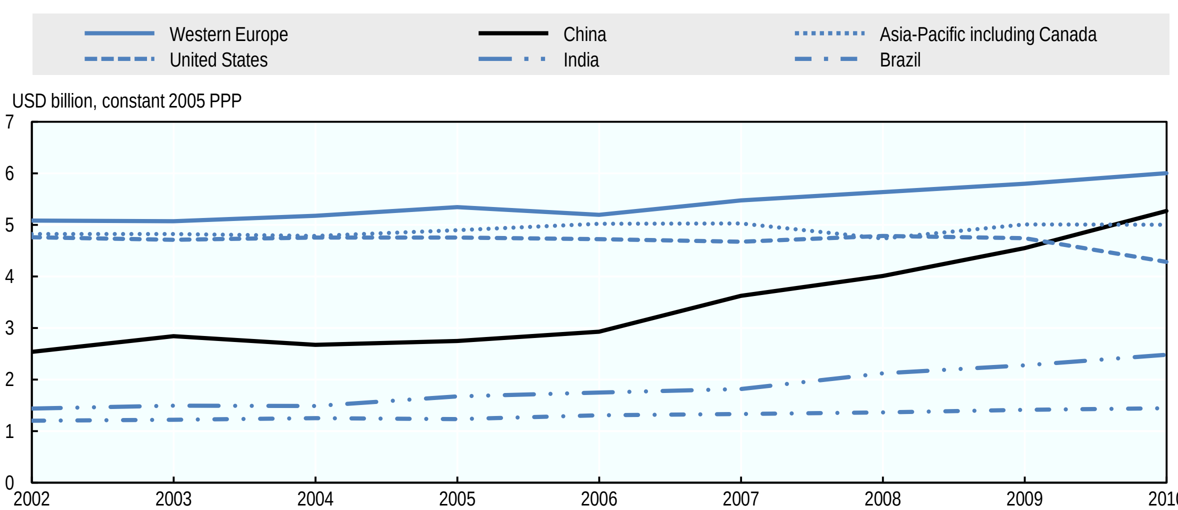
Figure 6.6. Expenditures for public agricultural research by China and selected countries and regions, 2002 to 2010



Source: Agricultural Science and Technology Indicators (2015) (ASTI), OECD and USDA (2015) Economic Research Service.

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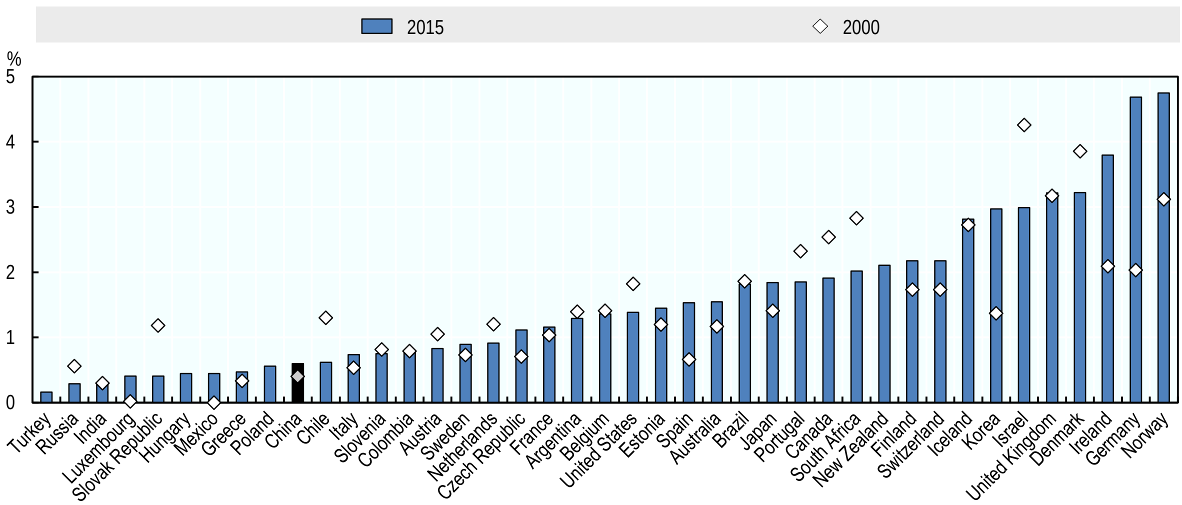
Despite an increase in public agricultural R&D expenditure, the intensity of agriculture R&D spending in China remains lower than most OECD countries and Brazil.[4] China's intensity in agricultural R&D is lower than the average intensity of 1% around the globe and 2% in developed countries (Figure 6.7).

Figure 6.7. Share of agriculture R&D spending as a percentage of agricultural gross value added, 2015 and 2000*



Notes: * or closest available year.
Total agricultural R&D spending (excluding private for-profit sector) includes salaries, operating and programme costs, as well as capital investments for all government, non-profit, and higher education agencies involved in agricultural research in the country.
Source: OECD (2017b), [Research and Development Statistics, National Accounts]; ASTI (2017) for Argentina, Brazil, Chile, China, Colombia and South Africa (accessed in June 2017).

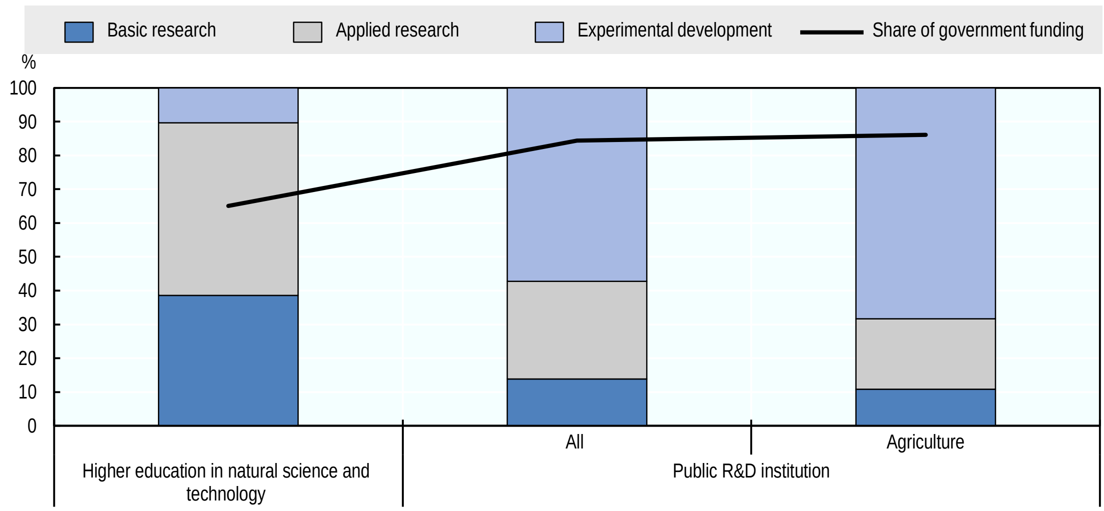
StatLink http://dx.doi.org/10.1787/888933829531

The public agricultural R&D institutions financed 86% of R&D expenditure with government funding in 2015, which is higher than the public R&D institutions in other research areas (Figure 6.8). By contrast, R&D expenditure in higher education is financed more by non-government funds, which accounted for 35% of R&D expenditure in natural science and technology in 2015. Although China is trying to establish a system of diversified channels of investment for public agricultural R&D, considerable room still exists for a greater involvement of the private sector. The role of the public R&D system in China needs to be redefined, increasing the agricultural R&D capacity in the private sector.

In the area of research, 68% of the expenditure of agricultural R&D in public agriculture R&D institutions in 2015 was directed to experimental development, and basic research accounted for 11%. By contrast, higher education institutions focus more on basic research, which accounted for 38% of their R&D expenditure. Public R&D investment should concentrate more on areas of public interest and on those in which the private sector would under-invest, such as basic and pre-competitive applied research.

The distribution of R&D expenditure in public R&D institutions and higher education in China shows a strong focus on the crop sector (Figure 6.9). In 2015, investment in the crop sector accounted for 56% both in public research institutions. While the share of livestock products in agricultural production has increased, public R&D investment still favours the crop sector, reflecting the self-sufficiency objective in grain production (Box 6.3).

Figure 6.8. R&D expenditure by research area and funding source in China, 2015



Source: NBSC and MOST (2016), China Statistical Yearbook on Science and Technology 2016; MOA (2016), National Statistics of Agricultural Science and Technology 2016.

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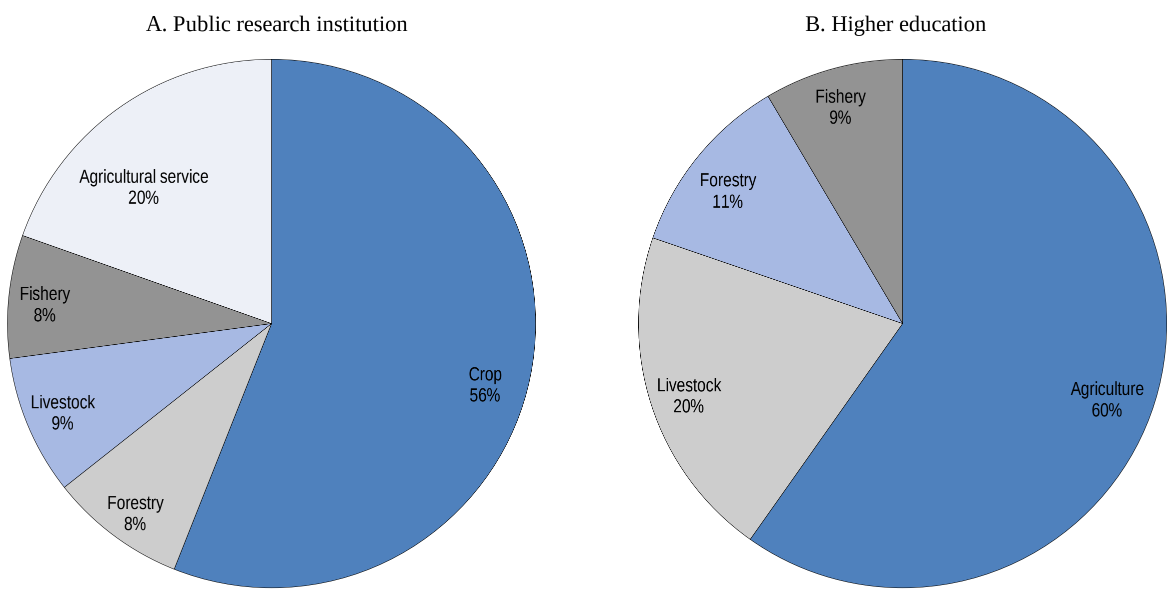
Figure 6.9. Distribution of agricultural R&D expenditure by area in China, 2015



1. Area of research is classified by industry area and discipline in public research institution and higher education, respectively.
2. Numbers may not add up to 100 due to rounding.
Source: NBSC and MOST (2016), China Statistical Yearbook on Science and Technology 2016; MOA (2016), National Statistics of Agricultural Science and Technology 2016.

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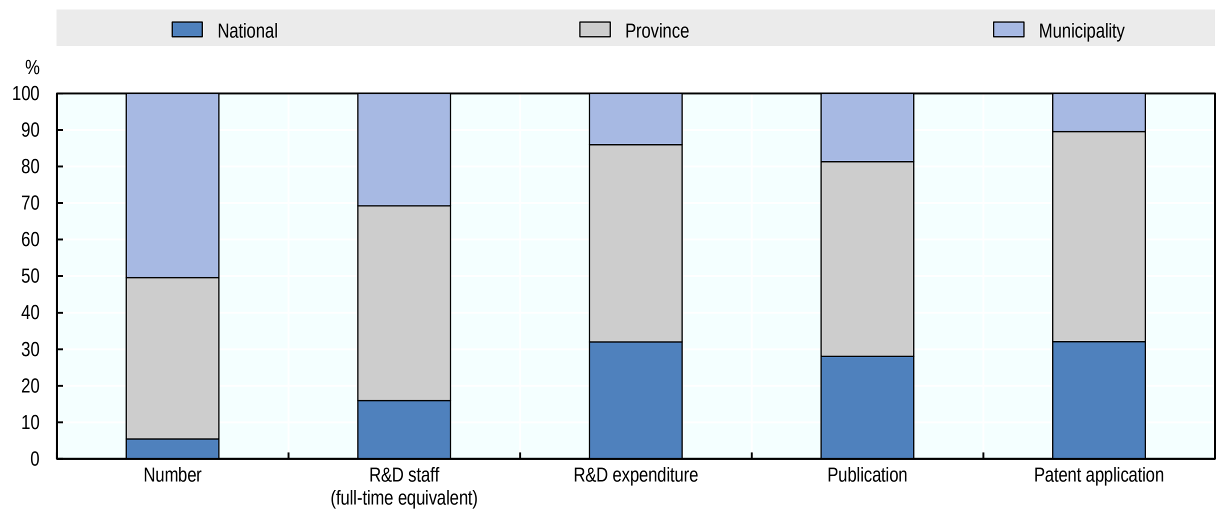
Public agricultural research institutions exist at national, provincial and municipality levels. The majority of R&D staff in public agricultural research institution is at the provincial level institutions, which account for more than half of the R&D expenditure (Figure 6.10).

The national level institutions, which belong to the MOA, account for 16% of overall R&D staff in public research institutions, but their share in R&D expenditure is around 32% in 2015. They also spent a higher share of R&D expenditure for basic research (21%) than those at provincial level (7%) and municipality level (2%). R&D on experimental development accounts for nearly 90% of R&D expenditure for the public research institutions at the municipality level.

Figure 6.10. Public agricultural R&D institutions at national and sub-national level in China, 2015



Source: MOA (2016), National Statistics of Agricultural Science and Technology 2016.

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Box 6.3. R&D of farm machines and seeds in China

Over the past 10 years, China has achieved remarkable results in developing large agricultural machinery for the plains of north and northeast China, but there is a lack of suitable machinery for the mountainous southwestern regions. In the future, mechanisation is expected to expand from grains to cotton, rapeseed, sugar cane, potato and forage as well as livestock production. The scope of mechanised tasks is also expected to expand from planting and harvesting to deep ploughing, deep loosening, prevention of plant diseases and insect pests, as well as marketing activities such as processing, packaging, warehousing, and transportation of agricultural products.

To encourage R&D in agricultural machinery technology, the Chinese government promulgated the Law on Promotion of Agricultural Mechanization in 2004, with articles providing support of capital, projects and policies for R&D, extension and social services of agricultural machinery. Since then, a series of documents have been issued emphasising support for agricultural mechanisation, such as the Opinions of the State Council on Promoting Fast and Sound Development of Agricultural Mechanization and Agricultural Machinery Industry, the Development Plan of Agricultural Machinery Industry (2011-2015), China's 12th Five-Year Plan of Agricultural Mechanization Technology Development (2011-2015), and China's 13th Five-Year Plan of Agricultural Mechanization Technology Development (2016-2020).

Over four decades after the opening-up reform, China has made significant achievements in agricultural biotechnology and other high-tech fields, like breakthroughs in core technology including hybrid rice, transgenic insect-resistant cotton, dwarf male-sterile wheat, and genetically engineered vaccines for major animal diseases. China has built a system for space-breeding technology to cultivate new varieties and strains of rice, wheat, cotton, green pepper and tomato; it has successfully applied, in a wide range, the technologies of livestock embryo transfer and splitting, gender determination and in vitro fertilisation, and produced test-tube sheep and cattle, clone sheep and cattle, and genetically-modified cattle. China has also fostered new high-quality aquatic species with nuclear transplantation and transgenic technology. In addition, China has selected core and micro-core germplasm of rice, wheat, and soybeans, and cloned a number of important genes. At the same time, further efforts are needed to strengthen survey, collection, protection, evaluation and use of germplasm resources, advance the reform concerning the rights and interests of R&D achievements in the seed sector, and speed up the cultivation of modern seed enterprises which are internationally competitive.

6.4. Fostering knowledge flow: Intellectual property protection

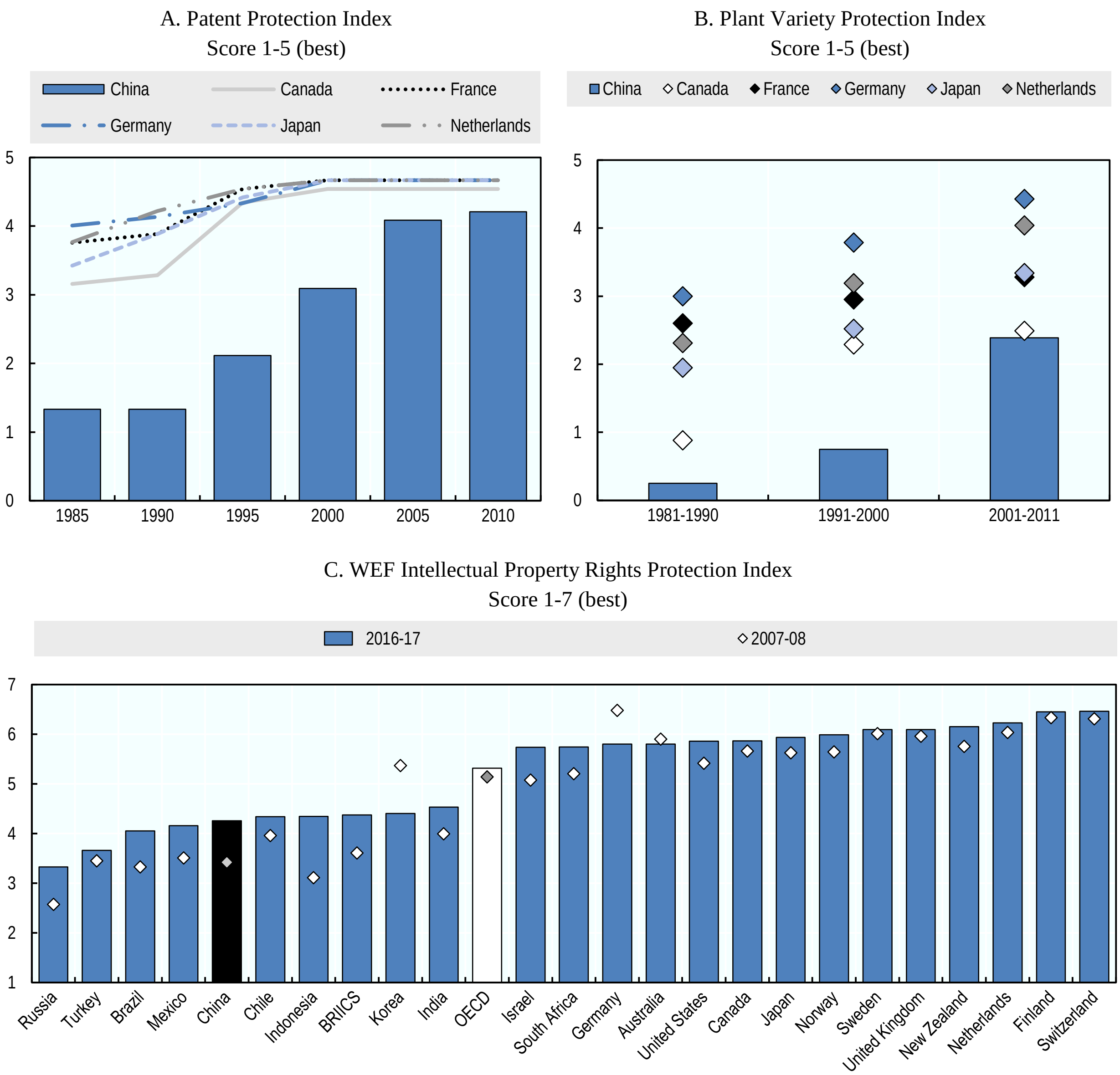
The fragmented structure of agricultural production (relatively small firms producing multiple homogeneous products) makes few farms willing to invest in private R&D activities. Meanwhile, the biologically self-replicating nature of improved crop seed and animal breeds complicates the ability of innovators to protect intellectual property (OECD, 2016). Private firms would not have an incentive to invest in agriculture R&D unless they can recover the cost of doing so. To foster private R&D, China should allow private firms to maintain exclusive control over their discoveries by protecting intellectual property rights (IPR).

Although a system granting inventors' certificates and exclusive patent rights has existed since the 1950s, the modern IPR protection system in China was established after the late 1970s, when the country initiated its opening-up reform policies. Since the 1980s, China has developed a number of laws and regulations covering the main areas of IPR protection and has continued strengthening them.[5] For example, the Patent Law first enacted in 1985 was amended three times (1992, 2000 and 2009). China has also issued a series of relevant rules for the implementation of these laws and regulations, and their legal interpretations.[6]

China is increasingly participating in the international rules of IPR protection. For instance, China joined the *Madrid Agreement Concerning the International Registration of Marks* in 1989, the *Universal Copyright Convention* in 1992, and the *Patent Co-operation Treaty* (PCT) in 1994. China also made comprehensive revisions to its laws and regulations regarding IPR protection and their legal interpretation prior to its participation to the WTO in 2001, to comply with the WTO's *Agreement on Trade-related Aspects of Intellectual Property Rights*. China joined the International Convention for the Protection of New Varieties of Plants and World Intellectual Property Organization Copyright Treaty in 1999 and 2007, respectively.

Several cross-country indicators confirm the improvement of IPR protection in China in recent years. For example, the patent protection index developed by Park (2008), which accounts for patent duration, enforcement, loss of rights, membership and coverage, improved significantly between 1990 and 2005 (Panel A in Figure 6.11). Similarly, the Plant Variety Protection Index, developed by Campi and Nuvolari (2013) shows an improvement, particularly during the 2000s (Panel B in Figure 6.11).

Figure 6.11. Intellectual property protection, selected years



Note: Indices for BRIICS and OECD are the simple average of member-country indices. The OECD aggregates do not include Lithuania.

Source: Unpublished update to the series from Park, W. G. (2008), "International Patent Protection: 1960-2005", Research Policy, No. 37, pp. 761-766 (panel A); Campi, M. and Nuvolari, A. (2013): Intellectual property protection in plan varieties: A new worldwide index (1961-2011), LEM Working Paper Series, No. 2013/09 http://hdl.handle.net/10419/89567 (panel B); World Economic Forum (2016), The Global Competitiveness Report 2016-2017: Full data Edition, Geneva 2016. www.weforum.org/reports/the-global-competitiveness-report-2016-2017-1 (panel C).

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Despite improvements, these indices show that China's IPR protection is still weaker than in most OECD countries. According to the World Economic Forum, IPR protection in China is still weaker than OECD and BRIICS averages (Panel C in Figure 6.11). The literature finds that the enforcement of IPR laws and regulations remains an issue (e.g.

Yueh, 2009). In China, enforcement can occur through the judicial system or the administrative system, but both judicial and administrative decisions are difficult to enforce owing to the lack of appropriate infrastructure and mechanisms as well as of manpower (OECD, 2008). Effective enforcement is often restricted by local government (Shi, Pray and Zhang, 2012). China should improve the enforcement of the laws, especially at the local level, to attract more private R&D investment in agriculture.

6.5. Facilitating knowledge flows and linkages within AIS

Reinforced linkages across participants in agricultural innovation can help match the supply of research to demand, facilitate technology transfer and increase the impact of public and private investments. Many agricultural technologies tend to be geographically specific, meaning that they do not transfer directly to other locations with different soil types, weather patterns, or topography. These features imply that unique policies to foster innovation in agriculture are required (OECD, 2016).

Traditionally, public agricultural extension services facilitate knowledge flows from public research institutes to producers. With the introduction of the household responsibility system in the late 1970s, China started to establish a public agricultural extension system (PAES), and had built extension service centres in all rural counties and municipalities by the mid-1980s. In 1985, to reduce public expenditure for the PAES, the central government started to encourage PAES to earn income through commercial activities such as selling farm inputs. However, some studies find that the conflict of interest that resulted from allowing public extension agents to pursue commercial activities resulted in weakening the public function of the extension system (Hu, Huang and Li, 2004; Qia, Zhang and Hu, 1999; Sun, 1993; Hu and Huang, 2001). In 2000, the government started to enhance the non-commercial function of PAES.

A MOA survey indicates that the government financed 80% of funding of the local extension organisations in 2011 (Zhong, 2014). PAES centres provide a range of services: introducing modern input factors to rural areas, including new technology, information, human resource management and capital. They also help to develop new businesses and to build agricultural technology parks and industrialisation bases. At present, they cover 90% of counties and municipalities. By the end of 2015, there were 16 000 technical service centres, housing 729 000 extension officers who provided technical services to 12.5 million farming households, equivalent to a total of 60 million farmers (MOST, 2016). Agricultural extension officers have three ranks according to experience and qualification, which is a part of the national vocational qualification system.

China also started an initiative to build agricultural technology parks to demonstrate new technologies and facilitate the collaboration between agriculture and other industries. National Agricultural Science and Technology Parks (NASTPs) are intended to create innovation hubs and an entrepreneurial chain to strengthen the transformation and incubation function of agricultural science and technology achievements. In 2001, MOST, MOA and six other Ministries jointly launched a pilot project to construct 65 NASTPs nationwide. By the end of 2015, 246 NASTPs had been established by both public and private funds. This system also combines non-profit and profit services, special and comprehensive services (MOST, 2016). Each park is composed of a core area, a demonstration area and an extended zone. The principle of the operation is defined as "government guidance, enterprise operation, intermediary participation, farmers benefit". The most recent 2017 No. 1 Document also promoted the development of NASTPs to demonstrate innovative technologies, apply R&D outputs, train human resources and support new business plans.

The Chinese government has also established a system for training and extension of agricultural machinery technology, including trials, demonstration and on-farm technical advice. Local governments and non-government organisations set up agricultural machinery leasing centres, harvesting machinery service centres and agricultural mechanisation associations; these provide comprehensive services related to the use of various agricultural machines, compensating for gaps in government services.

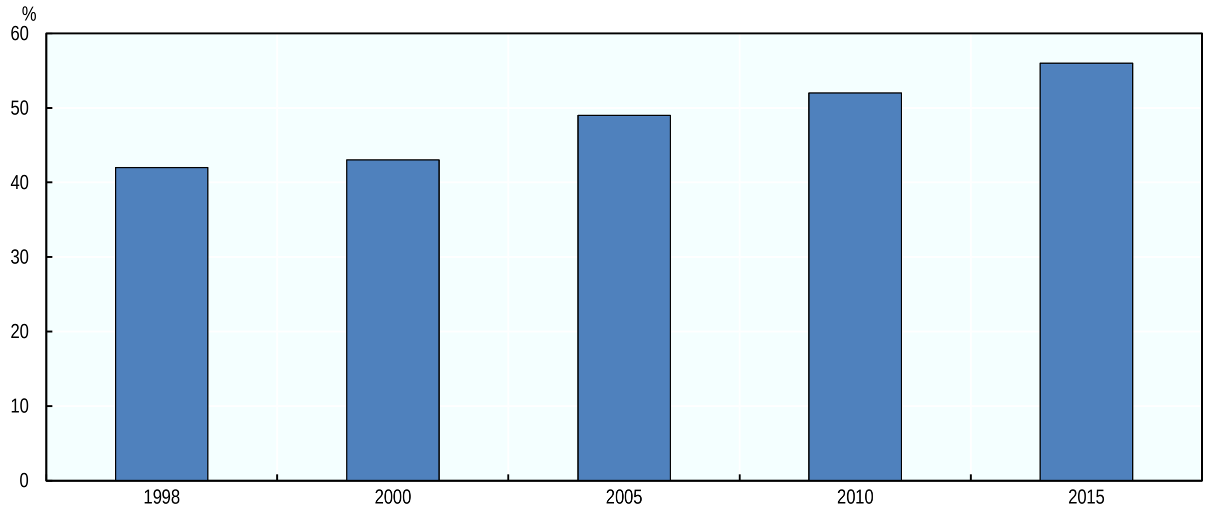
The government recently increased public support to training of farmers and agriculture co-operatives as a part of an initiative to foster the new professional farmer. For example, the central government allocated CNY 1.1 billion (USD 175.1 million) in 2015 to carry out training programmes for large specialised farmers, operators of family farms, leaders of agricultural co-operatives, personnel from agribusinesses and agricultural service providers, as well as returning migrated workers. This programme covers 4 provinces, 20 municipalities and 500 demonstration counties. Other programmes include training programmes for rural practical talents and for rural leaders with university degrees, the "million vocational school students" plan to increase the annual enrolment to vocational school to more than 70 000, and the National Top Ten farmers' funded projects.

Several forms of education and training of the new professional farmer exist in China. First, farmers' cooperatives offer training courses, which often meet the practical needs of farmers to understand technical issues such as rice cultivation technology. Second, some communities offer farming schools, which are normally designed for farmers who have lost land to find new employment in intensive agricultural production operations. Third, evening school is organised in many rural areas in China developing a "one village one product" initiative to produce a village speciality product. Training classes are organised at night to learn production and processing technologies such as planting tobacco and hybrid rice cultivation, off-season vegetable production technology and rice flour processing technology.

The government needs to ensure that outcomes and impacts of agricultural innovation policies are evaluated against their policy objectives. Monitoring progress in innovation across time and across countries can be useful in evaluating and adjusting R&D policy. Overall progress to create and adopt relevant innovations can be monitored by proxy measures, such as the number of patents and of bibliographic citations, which is available from international databases (OECD, 2015).

As a result of its increasing public investment in agricultural R&D, China achieved significant improvements in breeding technology for major grains. Along with subsidy polices for quality seeds and a public extension system to ensure 96% of crop seeds are of high quality, development of new breeding technology strongly supported the stable yield growth of major agricultural products. Per-ha yield of rice, wheat and corn increased by 9.9 %, 44.2% and 28.1% in 2000-15, respectively, achieving one of the highest yield levels in the world. But this has been achieved at the cost of increasing environmental pressure due to the intensive input use.

Figure 6.12. Contribution of Agricultural Science and Technology Progress to agricultural output in China, selected years



Source: Song Hongyuan (2000) and Han Changfu (2015a).

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Despite strong growth of output and productivity, China still lags OECD countries in creating new knowledge and technology in agriculture and food science. Although the number of patents is not a comprehensive indicator of R&D outcomes as not all innovations are patented, it can be considered as a proxy for the output of the R&D system.

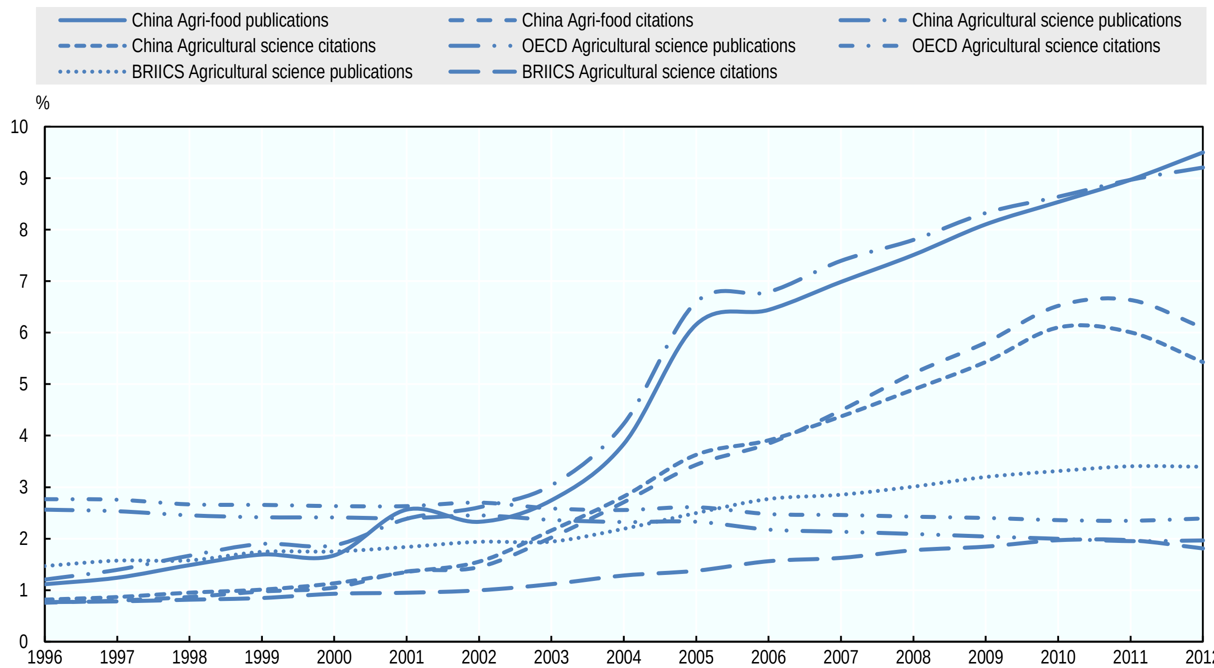
According to the agricultural patent application filed under the Patent Co-operation Treaty (PCT), which protects inventions in all signatory countries, China has become a significant contributor to total world agri-food patents (Table 6.3). China's share in patents is higher than OECD and BRIICS averages, but still lags that in the United States, the EU28 and Japan. Data on agricultural publications and citations also shows that China's contribution to world innovation increased rapidly from the early 2000s. China's share in global agri-food publication increased from 1% to 9% between 1996 and 2012, while the average contribution in OECD countries declined over time (Figure 6.13).

The number of applications for agricultural patents and new plant variety rights has been increasing in China; from 2007 to 2012, it grew by an annual average of 26%. According to the China Center for Intellectual Property in Agriculture, the number of applications and of those granted increased by 12.0% and 13.1%, respectively in 2013-14. However, there is still a large gap in the intensity of patent application between China and some OECD countries (Table 6.3).

Bibliometrics on agriculture and food sciences provide an additional measure of R&D outcomes. The number of China's agricultural science publications has been increasing rapidly since 2000, to the point that their share in the global total began to exceed that of the OECD. China's share in the world's agricultural science publications increased from 1.9% to 9.2% in 2000-12. Moreover, the number of China's agricultural science citations rose dramatically, from less than 2% to 6.1% of the world total between 2003 and 2010, outnumbering that of OECD (Figure 6.13).

Figure 6.13. Evolution of scientific output and impact in agricultural sciences, 1996 to 2012

Percentage of world output



Note: The OECD aggregates do not include Latvia and Lithuania.
Source: SCImago (2014), SJR — SCImago Journal & Country Rank, http://www.scimagojr.com (accessed March 2014).

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Table 6.3. Agriculture and food science R&D outcomes, 2007-12

	China	United States	EU28	Japan	Brazil	Russia	BRIICS average	OECD average
Agro-food specialisation: Agro-food science outputs as a share of country's total (%)								
Patents	2.8	6.8	5.7	3.5	11.0	5.4	3.8	5.6
Publications	5.1	6.7	8.4	6.8	19.4	5.2	12.3	9.4
Citations	6.8	6.3	10.7	6.9	15.5	5.2	12.0	11.9
Country's contribution to world agro-food science output (%)								
Patents	1.0	10.8	9.5	3.7	0.2	0.2	0.3	0.7
Publications	8.3	18.3	30.8	4.3	4.7	1.0	3.1	2.0
Citations	6.7	27.2	36.6	4.2	1.2	0.8	1.8	2.4

Note: Patent data refer to 2006-11.
Source: OECD Patent Database, January 2014; SCImago (2007), SJR - SCImago Journal and Country Rank, retrieved March 19, 2014, from http://www.scimagojr.com.

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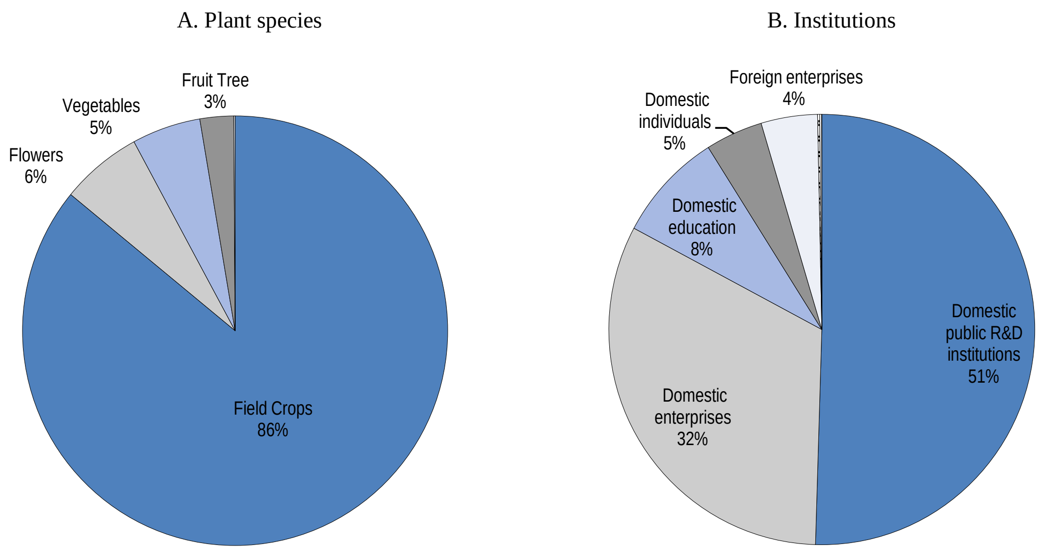
China applied for a total of 15 552 new plant varieties, 6 258 of which were granted for patent protection between 1999 and 2015. Field crops account for 86% of the new plant variety granted, followed by flowers, vegetables and fruit trees (Figure 6.14). In China, public R&D institutions received a majority of new plant variety rights, and foreign enterprises and institutions account for less than 4% of patents granted in 1999-2015.

During the 12th Five-Year Plan Period (2011-2015), China applied for the protection of 1 450 new varieties annually, a number that increased by 52% from the previous five-year period. Notably, in 2015, the number of applications of new varieties reached 2 000, reaching the second largest in the world (MOA, 2015a).

Figure 6.14. Share of new plant variety rights granted in China, 1999-2015



Note: Numbers may not add up to 100 due to rounding.
Source: NBSC and MOST (2016), China Statistical Yearbook on Science and Technology 2016.

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Box 6.4. R&D and production of transgenic crops

The Chinese government identifies biotechnology as a strategic industry. China's agricultural biotechnology research started in the early 1970s. In the late 1970s, China began R&D on genetic engineering technology. The sustained funding for biotechnology started under the National High Technology Development ("863") Program issued in Mach 1986. Transgenic crops in China were developed in the mid-1980s and virus-resistant tobacco was the first commercialised crop in early 1990. Although China has commercialised six genetically modified plants since 1997 (cotton, tomato, sweet pepper, petunia, poplar, and papaya), only papaya and cotton are in production today due to difficulties in bringing the products to commercialisation (GAIN-CH16065). Although the MOA approved the bio-security certificates of Bt rice and phytase maize, none has yet been approved for commercialisation. An important reason is public concern about the commercialisation of genetically modified crops. The government is also concerned that China's food biotechnology will be controlled by multinational companies, thus affecting the country's food security (Cai et al., 2017).

While China established a biosafety regulatory system in the mid-1990s and strengthened it in the early 2000s, the discovery of unapproved transgenic crops or unlabelled derived products implies that enforcement of the biosafety regulatory system could be improved (Karplus and Deng, 2006). The National Biosafety Committee developed a guideline for biosafety assessment (environmental and food safety) to streamline the processes. The Committee consists of 44 experts with diverse backgrounds from different Chinese ministries, research institutions, and universities (GAIN-CH13033).

In 2014, China was the 6th largest producer of transgenic crops worldwide. This ranking is primarily driven by 3.9 million hectares of insect-resistant Bt cotton produced by 7.1 million farmers (GAIN-CH15032). Since the approval of Bt cotton for commercial production in 1997, adoption has risen to approximately 80% of total cotton production. While there have been regional differences, empirical evidence suggests that farmers have achieved higher yields and net income gains from the use of Bt cotton compared to non-Bt traditional varieties (e.g. Smale et al., 2009; Qiao et al., 2016). In addition to increasing productivity, Bt cotton has also reduced environmental pressure and input costs through a reduced demand for pesticides. In the Hebei province, for instance, Bt cotton is associated with a 55% decrease in pesticide use (Pray et al., 2011). Interestingly, pesticide use has also declined on non-Bt cotton fields since 1999, suggesting that the spread of Bt cotton has reduced bollworm infestation on neighbouring crops (Pray et al., 2011).

Since 2004, China's imports of genetically modified food have increased rapidly. In particular, the annual import of genetically modified soybeans jumped from less than 20.17 million tonnes in 2004 to more than 81 million tonnes in 2015, almost seven times the total domestic production of soybeans in China. In addition to soybeans, China imports a large quantity of transgenic maize and rapeseed each year.

Accelerating the breeding of Genetically Modified Organisms (GMO) is listed as one of the strategically important R&D topics in the most recent 13th Five-Year Plan for National Science and Technology Innovation of 2016. The Plan promotes the commercialisation of key products, including the new generation Bt cotton, Bt corn, and herbicide-tolerant soybeans and pledges to establish the technical system for biosafety evaluation to guarantee safety of genetically engineered products (GAIN-CH16065). In 2016, China also revised the biosafety regulation on transgenic organisms. The amendments remove timelines for approvals, extend the National Biosafety Committee’s term from three to five years, and emphasise that entities engaging in GMO research and experiments are accountable for safety management (GAIN-CH16065).

The lack of a clear path to commercialise major biotechnology crop varieties (other than cotton) has limited incentives for local seed companies to invest in biotechnology. It has also encouraged public labs to focus on basic research rather than develop commercially viable seeds. Inconsistent protection of intellectual property and the fragmented nature of China’s seed industry further discourage private sector investment in biotechnology (GAIN-CH16065).

6.6. International co-operation on agricultural innovation

International co-operation in agriculture R&D offers universal benefits. The benefits of international co-operation for national innovation systems stem from the specialisation it allows and from international spill-overs. International co-operation in agricultural R&D is particularly important where global challenges (as in the case of responding to climate change) or trans-boundary issues (related to water use or pest and disease control) are confronted, and when initial investments are exceptionally high.

China’s key policies and documents have been focusing on promoting open development of agriculture, strengthening international exchanges and co-operation in agricultural science and technology, introducing and adapting foreign agricultural technology, and science and technology playing a better role in agricultural development. According to the plans of MOA and MOST, the key fields of international co-operation in agricultural science and technology include crop breeding and germplasm resources, animal and veterinary sciences, plant protection, agricultural applied microbiology, agricultural resources and environmental science, agricultural product processing and food safety, agricultural mechanisation and agricultural engineering, digital agriculture and agricultural information, agricultural economy and development as well as fishery and aquaculture.

China has undertaken both bilateral and multilateral co-operation efforts, but most of its agreements have been concluded on a bilateral basis. According to existing but incomplete statistics, China has established long-term bilateral co-operation agreements in agriculture with more than 140 countries, signed 189 agricultural co-operation and substantive agreements, and established 64 agricultural committees and working groups since 2011. Partners include both developed and developing countries. For example, the EU-China Cooperation Plan on Agriculture and Rural Development includes the FAB Flagship Initiative, which focuses on the areas of food security, sustainable agriculture and marine and inland water research and the bio-economy.

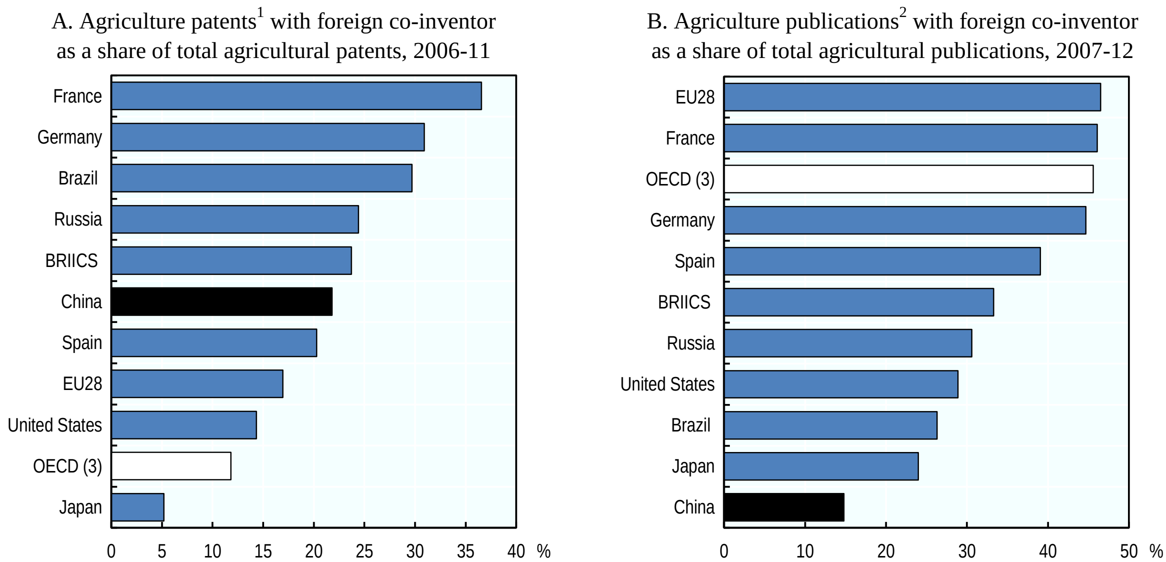
Multilateral co-operation includes partnerships with international organisations such as the FAO, UNDP, EU, ASEAN, CGIAR, CABI, PPIC, IAEA, IFS and the WWF. In addition, China has participated in regional agricultural co-operation efforts such as the co-operation between ASEAN, China, Japan and Korea (ASEAN+3), agricultural co-operation in the Shanghai Co-operation Organization, the China-FAO South-South Co-operation within the framework of the "Special Program for Food Security", and agricultural co-operation forums between China, central and eastern European countries.

China established a mechanism for introducing, training and stimulating talents to engage in international co-operation in science and technology, implement training plans of innovative talents and outstanding agricultural scientific research personnel, and speed up cultivating leading talents and innovation groups for international co-operation in agricultural science and technology.

By the end of 2014, China had arranged over 14 000 overseas visits and study-abroad programmes for Chinese scholars, students and short-term training staff, and invited more than 30 000 foreign experts to China. Over more than a decade, under the ASEAN+2 and ASEAN+3 frameworks, China has initiated over 150 agricultural exchange and co-operation projects, and trained more than 1 000 technical and managerial staff in ASEAN countries through courses in agricultural technology. Since 2004, China had trained more than 4 000 agricultural technical and managerial staff from Africa.

Internationally co-authored patents and publications reflect the degree of international collaboration. China's co-authored patents represented 22% of its all agri-food patents; a similar share for the OECD area was 12%, and 17% for the European Union. Around 10% of the country's co-authored patents was in the areas of agriculture and food processing, which is below OECD and BRIICS averages. (Figure 6.15 and Annex Figure 6.A.5). Between 2007 and 2012, Chinese authors produced a relatively small number of joint publications with foreign co-authors in agri-food sciences. In an international comparison, this constituted one of the lowest shares of total agricultural science publications in a country. Less than 15% of agriculture science publications by Chinese scholars had foreign co-authors, while almost every second publication in both the OECD area and in the European Union, and one-third in BRIICS had at least one (Figure 6.15 and Annex Figure 6.A.5). These indicators suggest that while China has been active in the integration of international collaboration frameworks in the agri-food area, it has yet to advance substantially in exploiting the potential of these frameworks.

Figure 6.15. International co-operation in agri-food R&D



1. Agriculture patents include IPC classes A01, A21, A22, A23, A24, B21H 7/00, B21K 19/00, B62C, B65B 25/02, B66C 23/44, C08b, C11, C12, C13, C09K 101/00, E02B 11/00, E04H 5/08, E04H 7/22, G06Q 50/02. Patent counts are based on the priority date (first filing of the patent worldwide), the inventors' country of residence, using simple counts.
2. Agricultural science publications include the following Scopus journal classifications: agronomy and crop science, animal science and zoology, aquatic science, ecology/evolution/behaviour systematics, forestry, horticulture, insect science, plant science and soil science, and miscellaneous agriculture/biological sciences.
3. The OECD aggregates do not include Latvia and Lithuania.
Source: OECD (2014b), Patent Database, http://www.oecd.org/sti/inno/oecdpatentdatabases.htm (panel A); SCImago (2014), SJR - SCImago Journal and Country Rank, http://www.scimagojr.com (accessed March 2014) (panel B).

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6.7. Summary

China has developed the world's largest and most decentralised public agricultural R&D system (Chen, Flaherty and Zang, 2012). Public investment in agricultural R&D accelerated in the 2000s both in expenditure and R&D personnel. The expenditure for agricultural R&D increased nearly four times between 2000 and 2013 in real terms (Stads, 2015). Although the size of expenditure for public agricultural R&D in China already exceeded that of the United States, making China the largest investor in public agricultural research, the intensity of public agricultural R&D expenditure is still lower than in most OECD countries.

In addition to technological progress and extension, institutional innovation is a core part of China's agricultural innovation system. The first stage was the introduction of the household responsibility system, which dissolved the collective farming system and provided households with individual land contract rights. The second stage removed agricultural taxes and fees, implemented a direct payment system and strengthened rural public services. The third stage includes a reform of the rural land system, introduction of new types of agribusinesses and building of new agricultural operation system such as Famer Professional Co-operatives and Specialized Custom Plowers, Planters and Harvesters (Han Changfu, 2015b).

With growing public investment in agricultural R&D, the output from agricultural R&D systems has improved significantly. China's share in global agri-food publication increased from 1% in 1996 to 9% in 2012. The number of applications for agricultural patents and new plant variety rights has been rapidly increasing in China, with an annual average growth rate of 26% between 2006 and 2011. However, China's global share in agri-food patents, publications and citations remains far below those in the United States and the EU28. The output of agricultural R&D systems indicates scope to improve the productivity of R&D expenditure in China.

In China, agriculture R&D activities are dominated by public agricultural R&D institutions, and private agriculture R&D expenditure is estimated to account for only 10-20% of overall agriculture R&D. The role of private agriculture R&D is lower than most OECD countries. In the United States, the private sector funded 76% of food and agriculture research and performed 72% of research activities in 2013. In particular, the private sector performs the majority of commercially viable areas of research such as food and feed manufacturing, farm machinery, and plant system and crop protection (OECD, 2016). By contrast, nearly three-quarters of the R&D expenditure of public agricultural R&D institutions in China is directed to experimental development research. The dominance of public R&D institutions is likely to be crowding out private investment in agriculture R&D in China.

Public agricultural R&D institutions in China are composed of numerous research institutes administered by multiple ministries and agencies both at national and sub-national levels. While the current governance structure provides local governments and research institutions with the freedom to take initiatives and to adapt and implement policies at the national level, this complex structure limits their co-ordination and has led to funding inefficiencies and duplication of research efforts and investment (OECD, 2008; Huang and Rozelle, 2014). The lack of a co-ordination mechanism between the central and provincial governments may reduce the efficiency of China's innovation system as a whole and delay the creation of a coherent system of agricultural innovation.

China's public agricultural extension system has undergone a series of reforms to make it more responsive to farmers' needs. The commercialisation of extension activities reduced their capacity to provide a variety of technical advice. More recent reforms to improve the quality of service to farmers by separating commercial activity from extension services and introducing a more inclusive approach at the local level are more favourable. At the same time, private organisations are increasingly playing a major role in facilitating knowledge flows in China. For example, farmers' co-operatives often function as intermediate agents to facilitate the adoption of technology and reduce transaction costs, allowing smallholder farms to overcome systematic constraints in adopting technology, integrating them in supply chains and increasing their operational size. The public extension system should evolve so that it can provide advisory services which private organisations have less incentive to provide, such as promoting agricultural production technologies to conserve resources and protect the environment. A greater use of ICT would also improve the performance of advisory services.

Protection of intellectual property rights (IPRs) is an important factor influencing the performance of agricultural innovation systems. Adequate protection of IPR enhances private R&D investment in agriculture, including those from abroad. While IPR policies and regulations are largely in line with international rules and guidelines, China's protection of IPR still lags most OECD countries, particularly in terms of enforcement.

Notes

[1] As defined in the Frascati Manual (OECD, 2002), basic research refers to experimental or theoretical research aiming to obtain new knowledge about the fundamental principles of phenomena and observable facts (for example, revealing the nature of objects and the rules of their operations, acquiring new discoveries, and establishing new theories). Applied research refers to creative research carried out in order to acquire new knowledge, mainly aimed at a certain purpose or objective. Experimental development refers to systematic work carried out for the production of new products, materials and devices and the establishment of new manufacturing techniques, systems and services, and the fundamental improvement of such items on the basis of application of knowledge available from basic research, applied research and practical experience.

[2] The National Centre for Science and Technology Evaluation (NCSTE) is in charge of evaluating government-sponsored R&D projects. The NCSTE aims at "providing an objective and impartial basis for government departments, enterprises and investment organisations to make better decisions, to offer consulting service in a wide range of sectors, and to promote dialogue between government, industries and academies". The NCSTE was created in 1997 based on a research team active in evaluation as early as 1994 (Fang, 2013).

[3] A process of mid-term evaluation of the Medium and Long-term Plan for Science and Technology Development was launched in 2014. The management of the main science and technology development programmes have been revised to simplify the application process; scientists applying for project funding run by MOST do not have to conduct the questions and answers session in person, as most of the application and evaluation procedures can be done through the Internet; additionally, the budget management system was improved by building a project library and science and technology programme information system (OECD, 2014a).

[4] ASTI's national agricultural research expenditure data is categorised as salary-related expenses, operating and programme costs, and capital investments by government, non-profit, and higher education agencies. Data on spending by private entities are excluded, due to lack of availability. OECD's GERD data captures all performing sectors for agricultural science. However, it is difficult to obtain a comprehensive estimate of GERD in the ago-food sector which would cover multiple fields of science beyond agricultural science.

[5] In addition to General Principles of the Civil Law that has specific articles concerning intellectual property rules, the Civil Law and the Criminal Law also include articles on IPR, and other related laws and regulations have been promulgated like the Patent Law, the Copyright Law, the Trademark Law, the Foreign Trade Law, the Anti-Unfair Competition Law, the Regulations on the Protection of New Varieties of Plants, the Seed Law, and the Regulations on the Customs Protection of Intellectual Property Rights.

[6] They include, for example, the Detailed Rules for the Implementation of Regulations on the Protection of New Varieties of Plants, and Several Provisions of the Supreme People's Court on Applying Specific Laws in Cases of Infringement of New Plant Varieties.

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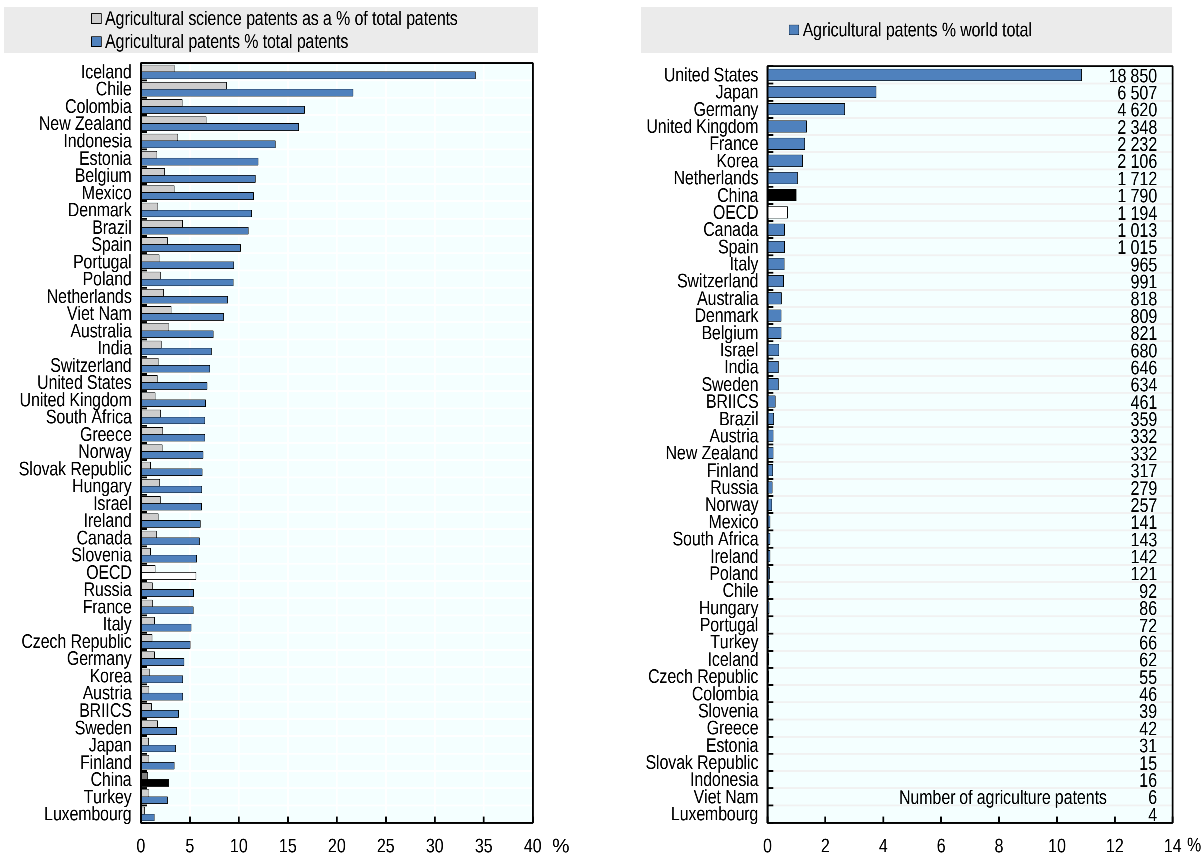
Annex 6.A. Background indicators of R&D outcomes

Annex Figure 6.A.1. Agricultural patent applications filed under the Patent Co-operation Treaty (PCT) in agriculture, 2006-11

A. Agricultural specialisation (using fractional counts, country receives partial count for co-inventions)

B. Share of countries in total agriculture patents, 2006-11

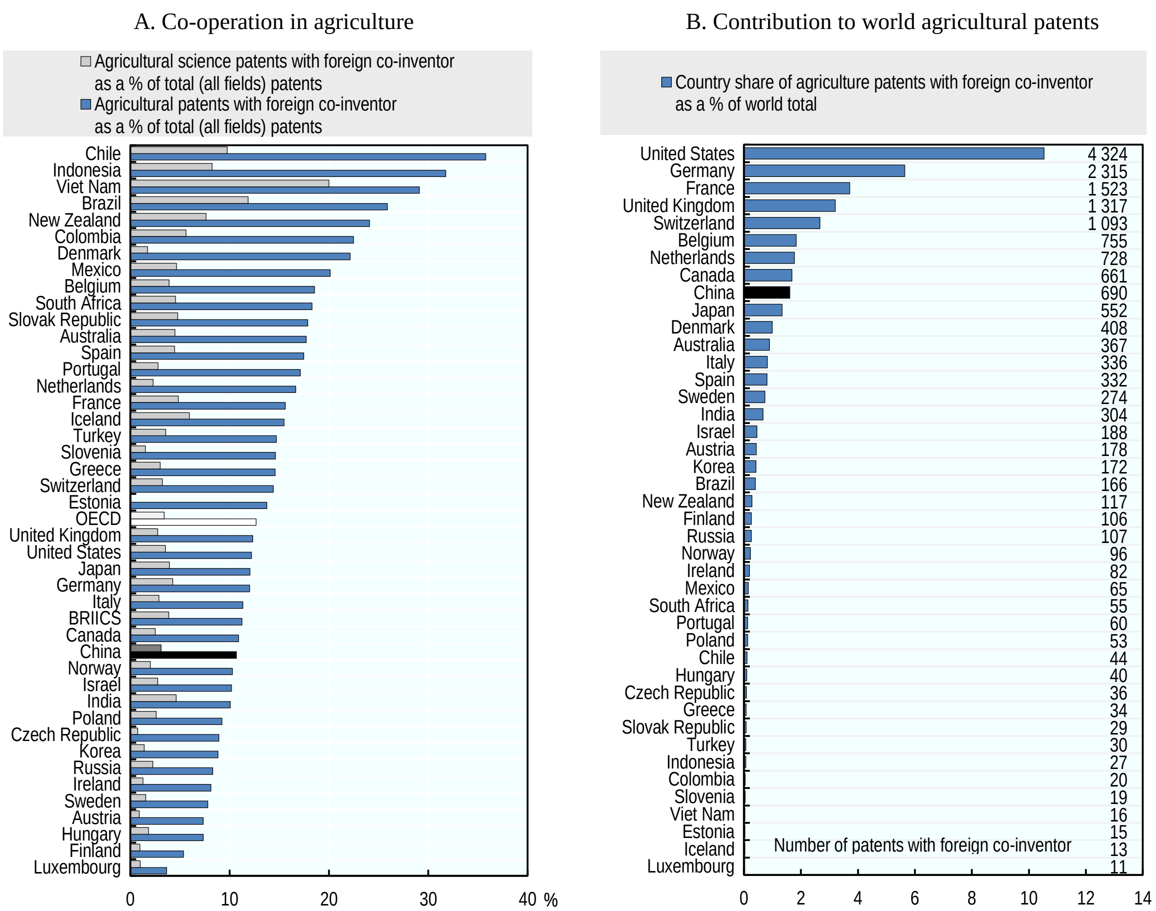


1. Agriculture includes patents from IPC classes A01, A21, A22, A23, A24, B21H 7/00, B21K 19/00, B62C, B65B 25/02, B66C 23/44, C08b, C11, C12, C13, C09K 101/00, E02B 11/00, E04H 5/08, E04H 7/22, G06Q 50/02.
2. The OECD aggregates do not include Latvia and Lithuania.

Source: OECD (2014b), OECD Patent Database (accessed January 2014).

StatLink http://dx.doi.org/10.1787/888933829702

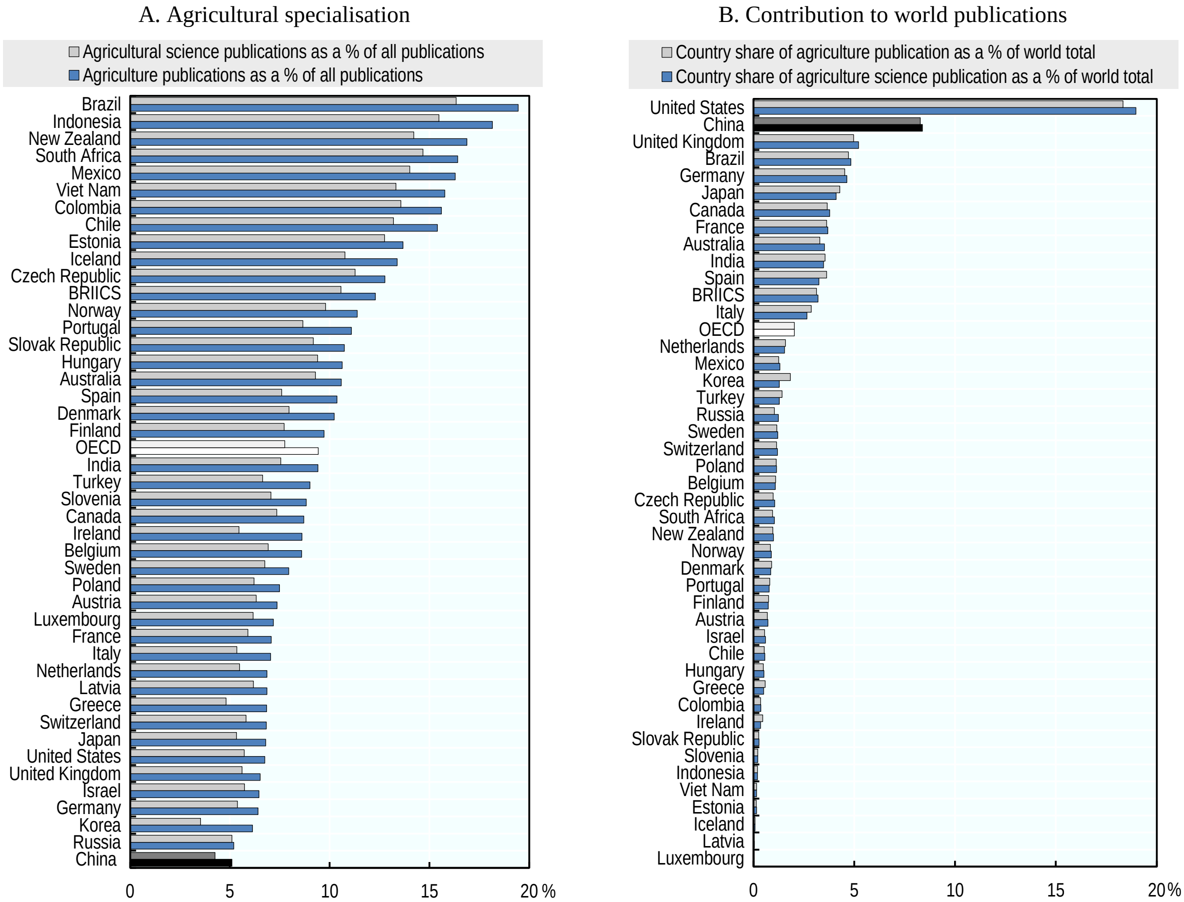
Annex Figure 6.A.2. Agriculture patents with a foreign co-inventor filed under the Patent Co-operation Treaty (PCT), 2006-11



1. Agriculture includes patents from IPC classes A01, A21, A22, A23, A24, B21H 7/00, B21K 19/00, B62C, B65B 25/02, B66C 23/44, C08b, C11, C12, C13, C09K 101/00, E02B 11/00, E04H 5/08, E04H 7/22, G06Q 50/02.
2. The OECD aggregates do not include Latvia and Lithuania.
Source: OECD (2014b), *OECD Patent Database* (accessed January 2014).

StatLink http://dx.doi.org/10.1787/888933829721

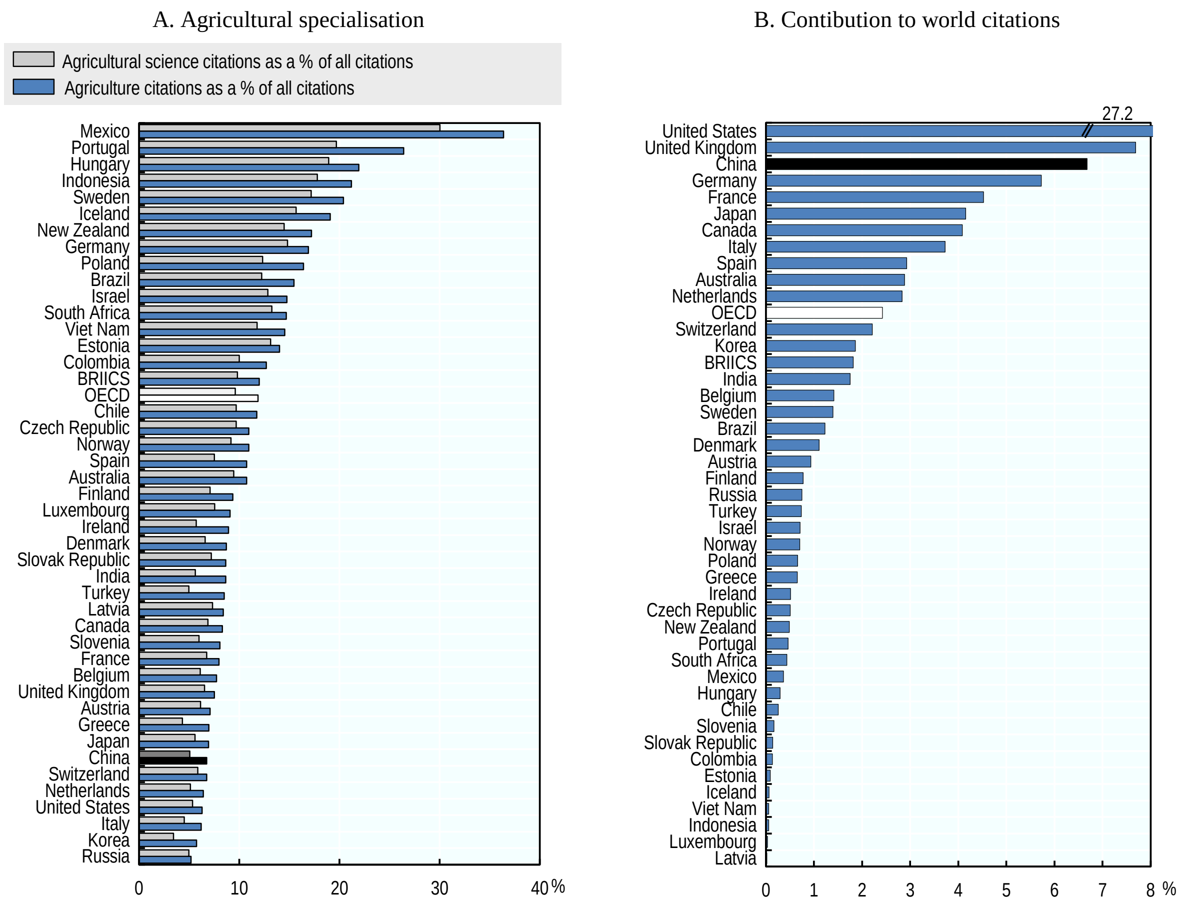
Annex Figure 6.A.3. Agriculture publications, 2007-12



1. Agricultural science include Scopus journal classifications: agronomy and crop science, animal science and zoology, aquatic science, ecology/evolution/behavior systematics, forestry, horticulture, insect science, plant science and soil science, and miscellaneous agriculture/biological sciences.
2. The OECD aggregates do not include Latvia and Lithuania.
Source: SCImago (2014), SJR — SCImago Journal & Country Rank, http://www.scimagojr.com (accessed March 2014).

StatLink http://dx.doi.org/10.1787/888933829740

Annex Figure 6.A.4. Agriculture citations, 2007-12

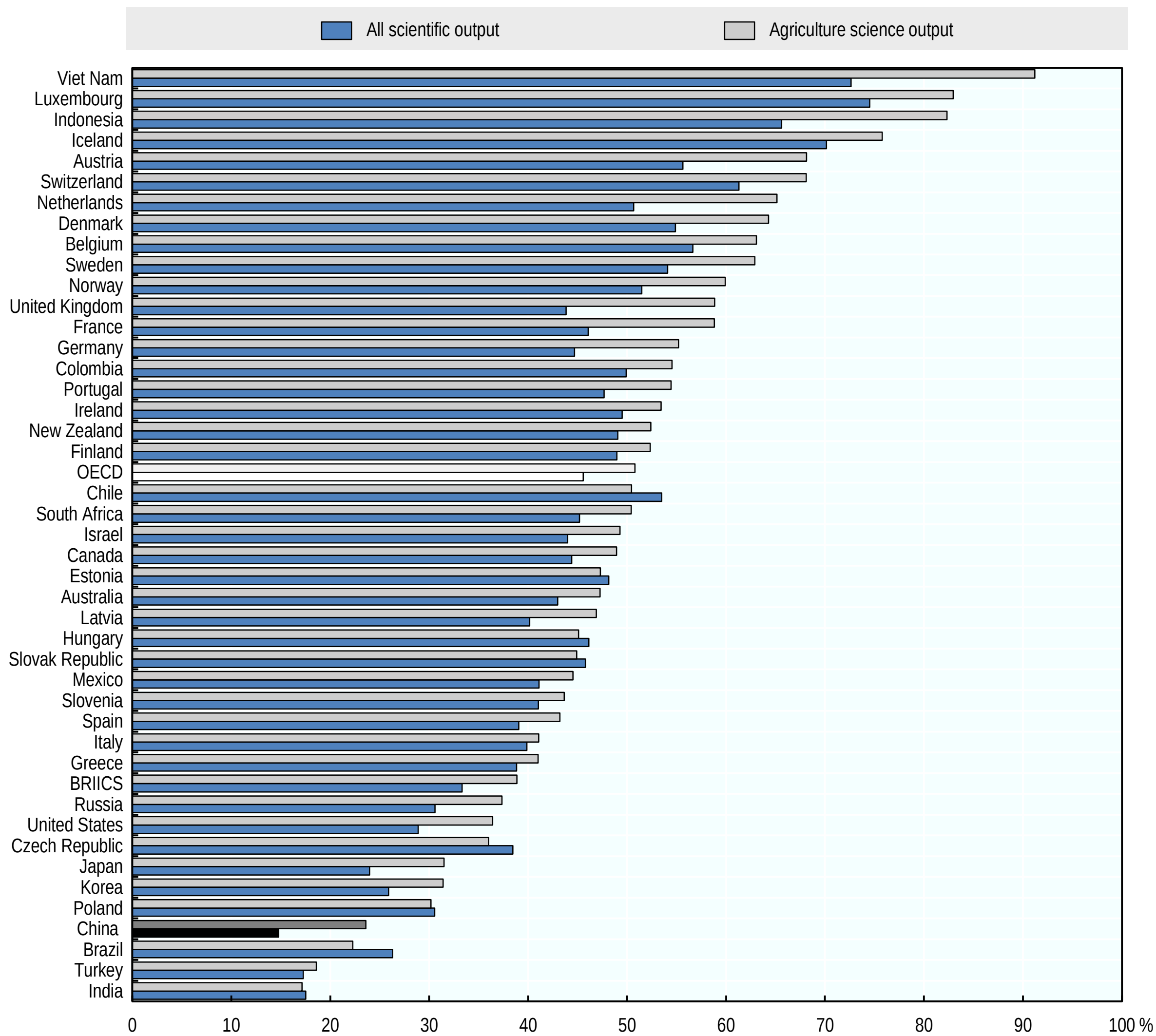


1. Agricultural science include Scopus journal classifications: agronomy and crop science, animal science and zoology, aquatic science, ecology/evolution/behavior systematics, forestry, horticulture, insect science, plant science and soil science, and miscellaneous agriculture/biological sciences.
2. The OECD aggregates do not include Latvia and Lithuania.
Source: SCImago (2014), SJR — SCImago Journal & Country Rank, http://www.scimagojr.com (accessed March 2014).

StatLink http://dx.doi.org/10.1787/888933829759

Annex Figure 6.A.5. International collaboration, 2007-12

Percentage of documents with collaborating authors in foreign country



Notes: Agricultural science include Scopus journal classifications: agronomy and crop science, animal science and zoology, aquatic science, ecology/evolution/behavior systematics, forestry, horticulture, insect science, plant science and soil science, and miscellaneous agriculture/biological sciences.
The OECD aggregates do not include Latvia and Lithuania.
Source: SCImago (2014), SJR — SCImago Journal & Country Rank, http://www.scimagojr.com (accessed March 2014).

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