Industrial upgrading for green growth in China

Thematic focus on environment: key findings and recommendations

DRC

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The project jointly conducted by the Development Research Centre of the State Council of China (DRC) and the OECD focuses on how to better align industrial and environmental policies in China, with the aim of simultaneously promoting industrial restructuring, addressing challenges arising from the "New Productive Revolution" while improving environmental and resource efficiency of the economy. This policy paper is one in a series of reports resulting from two years of joint research and collaboration. It summarises some of the key findings and recommendations, with a focus on the priories for policy reforms[1].

Executive Summary

The rapid industrial expansion in China since the early 2000s has been associated with over-investment and misallocation of resources, and has also generated enormous pressure on the environment. The Chinese government has taken many steps to promote the transformation of industry, encourage structural adjustments and initiatives aimed at boosting efficiency and performance. Efforts have been made to assist heavy industry sectors, particularly those plagued by excess capacity, through improved policy settings which encourage the closure of less productive plants, the facilitation of mergers and reorganisation, as well as to continue strengthening the binding force of environmental policy. In the meantime, the reinforcement of the "ecological civilisation" concept and the emphasis on innovation in the heart of the 13th Five-Year Plan mark an important milestone in China's transition to a more balanced, higher-quality and greener growth path. Moreover, the central government has explicitly put forth the need to reform the GDP-centred performance evaluation system for subnational government officials, at the same time adding more indicators to assess progress towards green development. This will certainly pave the way for ensuring greater attention to environmental protection across provinces and for accelerating the transition to a greener and more sustainable growth path.

The ongoing restructuring process therefore represents a not-to-be-missed opportunity for China to address longstanding structural imbalances and misallocation of resources, and to reallocate resources to more productive segments of the economy, in order to achieve the dual objectives of sustained economic growth and a progressive reduction of pollution that has been impacting the life of those living close to clusters of heavy industry.

[1] Recommendations addressing industrial policy are discussed in companion documents in the series of reports prepared under this joint DRC-OECD project.

Macro managing industrial restructuring is a highly complex task given the level of uncertainty and the intricacies of demands from various interest groups in the course of reform. A two-pronged strategy is usually effective. First, through a mix of "carrot" incentives (e.g. support for R&D), it is necessary to encourage efficient firms to speed up the upgrading process, make greater use of advanced technologies and enhance their environmental performance. In this process, the beneficiary firms should be required to report transparent and high-quality financial and environmental data. Second, facilitate the quick and smooth exit of inefficient firms through a set of policies, for instance by providing adequate support to the workers and regions affected by plant closures, and firmly addressing the issue of "zombie enterprises"[2].

In the short term, stimulating demand could align conflicting interests and create space for better calibrating restructuring measures, but it weighs on public finances and in the long term, it does not provide fundamental resolution to the problems of excess capacity and low investment returns in industry. Due consideration must be given to both long-term and immediate interests when new policies are formulated, and more stringent environmental standards should be used to minimise the impact of inefficient firms on the environment, in particular when these new policies have the potential of increasing demand for energy-intensive and polluting activities.

Scene setting and key assessments

Industrial policy and environmental policy are inherently intertwined and should be coordinated in their implementation: industrial upgrading provides an important means to foster green growth, and green growth helps industrial upgrading in turn.

The experiences and lessons of OECD countries suggest that, as a country reaches a certain stage of development, the balance between industrial and environmental policies as well as coherence between these two policy areas becomes not only necessary and urgent but also more than ever feasible. First, technological progress means more (and cost-effective) solutions are available. If negative externalities are accounted for when estimating the overall social cost, then green growth can be achieved without undermining economic output. Second, as living standards continue to improve, people's willingness and ability to foot the bill for better environmental quality also increase. China has come to this stage of development where its industrial and environmental policies have to be effectively combined.

The upgrading of China's manufacturing is already happening, but industries affected by excess capacity will face difficult challenges for the foreseeable future.

Since the global financial crisis, the share of manufacturing in China's economy has continued to shrink, dropping to 27% of GDP in 2015. Although this share is still higher than the levels observed in other emerging economies, it is declining at an earlier stage of development (measured in GDP per capita) compared to the historical experience of many OECD countries. Looking ahead, while it seems unlikely that the share of manufacturing will rise again given that demand is peaking in most of the sectors plagued by excess capacity, there needs to be continued emphasis on improving the quality, efficiency and core competitiveness of manufacturing industries as sectoral shifts will continue to be the focus.

In the long term, enhancing productivity is instrumental in achieving the dual objectives of sustained economic growth and better environmental outcomes.

China has made great strides in increasing productivity. Further increasing the efficiency of the use of natural resource inputs and minimising pollutant emissions more generally, will result in

[2] "Zombie enterprises" are those firms that have encountered serious operating difficulties, suspended or semi-suspended production, are insolvent or deficit-ridden in successive years, or are mainly dependent on government subsidies or loan renewals to sustain businesses, irrespective of whether these firms are private or state-owned enterprises.

improved environmentally-adjusted multifactor productivity. Moreover, China has started to deploy an arsenal of measures to embrace the Next Production Revolution (NPR), with particular attention to new technologies such as digitalisation, new materials and innovative industrial processes. Initiatives such as "Made in China 2025" and "Internet Plus" aim to elevate China to the rank of the world's top manufacturing powers within the next decade, and to lower energy and resource consumption and pollution emissions per unit of industrial value added. Nevertheless, among other challenges, current policies in this field could be better integrated or coordinated, and more efforts are needed to improve the synergies between different sets of measures.

China has actively explored the pathway to foster green development in the industry sector; a more comprehensive assessment of the costs and benefits is needed to provide direction for the next step.

China has taken significant steps in strengthening environmental legislation and policymaking. The objectives of these laws and regulations have been given further clarity through the elaboration and implementation of the 11th, 12th and 13th Five-Year Plans, which also helps raise awareness of the wider public and unite forces on all fronts to reallocate resources and achieve specific environmental targets. As compared to OECD countries, China has achieved the decoupling of SO_2 and NOx emissions from economic growth at an earlier stage of development (measured in GDP per capita). The key for next step is how to sustain the green development.

A variety of policy levers should be mobilised in fostering industrial restructuring and the transition to green growth.

Restructuring of the industry sector requires not only a quicker exit of unprofitable and polluting firms, but also the reallocation of some of these resources, within and across sectors, to more productive uses, so as to boost productivity in a more sustainable and less environmentally damaging manner. In the process of reducing excess capacity, corporate mergers and reorganisation may have a role to play, but need to be taken in accordance with market principles, and primarily through the elimination of unnecessary institutional barriers to merger and acquisition. If firms with persistently low capacity utilisation rates, or "zombie enterprises", can stay in the market, their presence will significantly hinder the effective functioning of market forces, and may even result in adverse selection where the "peaches" are crowded out by the "lemons". Hence, the policy challenge is how to ensure that efficient firms continue while inefficient ones are eliminated. Another challenge for the government is to provide targeted interventions to workers affected by firm exit, as has been done in the past in OECD countries. On the front of green growth, although the environment is a public or quasi-public good, market-based instruments can also be introduced in addition to governmental regulation (for instance China is in the process of developing emission trading platforms).

Recommendations for improving environmental policy

Develop more efficient and effective environmental policies for the manufacturing sector and strengthen their enforcement

Develop cost-efficient environmental policies through improved environmental information on industrial processes (natural resources and materials used, pollutants and waste generated, etc.). Expand the use of market-based instruments, and monitor environmental compliance. The effective implementation of environmental policies requires strengthened enforcement across the board, to ensure a level playing field between all companies. This includes the enforcement of the obligation to conduct appropriate Environment Impact Assessments (EIA) for all major new or expanded industrial plants, and the establishment of an effective integrated permitting system linked to the EIA process.

Improve the effectiveness and coverage of environmental policies, and in particular:

- Strengthen assessment of environmental policies before and during their implementation. Specifically, introduce institutionalised environmental regulatory impact assessment

(including effectiveness and cost-benefit analysis) before, during and after the implementation.

- Strengthen top-level design of the mix and coordination of various regulatory instruments, including pollution permit, EIA, pollution levy (to be replaced with environmental taxes), total emission control and emission trading platform.
- Continue to shift focus from achieving a limited number of emissions reduction targets in Five Year Plans to achieving a broader range of environmental quality objectives.
- Phase out fossil fuel subsidies, starting with those that are most inefficient and environmentally damaging.
- Make greater use of market-based instruments to incentivise pollution reduction and better management of natural resources.
- Design and implement environmental policy instruments to be cost-effective, provide incentives for innovation and the adoption of integrated solutions, foster competition, and, where appropriate, support inefficient firms (and plants) to exit.

Strengthen environmental policies that focus on the industrial sector, including by:

- Improving the EIA system, ensuring that all proposals for new or expanded industrial facilities are subject to an appropriate EIA.
- Accelerating the implementation of an effective and, where applicable, integrated permitting system with appropriate links to the EIA process; ensuring that both the EIA and permitting procedures are systematically implemented.
- Ensuring that potentially hazardous industrial facilities are located so as minimize risks to human health and ecosystems.
- Assessing how the Leading Plan for the Circular Economy could provide further support to improve the environmental performance of the industrial sector.

Develop a more systematic, effective and consistent approach for securing compliance with environmental requirements throughout China's territory, including by:

- Strengthening the enforcement of environmental regulation across the board for ensuring a level playing field between all companies.
- Establishing an inventory of companies that require an environmental permit or that are subject to general binding conditions.
- Establishing institutional arrangements that further reduce the influence of sub-national authorities on the activities of environmental agencies.
- Developing an appropriate mix of activities involving compliance promotion, monitoring and enforcement; ensuring that enforcement actions are proportional to the seriousness and economic benefits of non-compliance.
- Carefully assessing the human and institutional capacities needed to support a more effective system of enforcement and compliance and how they would be financed; ensuring that environmental agencies at all levels are fully equipped to perform their duties; increasing the level of salary of environmental supervisors, and establishing a salary system commensurate to the degree of specialisation and professionalization of the regulatory and law enforcement officials.
- Improving mechanisms for environmental law enforcement, with emphasis on encouraging voluntary reporting by companies on their compliance record

Strengthen the system of environmental governance and policy coordination

Much has been done in improving environmental legislation. Nonetheless, no significant progress can be achieved in improving environmental quality without further enhancing compliance and enforcement. This implies further empowering the Ministry of Environmental Protection (MEP), separating policy guidance from inspection and enforcement functions and enhancing direct supervision by the MEP of local Environmental Protection Bureaus. Horizontally, enhancing coordination between the MEP, NDRC and MIIT, MOA, MWR and MLR[3], amongst others, helps better align environmental and industrial policies. Vertically, the recently released set of green growth and ecological civilisation indicators enhances the accountability of sub-national governments and provides a good basis for strengthening the oversight of their progress towards green growth. To achieve these objectives, a sound and comprehensive statistical and evaluation system needs to be established reflecting all relevant aspects of green growth.

Strengthen environmental institutions at the national level, including by:

- Improving coordination within MEP and between MEP and other Ministries/agencies with responsibilities for environmental protection.
- Enhancing information sharing, communication and coordination between different departments of the MEP, through better institutional setting and established working mechanisms.
- Assessing whether the current allocation of responsibilities at national level is optimal for implementing comprehensive and integrated environmental policies; further clarifying the powers and responsibilities between different agencies.
- Strengthening the capacity and resources of the MEP in line with its evolving responsibilities.
- Assessing the advantages of more clearly separating responsibilities for policymaking and regulatory functions, e.g. by establishing an Environmental Agency within the MEP to be tasked with regulatory matters.
- Consolidating the responsibility for environmental monitoring in the National Environmental Monitoring Centre. The Centre should operate at arms-length; ensure an integrated, nationwide management of environmental information; improve the coverage, timeliness and sharing of environmental information; improve the quality control of data; and ensure the accuracy and reliability of environmental information at all levels of government.
- Establishing an independent policy evaluation unit within the MEP, to conduct independent assessment of the design and implementation of environmental policies, as a step towards establishing internal mechanism for performance evaluation.

Better align environmental and industrial policies

- Ensure effective horizontal coordination across government ministries and agencies and regularly review policy objectives and measures to identify synergies and possible misalignments.
- Regularly review the environmental impacts of industrial (and other sectoral) policies and identify additional measures that could reduce such impacts. Similarly, review the economic impacts of environmental policies.
- Monitor progress in policy alignment, including through measures of environmentally-adjusted multifactor productivity growth.

[3] The abbreviations respectively stand for: Ministry of Environmental Protection, National Development and Reform Commission, Ministry of Industry and Information Technology, Ministry of Agriculture, Ministry of Water Resources and Ministry of Land and Resources.

Strengthen the vertical coordination of green-growth policies, in particular on the following aspects:

- Strengthen the oversight of sub-national governments' environmental performance, and integrate a wider range of targets about environmental quality in the evaluation system.
- Promote "top-runner" through regular reviews that benchmark performance of sub-national governments. Establish institutionalised and standardised system to improve MEP's oversight of sub-national governments and environmental agencies at various levels.
- Enhance the regulatory capacity of sub-national authorities, and equip them with necessary information and guidance. Empower regional environmental and river-basin authorities, starting with aspects related to the institutional setting, staffing, budgeting and delineation of responsibilities.
- Clarify the role of, and strengthen as appropriate, Regional Environmental Centres; clarify their relations with environmental agencies below provincial level, with a view to enhancing their role in supervising and coordinating cross-provincial policies.
- Expand opportunities for, and reduce financial obstacles to, citizens challenging non-compliance with environmental laws in courts.

Industrial upgrading for green growth in China:
Thematic focus on environment

After more than three decades of double-digit growth, the Chinese economy is going through a period of rebalancing and structural adjustment. A shrinking labour force, and slower investment and export growth, have reduced the annual rate of growth to less than 7%: the "new normal". Domestically, rebalancing the economy involves shifting emphasis from investment to consumption, from external to internal demand, and from manufacturing to services. Part of the rebalancing also involves reducing the pollution associated with economic growth and lowering energy and materials intensity of the economy to facilitate the transition to a greener pattern of growth.

The manufacturing industries in China now face two inter-related economic challenges. First, over-investment in the boom years has resulted in significant excess capacity, mounting losses and increasing levels of debt in some industries[4]. This challenge is also present in sectors beyond manufacturing, such as coal mining. Significant resources are now tied up unproductively and should be reallocated to activities where they could add greater value. Second, in a more competitive international context, Chinese manufacturing will increasingly have to compete in terms of efficiency, quality and productivity rather than low input costs. Several recent policy initiatives have shown the government's determination to address these challenges by restructuring and upgrading the traditional sectors, while promoting the expansion of higher value-added and knowledge-based activities through entrepreneurship, innovation and enhanced market mechanisms.

From a green growth perspective, China's manufacturing industries together with the energy sectors are a major source of pollution, greenhouse gas emissions and waste generation, which impose significant costs on the economy and are having an increasingly adverse impact on human health and the environment. These impacts have become a growing source of public concern. The industry sector is also a major user of energy, natural resources and materials. The manner in which these resources are used significantly affects short-term costs in downstream supply chains as well as long-term sustainability throughout the economy. The Chinese government has adopted a series of measures to improve the environmental performance of the economy, particularly the industry sector. It has also recognised that this is a unique opportunity to restructure the industry in a way that enhances productivity while reducing environmental impacts and promoting green growth.

This policy paper examines how this could be done by looking at how policies supporting environmental protection and green growth could be better aligned with the development of industry and the economy. This involves identifying win-win opportunities, better designing policies, and fostering institutional innovations in a way that maximises benefits for the Chinese economy and environment.

[4] Excess capacity is a challenge facing several heavy industry sectors, in China and in other economies. Steel is one such sector. The Global Forum on Steel Excess Capacity, called for by G20 Leaders in September 2016 and co-Chaired by China, will foster international discussion on these issues through increased information sharing and co-operation among G20 and OECD members on ways to address steel excess capacity around the world. The outcomes from this work should be of value not only to the steel sector, but also more generally.

China has a unique opportunity to restructure and upgrade its industrial sector while greening the economy

The industry sector has been a major engine of China's economic expansion from the beginning of the reform and opening era in 1978. It has grown at a faster rate than GDP for a rather long period, and the sustained high growth rate of the manufacturing industries is particularly salient. However, the pace has gradually slowed since the global financial crisis, and the share of manufacturing in the economy has continued to decline, falling to 27% of the GDP in 2015, a 5.4 percentage point decrease from the 2007 level. While this is still higher than the levels observed in other emerging economies, it is decreasing at an earlier stage of economic development (i.e. lower level of GDP per capita) than in major OECD economies (Figure 1). This implies that shifting to more sustainable manufacturing remains an important objective for the Chinese economy today.

China has been the world's largest producer of industrial goods since 2010, having successively displaced Germany, Japan and the United States during the first decade of the 21st century (Figure 2). In 2015, China accounted for over a quarter of total world manufacturing value added, and the share is likely to continue to increase in the coming years. In the broader industrial sector, the total value-added of industry in China at market exchange rates amounted to USD 4.4 trillion in 2015, well ahead of the European Union (USD 4.0 trillion), the United States (USD 3.5 trillion) and the BRIIS (USD 1.7 trillion).

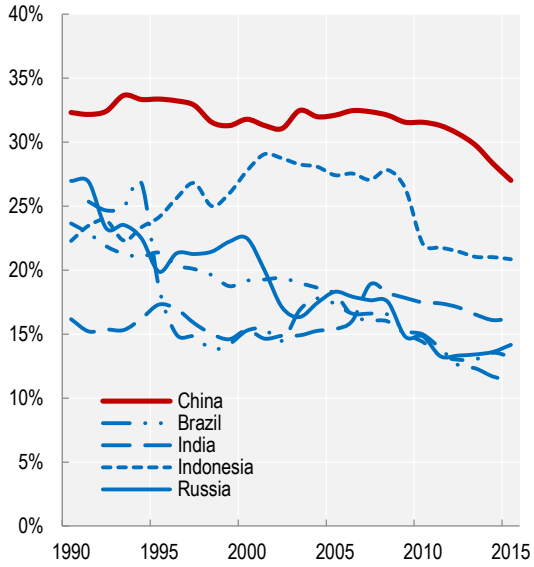
The dominance that China achieved as a global manufacturing power has been driven primarily by a large and fast-expanding domestic market as well as the country's increasing integration in global value chains (GVC). The interactions between industrialisation, urbanisation, progressive opening-up of the economy, real estate and infrastructure development have been mutually reinforcing and created strong demand for the products of the industry sector. This has underpinned China's long phase of sustained economic growth. At the same time, reforms in the state-owned enterprises (SOEs) during the late 1990s and early 2000s, along with measures to facilitate private sector development and encourage foreign capital investment, have unleashed efficiency gains and productivity growth in the manufacturing sector. The share of SOEs in industrial output (of firms above the designated threshold) has declined, from more than 70% during the 1960s and 1970s to below a third since 2005.

China has become the factory of the world, and Chinese manufacturing has been competitive internationally. However, while in volume, China became the world's largest exporter and the second largest importer of merchandise in 2012, its share of world trade is much lower when measured in value added terms, reflecting its position in mainly low value added segments of GVCs. Nevertheless, a growing share of value added in Chinese exports has been produced domestically, particularly in a number of high-tech sectors, which reflects an increasing ability to upgrade within the value chain. Meanwhile, changes in China's export structure (of trade in goods) also show signs of the country moving up in GVC. In the period since 1995, China's main exports shifted from low-tech goods such as textiles to high-tech products such as ICT and electronics, electrical machinery and transport equipment.

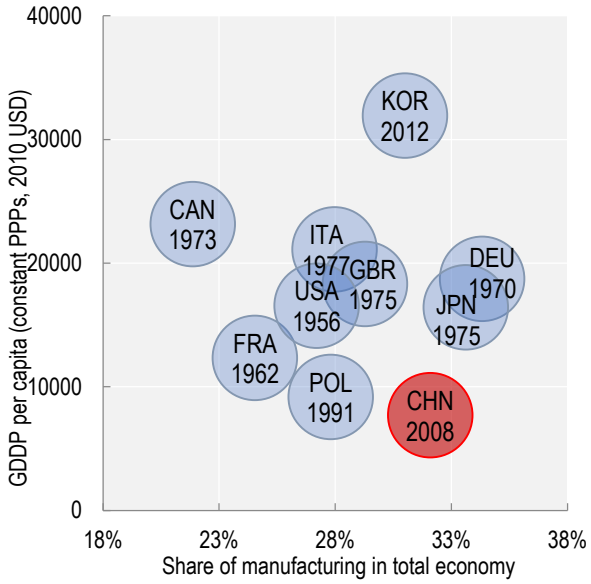
Being the factory of the world has many environmental implications. The rapid industrial expansion in China over the past decades has generated significant pressures on the environment (Box 1). Several factors associated with the structural features of the industry (including mining, manufacturing and energy) have contributed to the increasing environmental damage. First, the preponderance of heavy industry in the industrial sector has intensified its impact on the environment and human health. Second, the industrial processes used in China are predominantly resource and pollution-intensive; although many outdated production capacities have been eliminated in recent years, there remains ample room to further develop and diffuse environmentally friendly technologies across the country. Third, many industrial processes rely heavily on coal for energy consumption, which exacerbates the generation of carbon emissions and other indirect environmental effects.

Figure 1. **Manufacturing remains an important driver of China's economic growth despite the recent decline**[5]

A. Share of manufacturing in GDP, 1990-2015

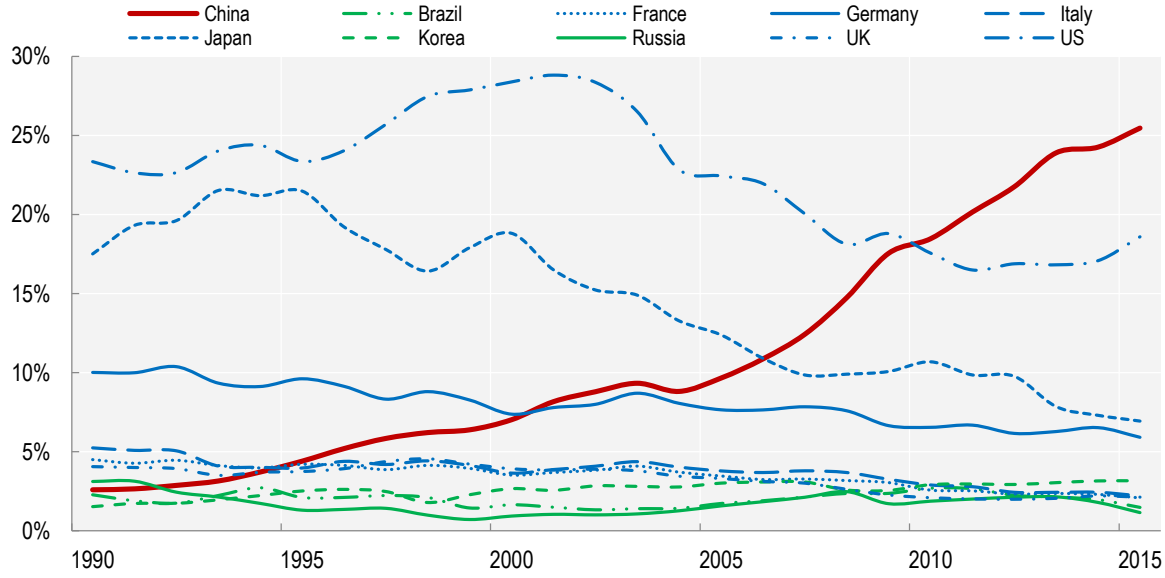


B. When the share of manufacturing starts to decrease



Source: World Development Indicators Database, UN National Accounts Main Aggregates Database, OECD National Accounts Database, Statistics Office of Japan, and the US Bureau of Economic Analysis.

Figure 2. **Percentage share of total world manufacturing value added, 1990-2015**



Source: United Nations National Accounts Main Aggregates Database.

[5] Unless otherwise specified, data referred to in this report originate from the OECD.

Box 1. **Environmental profile of the Chinese industry[6] sector**

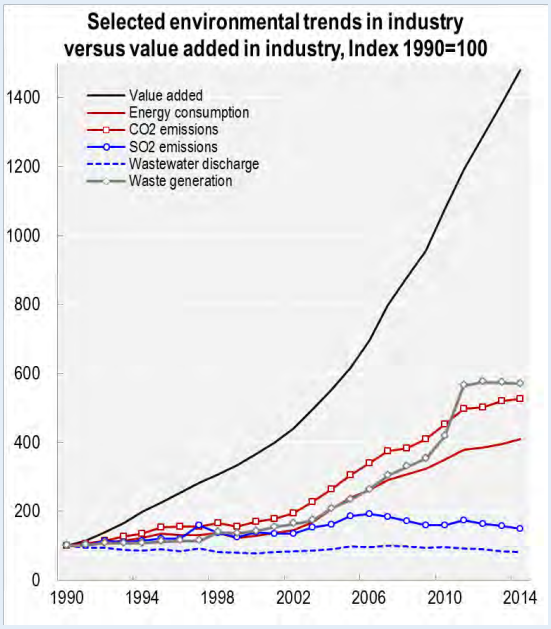
The energy-intensive manufacturing industries, such as basic metals, non-metallic minerals (e.g. cement), chemicals and oil processing have grown at a rapid pace, and their share in total industrial value added has substantially increased in the past two decades. These energy-intensive industries have exerted significant pressures on the environment by way of the emission of pollutants and greenhouse gases (e.g. CO_2, SOx, NOx and wastewater) and the depletion of many precious natural resources. Important progress has been made in reducing the environmental impact of the industrial sector, but much remains to be done in order to converge with the environmental performance of many OECD countries.

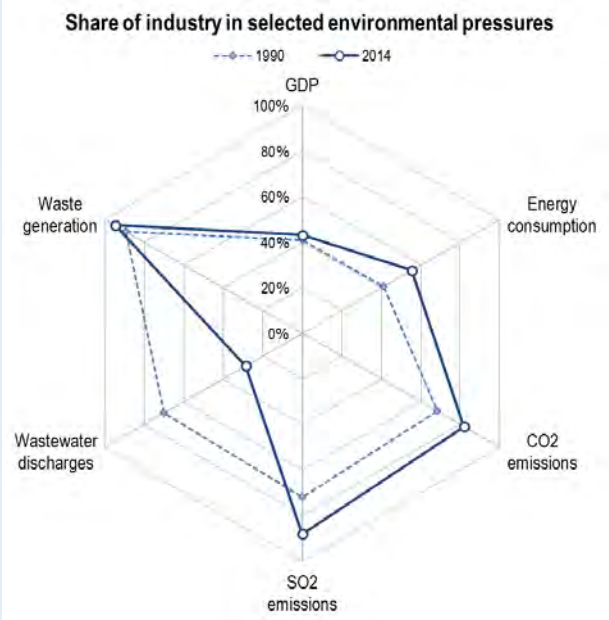
The 1990-2014 period saw a three-fold increase in energy consumption of the industry sector. The increase in CO_2 emissions was even greater as a large share of the increased energy demand was met through increased coal-fired power generation, in addition to the use of coal in industrial processes. Over the same period, the iron and steel sector also experienced rapid increase in energy consumption and emissions: with more than a 12-fold expansion in crude steel production (from 65.96 million tonnes in 1990 to 813 million tonnes in 2014), the sector more than doubled its share in national energy demand, accounting for 13.7% of total final consumption and almost 30% of the energy consumption of the manufacturing industries in 2014. In part due to its relatively high share in Chinese manufacturing, the sector also generated more than two-fifths of all CO_2 emissions from the manufacturing industries in China, higher than the OECD (22.1%) and world (33.4%) averages, and contributed to nearly two-thirds of global CO_2 emissions generated by this industry.

In 2014, the industry sector contributed more than 80% of total domestic SO_2 emissions and more than two-thirds of NOx emissions. The amount of these pollutants generated has started to decline in recent years but remains at high levels. A clear correlation exists between the production of energy-intensive industries and environmental pollution.

Industrial waste generation has increased but the intensity has decreased significantly. In 2014, the amount of waste generated by industry was estimated at 3.29 billion tonnes, a nearly five-fold increase from 1990. However, waste intensity (per unit of value added) decreased by almost 60% during the 1990s and has remained stable through the 2000s.

Industrial wastewater discharges have also remained stable since 1990, whilst discharges from households almost quadrupled partly due to urban population growth and improvements in living standards.





Source: varied issues of Report on the State of the Environment in China, Environmental Data Handbook, and China Statistical Yearbook on Environment; IEA (World Energy Balances database and CO2 Emission from Fuel Combustion database).

[6] The industry referred to in this box includes mining and quarrying, manufacturing and energy (electricity and heat production and supply) sectors.

China's stimulus measures in response to the financial crisis increased demand for heavy industry as well as the related environmental pressures

The main impact of the global financial crisis in China was a rapid deceleration of manufacturing as a result of the sharp fall in external demand, rather than disruption of financial markets. The immediate policy response was to expand domestic demand by substantially increasing investment in infrastructure and real estate. This helped stabilise economic growth but also increased demand for heavy industry products and led to mounting environmental pressures.

As the Chinese economy entered a "New Normal" phase of development and the impact of the early stimulus package weakened, growth has slipped to medium-high rates of 6.5-7% since 2012. While export-oriented sectors benefitted from the recovery of external demand, and new, high-tech sectors emerged, the traditional heavy industry sector entered a critical phase characterised by excess capacity, high levels of debt, fast declining returns on investment and price deflation (Figure 3).

Figure 3.A. **Growth in industrial production has been falling**

Source: OECD calculations based on the World Bank Global Economic Monitor database.

Figure 3.B. **Capacity utilisation rates (CUR) in several industries**

INDUSTRY	CUR 2011	CUR 2012	CUR 2013	CUR 2014	CUR 2015
Electrolytic aluminium	80.2%	71.9%	86.2%	86.5%	86.6%
Cement	73.0%	73.7%	75.9%	70.0%	68.4%
Coal	99%	93%	86%	78%	70%
Flat Glass	81.0%	71.0%	72.0%	68.0%	66.0%
Shipbuilding (CCI)[7]	93.7	73.6	60.9	63.3	64.4

Sources: NBS, in which shipbuilding data are from CANSI, and coal data are from the *Askci* China Business and Industry Research Institute, report "China's coal capacity and its utilisation in the past 11 years".

[7] The CUR data for shipbuilding are from the Shipbuilding Capacity Utilisation Monitoring Index (CCI) developed by the China Association of the National Shipbuilding Industry (CANSI). Figures in the table are the CCI original values divided by 10. The index has values between 0 and 1000. Above 900 means high CUR, and the sector exhibits signs of overheating; 700-900 means normal operation level; 500-700 means low CUR, and the sector is losing steam; below 500 means extremely low CUR, and the sector is sinking into deep mire. The CCI for 2009, 2010 and 2016 is respectively 921, 987, and 609.

Overcapacity in the industry sector is concentrated in six sectors: coal, steel, cement, flat glass, aluminium smelting and shipbuilding. In 2015, these sectors accounted for 12% of industry value-added and 10.4% of industrial employment. However, they accounted for only 2.3% of total industry profits and 31.6% of total losses. The underlying factors responsible for overcapacity vary among the sectors suggesting that some of the countervailing policies to address overcapacity will need to be sector-specific.

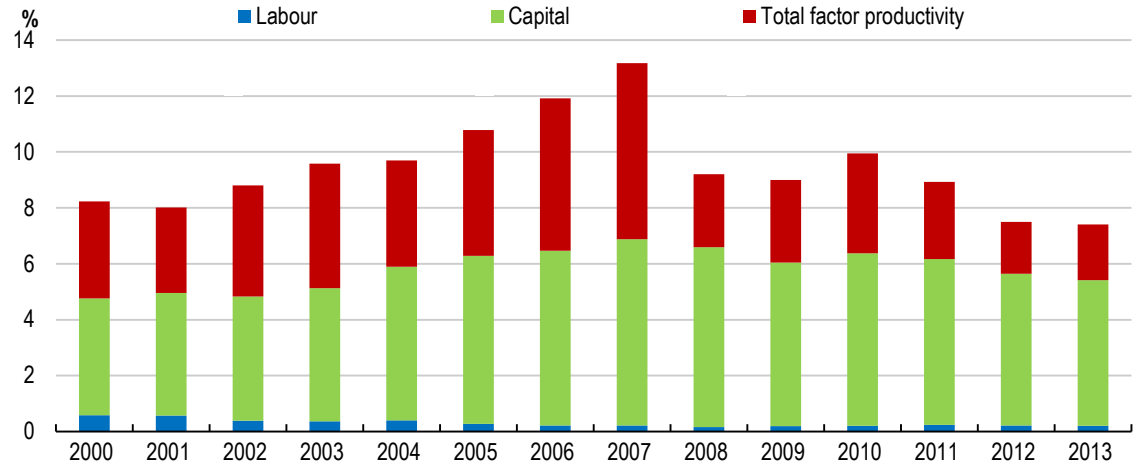
For example, in the shipbuilding sector, high cyclicality and over-optimistic expectations encourage shipbuilders to maintain unused capacities. In other heavy industry sectors, the high costs of closing and dismantling production facilities are also important barriers to exit. A thorough analysis of the challenges faced by different heavy industry sectors can be helpful to identify broader trends and more targeted and effective policy solutions for industrial sectors.

Harnessing the opportunities provided by the "next production revolution" and using more efficient and cleaner technologies to advance industrial restructuring

As the Chinese economy is experiencing problems of overcapacity in some sectors, the contribution of multi-factor productivity to growth has decreased in recent years, as it has in many OECD countries (Figure 4). The comparative advantage that China enjoyed in the manufacturing sector from low labour costs and access to inputs has also been substantially eroded. On the supply side, investments in capital stock have continued to provide the main means for reaching GDP growth targets, particularly so since the financial crisis.

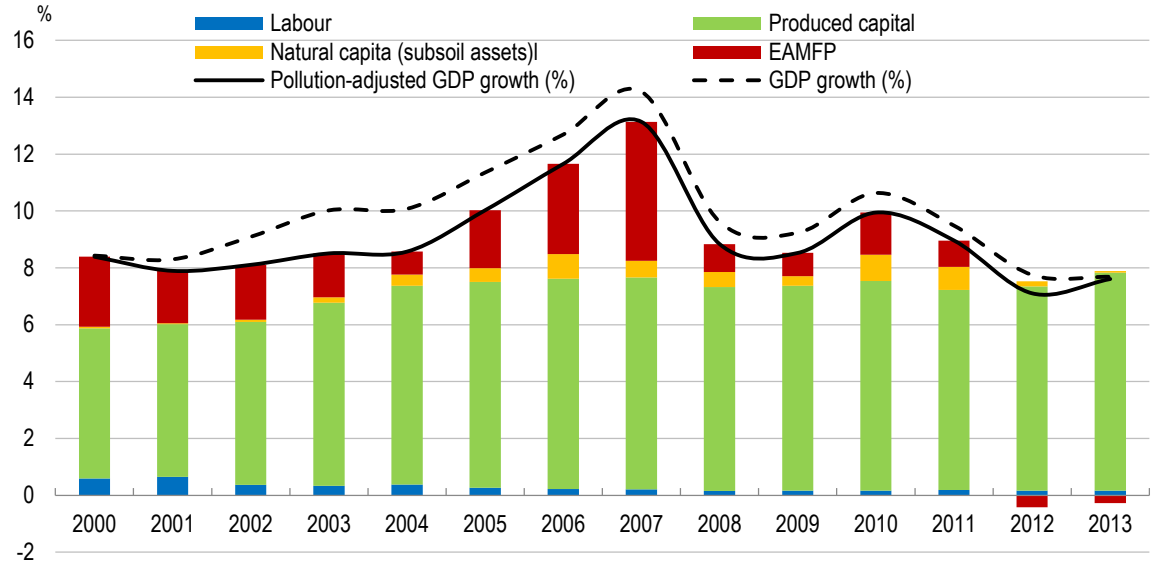
When account is taken of environmental factors such as the generation of pollution (essentially emissions of key air pollutants and GHG), China's GDP growth over the past two decades should be adjusted downward (Figure 5). Reliance on natural resource extraction (mainly subsoil assets) has continued to increase, though has been less pronounced since 2012. Environmentally-adjusted multifactor productivity (EAMFP), that is, the share of growth (after adjustment for pollution generation) that is not explained by the use of labour, produced capital and natural resources, has also weakened since 2008 and to a greater extent than the traditional measure of multifactor productivity.

Figure 4. **Contributions to growth in China**



Source: OECD (2017b).

Figure 5. **A more comprehensive measure of productivity in China incorporating environmental services**



Source: OECD Environmentally Adjusted Multifactor Productivity database.

In light of the ambitions to improve both environmental and economic outcomes at the same time, enhancing productivity (particularly the EAMFP) is the only way to regain competitive margins and sustain growth prospects in the long run. In this context, the restructuring of the industry sector requires not only a quicker exit of unprofitable and polluting firms, and the reallocation of resources to more productive uses, but also measures to boost productivity in a more sustainable, and less environmentally damaging, manner.

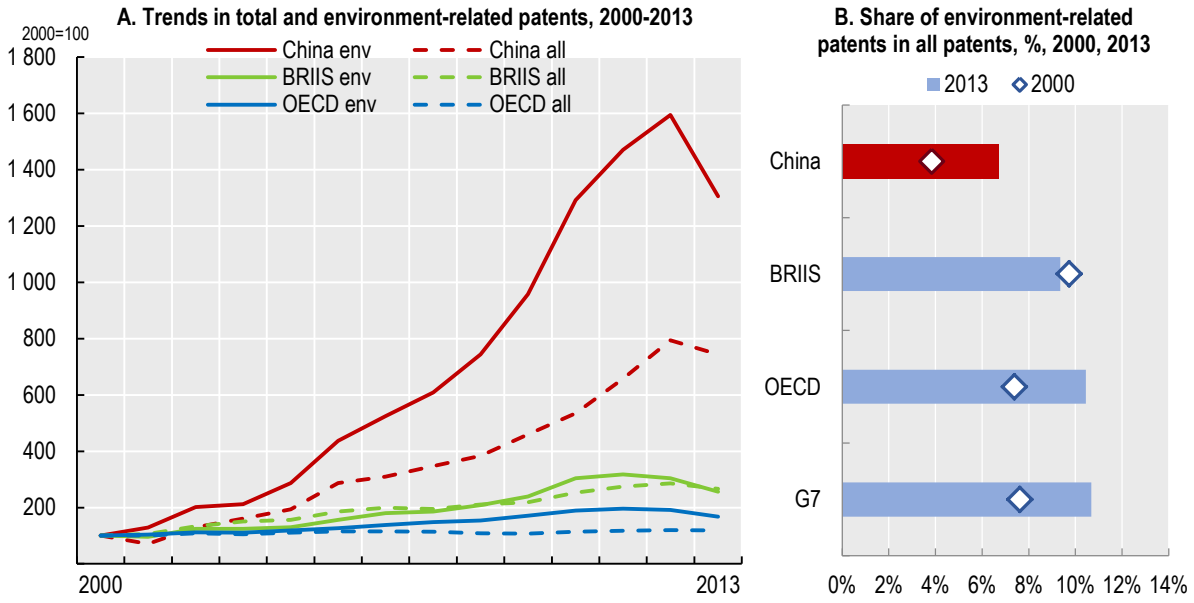
Improving the productivity and maintaining the competitiveness of the Chinese manufacturing sector will increasingly rely on innovation and entrepreneurship. There is also a growing recognition that innovation should not be confined to frontier-technology projects, and that more should be done to improve the efficiency and environmental performance of traditional manufacturing. Under the current Chinese innovation system, public funding is biased towards emerging and frontier projects, while research in developing new technologies in traditional industries receives scant attention (OECD 2017b).

China has steadily increased investment in science, technology and innovation for decades. It has surpassed Japan and the European Union to become the second largest host of R&D in 2014, accounting for 22.4% of global gross expenditure on R&D (GERD), just behind the United States. Nevertheless, its R&D intensity, measured by the share of GERD in GDP, which surpassed the level of European Union in 2014, is still below the OECD average and particularly the major innovators such as the United States, Germany, Japan and Korea (OECD, 2016b). The share of research personnel in total employment is also lower than in most OECD countries, and only 5% of total research spending was geared to basic research (as against 18% in the United States and 12% in Japan) (OECD, 2017b). As is pointed out by some experts, considering the current level of technology of China, it should best focus on applied rather than basic R&D. Nonetheless, it is also the case that many advances in future production technology are, and are likely to be, rooted in some basic areas of science. Higher and more efficient public investment in basic research is therefore crucial for accelerating the arrival of the "Next Production Revolution" in China, but also advancing the global knowledge and facilitating knowledge diffusion to a wider range of firms and segments of the economy (OECD, 2015).

The number of patents in China has also soared. In the environmental sphere, the number of environment-related patents increased 15-fold from 2000 to 2012, far greater than the range of increase in the OECD and BRIIS countries (Figure 5). However, the pace appears to have slowed in

2013. In absolute terms, China still lags significantly OECD countries (less than 5% of the latter in 2013), but has shown a marked shift towards greater specialisation in environmental technologies since 2005.

Figure 5. **Environment-related inventions in China and OECD countries**



Source: OECD, 2017c.

Nevertheless, despite the growing number of Chinese patents, the quality and relevance of the inventions protected still have room for improvement (Boeing et al., 2016). Most Chinese patents fall in the categories of utility or design patents, few are genuine inventions. A much smaller fraction of them are registered in the United States, the European Union and Japan compared to most OECD economies (OECD, 2017b). As with other categories of law enforcement, intellectual property rights (IPR) enforcement remains a serious challenge, although considerable efforts have been made in recent years to develop adequate enforcement mechanisms.

The Chinese government has taken several policy initiatives over the last couple of years to strengthen innovation, notably: Made in China 2025 (launched in 2015), Internet Plus (launched in 2015), and the 13th Five Year Plan (2016-20) which places a strong emphasis on innovation. The Made in China 2025 initiative has the goal of establishing China as a global manufacturing power by 2025. One of the objectives is to be among the world's leaders in terms of reducing (1) energy and resources consumed and (2) pollutants emissions released per unit of industrial added value by 2025.

By 2049, China's goal is to be among the world's leading manufacturing powers. To this end, one of nine strategic tasks is "green manufacture", and one of five strategic projects is "energy efficiency improvement, clean production, water conservation and pollution control, and recycling in traditional manufacturing industries". The Internet Plus initiative includes an environmental component focussing on improved environmental monitoring and support for waste recycling through the development of a system for trading in waste.

More broadly, China has launched a swathe of broad and ambitious initiatives to harness the potential of new technologies that form part of the "next production revolution". This involves a set of new technologies, particularly digital technologies, as well as new materials and processes, which many consider to have the potential to provide the platform for a new industrial revolution. As a result, many Chinese companies have made great strides in creating and using new production technologies. For instance, China is now the world's largest user of industrial robots, and the world's largest market for machine-to-machine services. By April 2015, China ranked third in the global

number of 3D printing patents. And by 2010 China ranked first in the number of Science Citation Index publications in nanotechnology. There are opportunities to apply these technologies to achieve environmental goals, principally by reducing the amounts of energy and materials used, and by providing alternative materials that are less hazardous than those currently in use (Box 2).

Past experience warns that new technologies may generate not only benefits but also new environmental hazards which need to be assessed and managed. If potential environmental risks are not identified, assessed and managed appropriately, regulatory uncertainty and public opposition can prevent their uptake. Questions have already been raised in OECD economies about several NPR technologies. For example, DNA synthesis presents biosecurity concerns, and there is a widely agreed need for a screening process for synthetic DNA manufacture and sale. The absence of sustainability standards for the feedstocks for bio-based products hinders their potential to substitute for products derived from more environmentally damaging petrochemicals. Lack of information about the potential risks of nanotechnology-enabled products, particularly in waste streams, is creating regulatory uncertainties and severely hampering the commercialisation of nano-technological innovation.

Box 2. **Next Production Revolution (NPR) Technologies and the Environment**

All of the NPR technologies (e.g. industrial biotechnology, digital technologies, 3D printing, nano-technology and new materials) could bring large environmental benefits. These positive impacts could arise through many routes. For instance:

Several decades of research in biology have yielded synthetic biology and gene editing technologies. When allied to modern genomics, the tools are in place to begin a bio-based revolution in production. Bio-based batteries, artificial photosynthesis and micro-organisms that produce biofuels are just some of the recent breakthroughs. With gene–related technology, even tiny marine plants (diatoms) have been harnessed to produce biofuels, an achievement which was technically unthinkable just ten years ago.

Bio-based manufacturing of fuels, chemicals and materials - the most potent symbol of which is the integrated bio-refinery – faces stiff competition from fossil-based industry. But nascent bio-based manufacturing is bringing new products to market. Today, almost one hundred bio-based chemicals are close to commercialisation.

Digital technologies, from the Internet-of-Things to artificial intelligence, will improve process efficiency and reduce waste in many aspects of production. For instance, Google Data centers use approximately 0.01% of the world's electricity. In July 2016, DeepMind – a leader in artificial intelligence – optimised cooling of data centres, cutting electricity consumption by 15%. And in another area of production, sensors in John Deere's latest equipment can help farmers manage their fleet, reduce tractor downtime and save energy.

Nanotechnology may also solve certain production-related environmental problems. For example, in making high-performance materials (such as turbine blades), nanotechnology can replace some alloys that contain carcinogenic metals (such as nickel powder) with ceramics. And the environmental safety of solar cells is being improved by substituting toxic materials (such as lead) with innocuous nano-composites.

3D printing's potential for enhancing environmental sustainability is also high. 3D printing can encourage less material and energy use through sophisticated design and lean production principles. 3D printing can also enable more sustainable material use because it: permits many materials to be shaped in ways previously possible only with plastics; lowers barriers to switching between materials by reducing economies of scale in some processes; and, allows fewer chemical ingredients to yield more variation in material properties. 3D-printed parts can also lower the environmental impacts of some products in two additional ways: (i) by printing replacement parts for legacy products that would otherwise be discarded (potentially avoiding situations where consumer goods such as washing machines are disposed of because a single part fails); and (ii) by reducing weight or otherwise improving a product's energy efficiency. Such energy savings can be quite large, especially in aerospace (G.E.'s lighter 3D-printed parts for a jet engine improved fuel efficiency by 15%).

Source: OECD, 2017d

China has begun to decouple some environmental pressures from economic growth, but a lot more progress is needed to improve environmental quality and resource efficiency

China has succeeded in decoupling some environmental pressures from economic growth in recent years. Most notably, emissions of SO_2 and NOx peaked in 2006 and 2011 respectively, while some water pollutants such as ammonia nitrogen have been declining since the early 2000s. It is expected that the next five to ten years will witness absolute decoupling of more pollutants. Most of the reduction of SO_2 and NOx emissions was achieved in the energy production sector, while emissions from manufacturing remained relatively stable. Given the high rates of GDP growth in China over the last 10-15 years, even relative decoupling (of other pollutants) will continue to intensify environmental pressures.

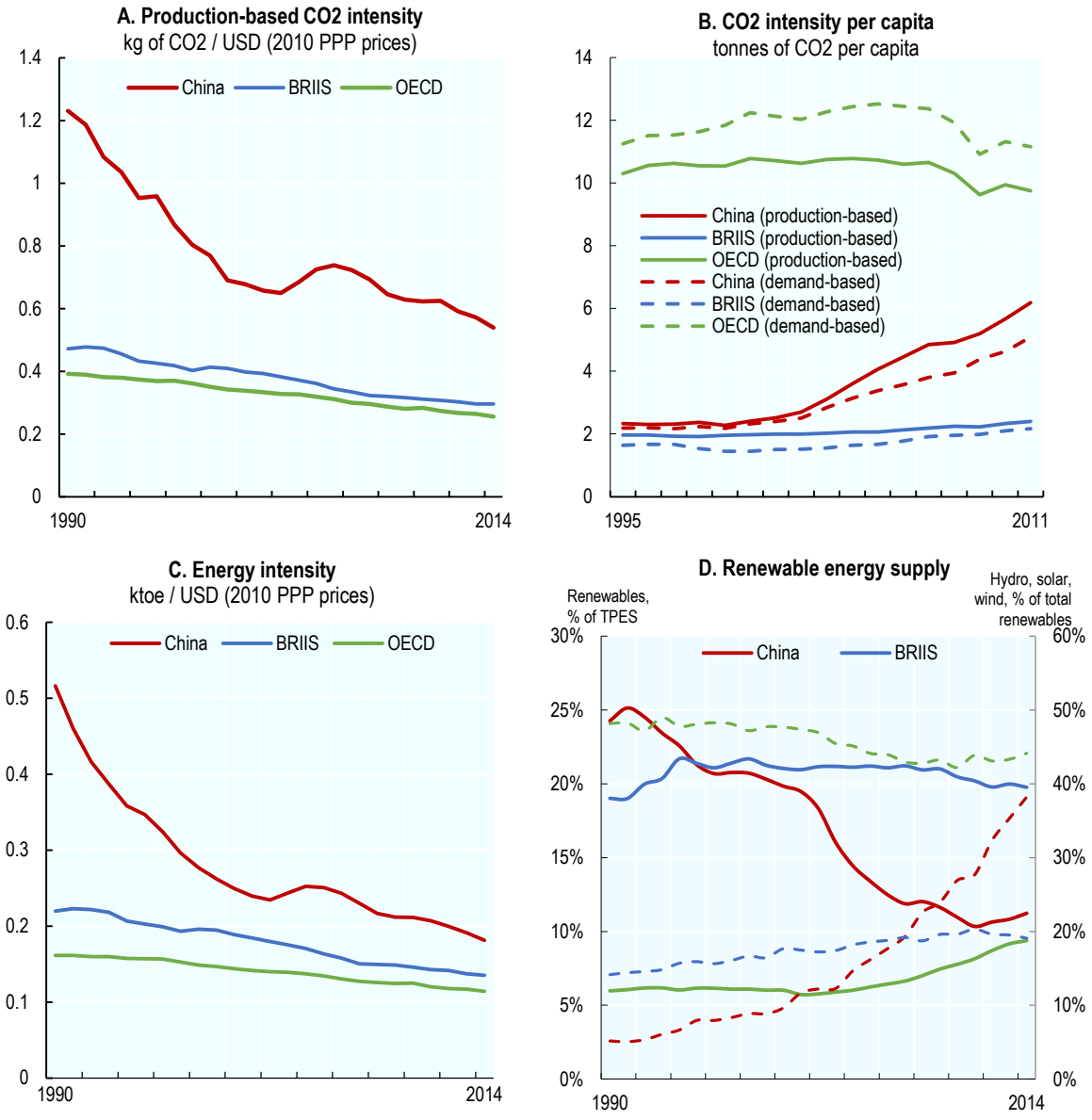
When assessing China's progress towards green growth through selected OECD environmental and green growth indicators (OECD, 2017c), several key trends emerge. The results are presented in Figure 6.

- The energy and carbon intensities of the Chinese economy have been considerably reduced since 1990, far more than the reductions in OECD and BRIIS countries over the same period. These reductions are essentially due to the combination of multiple factors, including the very high growth rates of GDP, structural changes within the economy as well as technological advancements. However, China still generates lower economic value (in terms of GDP) per unit of carbon emitted and per unit of energy consumed than the OECD and BRIIS countries. This indicates untapped opportunities for efficiency gains.
- Improvements in energy intensity since 1990 have been accompanied by development and use of cleaner fuels and renewable energy sources. The mix of renewables in primary energy supply has diversified, with solar, wind and hydropower increasing more than ten-fold during 1990-2014, while traditional use of biomass for cooking and heating, which can exert significant pressures on human health and ecosystems, considerably reduced. In 2014, China's share of renewable energy supply in total primary energy supply was 11.2%, slightly higher than the OECD average (9.4%). In terms of electricity generation, the use of hydropower increased eight-fold during the same period, while the use of solar energy has been growing exponentially since 2010. Nevertheless, coal continues to dominate the country's energy supply and power generation.
- Per capita carbon emission intensities have grown rapidly in China since 2000, while they have remained relatively steady in OECD and BRIIS countries. As GDP per capita increases in China, its per capita carbon emissions are likely to continue converging with those in OECD countries. When estimating the carbon emitted to satisfy domestic final demand, the amount of carbon emitted per person in China is also increasing but at a lower level and a slower growth rate than production-based per capita carbon emissions. This pattern is in contrast with OECD countries and is most likely linked with China's specialisation in more energy-intensive production and the high volume of exported goods with high carbon footprints. Although there is still a lot of debate over carbon emissions embodied in international trade, China has played an irreplaceable role in the international division of labour along global value chains and has made a substantial contribution to promoting the integration of the world economy.
- Material productivity has remained flat in China since the end of 1990s, while it has increased steadily in OECD countries. In 2012, the non-energy material productivity of China, that is, the economic value generated per unit of non-energy domestic material use, was half the level of the BRIIS economies, 22% of the OECD average, and less than 10% of the leading OECD countries such as Japan and the United Kingdom.
- Despite absolute decoupling, and the reduction in the total emission of some air pollutants, pollution levels remain high and represent a risk for the environment, the people and their quality of life. This is particularly the case for emissions of fine particulates ($PM_{2.5}$) and

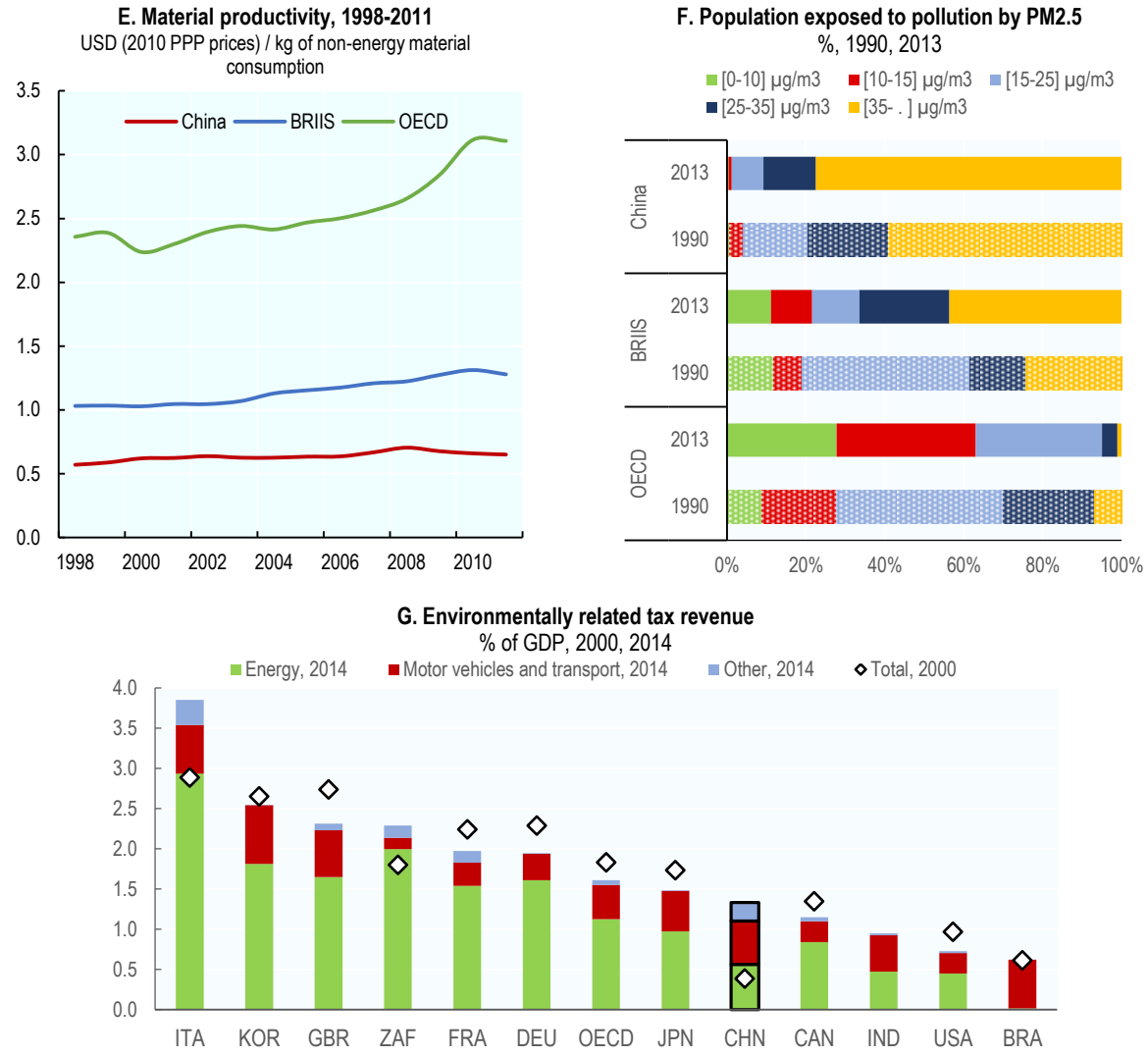
some other air pollutants where continued high levels of exposure have in significant impacts on human health and high social costs (WHO, 2016; OECD, 2016a).

- The use of environmentally related taxes[8] in China has grown and the share in total tax revenue has increased significantly in the past 15 years. The revenue they generated in 2014 represents 1.3% of GDP, nearly reaching the OECD average. Similar to the OECD countries, the tax base is dominated by transport and energy. Recent efforts have also been made to phase out inefficient fossil fuel subsidies and to move towards more market-based pricing of energy and resources.

Figure 6. **Selected indicators related to green growth in China**



[8] Environmentally related taxes include (i) energy products for transport purposes (petrol and diesel) and for stationary purposes (fossil fuels and electricity); (ii) motor vehicles and transport (one-off import or sales taxes, recurrent taxes on registration or road use and other transport taxes); (iii) waste management (final disposal, packaging and other waste-related product taxes); (iv) ozone-depleting substances and (v) other environmentally related taxes.



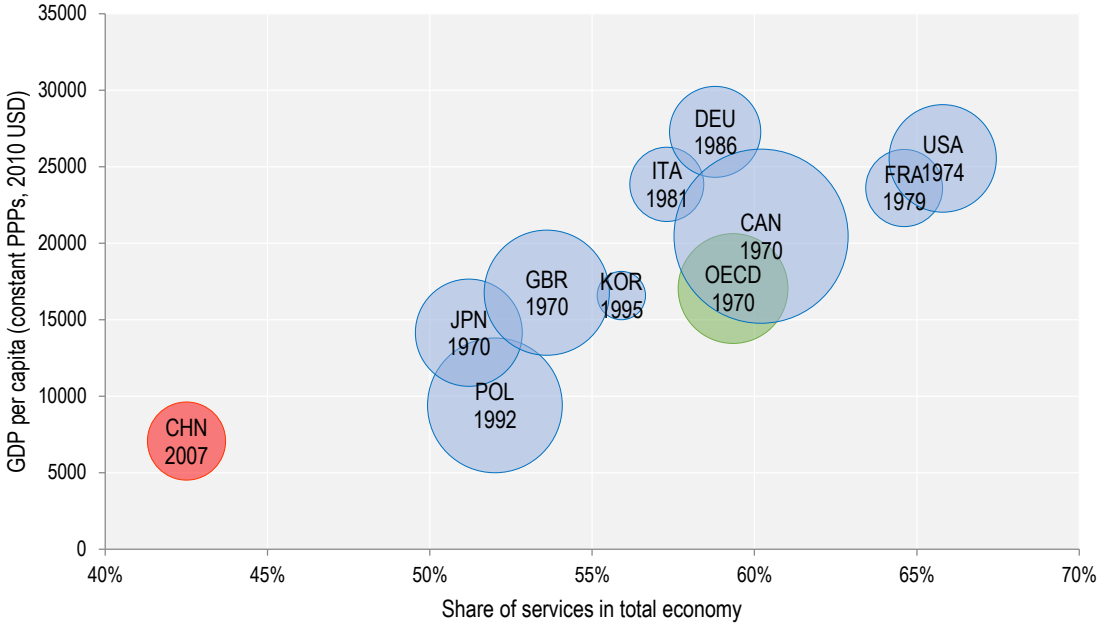
Source: OECD Environmental and Green Growth Indicators database (last update on 31 March 2017).

Environmental policies have become more stringent over time

The Chinese government has taken important steps to strengthen environmental policies and legislation. The 11th, 12th and 13th Five Year Plans have progressively integrated more ambitious environmental policy objectives. This has helped to raise public awareness, focus national efforts, mobilise resources and achieve tangible environmental results. The main pollutants that have been absolutely decoupled – particularly SO_2, NOx and ammonia nitrogen – have featured in these Plans. Moreover, SO_2 and NOx were decoupled at an earlier stage of economic development than in OECD countries (Figure 7). Technological leapfrogging and policy convergence aimed at improving environmental conditions may also have contributed to this achievement.

Nevertheless, the number and type of environmental targets that can be included in Five Year Plans are limited. There is growing recognition that the links between emission reductions achieved in the Plans and the environmental impacts of emissions on human health and natural resources are complex. The inclusion of ambient environmental quality standards in the 13th Five Year Plan is a positive step in this regard (Figure 8). Sound design of national targets and their decomposition across provinces are important prerequisites to the successful implementation of the Five Year Plans, otherwise the results may not be cost-effective and give rise to some perverse effects. For example, some provinces had to cut power supplies in order to achieve the energy intensity targets in the 11th Five Year Plan. Target-setting and allocation could be further improved by a fuller assessment of their benefits and costs.

Figure 7. Positioning of countries when absolute decoupling of SOx from economic growth first occurred



Note: The size of the bubbles represents the level of SOx intensity of the economy when absolute decoupling first occurred.

Source: OECD calculations.

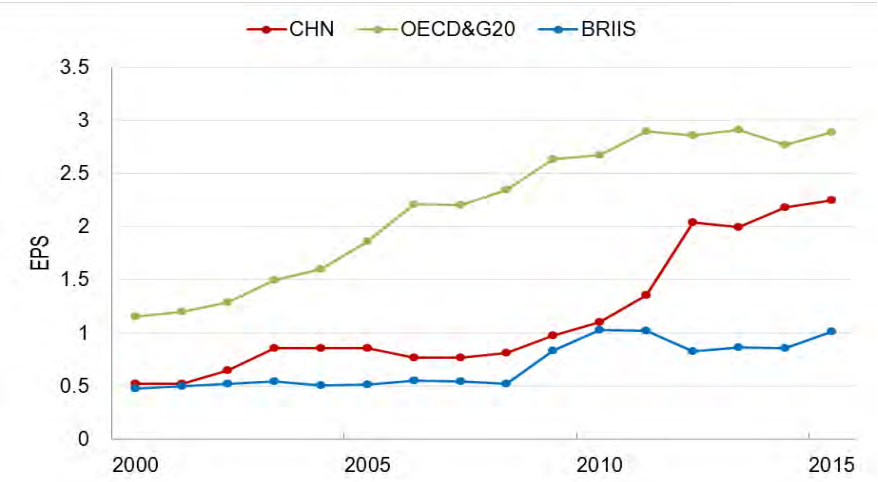
Figure 8. **Environmental targets in China's 11th, 12th and 13th Five Year Plans**

Environmental Indicator	11th FYP (2006-2010)		12th FYP (2011-2015)		13th FYP (2016-2020)	Management
	Target	Actual	Target	Actual	Target	
Main air/water pollutant emission reduction (%)						
SO_2	-10	-14.29	-8	-18	-15	
COD	-10	-12.45	-8	-12.9	-10	MEP
NOx	-	-	-10	-18.6	-15	
Ammonia Nitrogen	-	-	-10	-13	-10	
Energy supply intensity per unit of GDP (%)	-20	-19.1	-16	-18.2	-15	
Carbon dioxide emission intensity per unit of GDP (%)	-	-	-17	-20	-18	NDRC
Share of **non-fossil energy** in primary energy supply (%)	-	-	11.4	12	15	
Water consumption per unit of industrial added value (%)	-30	-36.7	-30	-35	-20	
Water consumption per unit of GDP (%)	-	-	-	-	-23	MWR
Total use of **water** (billion cubic metres)	-	-	-	-	< 670	
Air Quality						
Days with good urban air quality in cities at or above Prefecture-level	-	-	-	-	> 80	MEP
Reduction of PM2.5 concentration in substandard cities at or above Prefecture-level (%)	-	-	-	-	-18	
Surface Water Quality						
Surface water of at least Grade III quality (% of monitored sections)	-	-	-	-	> 70	MEP, MWR
Surface water worse than Grade V quality (% of monitored sections)	-	-	-	-	< 5	

Subsidies, as well as performance evaluation and greater accountability of local leaders, have been important instruments for achieving the environmental targets in the Five Year Plans. Substantial public financial support was provided to install end-of-pipe technologies to reduce emissions of SOx, NOx and COD, notably in the 11th Five Year Plan (CCICED, 2007). While this can be an effective way to achieve targets, it contravenes the Polluter-Pays Principle, and removes incentives for enterprises to develop efficient means of reducing pollution, including by plant modernisation. More recently, China has played a leadership role in the G20 context to promote green finance (G20 Green Finance Study Group, 2016), and the People's Bank of China, together with several other institutions, has issued guidelines for establishing a green financial system (People's Bank of China, 2016). Amongst other things, this involves identifying ways to improve access to finance in order to comply with environmental requirements. This is a more appropriate role for governments than subsidizing pollution control.

OECD analysis provides evidence that in recent years Chinese environmental policy has become more stringent; that is, environmental policy measures have increased the explicit or implicit cost of environmentally harmful behaviour. The analysis based on the OECD's Environmental Policy Stringency (EPS) proxy indicator shows that over the last 15 years, Chinese environmental policy has converged with OECD standards much more rapidly than other emerging economies [9], and particularly after 2010 (Figure 9). It should be noted, however, that the indicator is a proxy, weighting the stringency of a small number of selected environmental measures as defined in policy documents and laws. It does not measure how they are enforced.

Figure 9. **The stringency of environmental policies in China has increased over the past 15 years and is approaching OECD countries**



Source: OECD EPS Indicator, 2016

Overall, there is much greater similarity in the relative stringency of non-market rather than market-based regulation compared with OECD G20 countries. For instance, emission limit values for NOx, SOx and PM for new coal-fired power plants and for PM for new steel plants are comparable to OECD G20 countries. However, the average effective tax rates on transport energy (i.e. mainly gasoline and diesel) are well below levels of OECD G20 countries. Conversely, environmental tax rates for coal fired power plants appear to be relatively stringent.

Further analysis found that although older plants are also subject to increasingly stringent environmental requirements in China, there remain considerable challenges to remove backward capacities through environment standards.

[9]Brazil, Russia, India, Indonesia and South Africa

But now China needs to deploy a wider range of more cost-effective policy instruments

As China faces up to its environmental challenges in the 13th Five Year Plan and beyond, it will need to deploy a wider range of more effective and efficient policy instruments. Reliance on top-down, command-and-control approaches and subsidies can be effective in the early stages of economic development, but they entail high costs, and they reduce or eliminate incentives for the development of cleaner technologies. As the range of pollution sources becomes more numerous, diverse and complex, environmental policy must address this challenge by deploying a wider range of more cost-effective policy instruments. This suggests that opportunities should be sought to make greater use of market-based instruments in the overall policy mix. China has been experimenting with pollutant emission trading in over ten pilot provinces since 2007; some provinces have also volunteered some of their own cities and counties to take part in the pilots. Although challenges remain, the establishment of a nation-wide carbon emissions trading scheme soon to be rolled out in 2017, and the adoption of the Environmental Protection Tax Law, are important steps in this direction.

There has been a long debate in OECD countries about the relative merits and limitations of regulatory and market-based instruments. In practice, they are often used in combination. In such cases, the key challenge is how to design them to maximize synergies.

Most OECD countries have continued to place a heavy reliance on regulatory approaches, largely because of the clarity and predictability they provide both to government officials and enterprises. However, designing effective and efficient regulations poses a number of challenges, including: the need to overcome information asymmetries; the difficulties of targeting the precise source of environmental damage; and the risk that inflexible requirements increase costs and do not provide incentives for innovation once compliance has been achieved.

The principal advantage of market-based instruments is the incentives they provide to find least-cost, innovative approaches to meet environmental requirements [10]. However, they often face opposition because they explicitly impose a price on an activity, whereas regulations do so only implicitly. The use of market-based instruments may also involve some loss of control for administrators of where exactly the abatement takes place.

An important prerequisite for the effective application of market-based instruments is the reform of any subsidies that may negate their impact. This is especially the case for subsidies for fossil fuels that provide incentives for the generation of GHGs and local air pollutants such as SOx and NOx. Such subsidies are usually economically inefficient and a drain on public resources as well as being environmentally damaging. Together with the United States, China underwent the first voluntary peer review of fossil fuel subsidies within the G20 in 2016, and identified nine fossil fuel support policies as priority for reform. Most of these concern exemptions from excise or land-use taxes that benefit fossil fuels, while others relate to power or heat generation and transport. Implementing the recommendations of the peer review would be an important step in internalising environmental costs in the energy-intensive sectors and reducing incentives to pollute. It would also establish a better basis on which to apply market-based instruments to the energy and related sectors.

The main market-based environmental policy instruments are taxes and tradeable permits. Environmental taxes create certainty about the price on pollution, but the amount of pollution that will be reduced is uncertain and will depend on how producers and consumers respond to the tax. Tradeable permits in contrast, provide certainty about the environmental goal but not about the price. Both approaches have helped to reduce air emissions from the industrial sector cost-effectively. For example, it has been estimated that, in the US, changing the regime for controlling SOx from standards to a tradeable permit system helped to reduce compliance costs by between USD 153 – 358 million (Anthoff and Hahn, 2010). The introduction of a tax on NOx in Sweden, significantly accelerated the achievement of the emissions reduction target, largely driven by innovation, and

[10] Market-based environmental policy instruments, as well other instruments such as green public procurement, create demand for greener processes and products. They complement supply-side approaches such as R&D and tax incentives for research.

resulted in Swedish companies taking out a large number of patents (OECD, 2013). However, well-designed tradeable permits can be particularly useful instruments for marrying the objectives of emissions reduction and plant exit (Box 3).

OECD has conducted extensive analysis of environmental policy instruments. In order to optimize their design from economic and environmental policy perspectives, it suggests that, to the extent that institutional capacities allow, the following criteria should be borne in mind:

- *Environmental effectiveness* – the ability to achieve the environmental objective with a high degree of certainty.
- *Flexibility* – the extent to which the policy leaves room for the firm (or consumer) to choose the most cost effective means for reaching the environmental objective; less prescriptive policy interventions provide more opportunities for new ideas, innovation and technology adoption.
- *Predictability* – the consistency, credibility and clarity of current and future policy signals can affect the costs of compliance as well as investment, innovation and eventually productivity growth. Certainty on future requirements provides stronger incentives to adopt long-term abatement strategies.
- *Dynamic efficiency (or depth)* – the extent to which a policy instrument gives continued incentives to search for cheaper abatement options, particularly through innovation.
- *Competition-friendliness* – avoiding policies that distort competition by favouring incumbent firms over potentially more efficient new entrants, including: by establishing high administrative burdens to new entry; stricter environmental requirements on new firms; and providing licenses and permits on preferential terms to existing firms – "grandfathering"
- *Minimal administrative costs* – for the government and companies.

Box 3. **Tradeable Permits and the Closure of Facilities: Marrying Environmental and Industrial Policy Objectives**

Tradeable permits can be an effective means to provide incentives for emissions reduction in sectors with significant excess capacity, and for which plant exit may be required. Tradeable permits establish a cap on the total amount of specific types of pollution and then allocate permits specifying how much pollution each permit holder can emit. Permit holders can then buy or sell emission allowances depending on the number of allowances they have in relation to their optimal abatement strategy.

Grandfathering emissions standards – i.e. being more lenient on existing plants than new plants - can prolong the life of older, more polluting plants. Such differentiation is often introduced to address political economy constraints. However, if permits are tradeable and are allocated freely to existing emitters, the incentives for exit of older plants can be retained if the permits continue to be allocated even if the plant shuts down. Moreover, the revenues generated when exiting plants sell their remaining permits can be used to cover the costs of closure, for which alternative sources of financing can be difficult to obtain.

As such, the free allocation of permits to existing emitters can help to overcome resistance to the introduction of the tradeable permit policy. The principle of granting permits to facilities which have already been closed was applied in the case of the US Clean Air Act Amendments which introduced the tradeable permits system for acid rain precursors in the United States, as well as the Los Angeles RECLAIM programme for smog precursors. Under Phase 1 of the EU-ETS, some countries withdrew permits for facilities which had closed, but others did not do so.

Incentives for exit can remain in place even if the permits are allocated on an annual basis. However, policymakers may choose to place a statute on the period of time for which the rights are granted, consistent with more general principles of compensation for transition costs in the face of policy changes in other domains, e.g. tax policy.

In principle, similar results could be achieved by using a tax on emissions or by auctioning tradeable permits, with revenues recycled to those emitters present in the market when the scheme was introduced. However, it is likely to be more difficult to implement either approach both administratively and politically.

Source: OECD, 2017; Tietenberg and Johnstone, 2004

And address environmental challenges in the industry sector in a more targeted and coherent way

In OECD countries, environmental permits are fundamental instruments for translating environmental policies into explicit and enforceable requirements for industrial and other stationary sources of pollution. In many OECD countries, they are helping to drive the modernization of industry by linking permit requirements with the use of best available technologies. However, such an approach may not be feasible or cost-effective in emerging economies, and alternative ways of linking emissions standards in permits with environmental quality objectives have been developed.

China has been experimenting with pilots of (pollutant) emission trading since 2007, albeit with limited success. It also aims to launch a nationwide carbon emission trading platform in 2017, progressively covering eight energy-intensive industries, namely petrochemical, chemicals, construction materials, iron and steel, nonferrous metals, paper, power generation and aviation. Meanwhile, the Chinese government has recognized that the current environmental permitting system is inadequate, and has been making efforts to make it work better. On 10 November, 2016, the State Council approved an implementation plan to establish a new permit system. It set the objective of issuing permits for all stationary sources of pollution by 2020. The experience of OECD countries, particularly the European Union, can provide useful lessons in this regard.

Since issuing permits can be a complex and resource-intensive exercise, the requirements should be differentiated according to the size, location and potential environmental impact of the pollution sources. Many OECD countries distinguish between large, potentially hazardous plants that require a customized permit in order to operate, and smaller, less hazardous plants that must submit a declaration before starting operation, and then comply with general binding conditions that have been formulated for that type of installation. In countries such as France and the Netherlands, only about 10% of installations are subject to facility-specific permits (OECD, 2009).

For facility-specific permits, two different models have been followed in OECD countries. Some countries such as the US issue separate permits for air, water, waste and other environmental media at the same facility. Other countries, particularly within the EU, issue a single permit for a facility that aims to treat all environmental requirements in an integrated way. The main advantage of integrated over media-specific permits is that they avoid the risk of transferring a problem from one environmental medium to another. For example, depending on the technology adopted efforts to conserve water may result in greater energy use. In addition, integrated permits can foster closer cooperation among departments within Environment Ministries, a consideration that is relevant in the case of China.

Before plant operators apply for an environmental permit, they should undergo an environmental impact assessment (EIA). This is the case for new plants or significant modifications of existing plants. The precise scope of the EIA should be determined on the basis of a preliminary screening of potential environmental impact, but a robust EIA should be a prerequisite before a potentially hazardous installation receives a permit. In such cases, there are important linkages between the information used and the assessments made in EIA and permitting, and there are clearly advantages in ensuring consistency between the two processes. However, a recent review of environmental enforcement in Chinese Provinces revealed that EIA requirements have not been systematically enforced. The Chinese authorities have recently recognized that the linkage between EIA and permitting should be strengthened. Amongst other things, this would help to ensure that requirements for spatial planning and ecological functional zones were respected, and that new or expanded facilities were located in areas that minimized risks to health and the environment.

The full implementation of the permitting system during the 13th Five Year Plan period has important implications in several respects. First, the system sets clear and predictable rules to polluters for what is legal and what is not. Second, as a basic instrument for environmental regulation the permit can weave together a string of other regulatory tools, such as standards, EIA, pollution levy (to be replaced by environmental taxes), total emission control and emission trading. Third, from the perspective of regulatory reform, the permit could help improve internal coordination within the MEP by establishing an institutionalised mechanism for information sharing and regulatory coordination.

Nevertheless, important challenges remain to make the permitting system effective, and simultaneous efforts are needed to reform environmental regulatory governance.

Another area where opportunities exist for greater environmental policy coherence regarding the manufacturing sector is the circular economy and industry models that achieve greater resource efficiency by fully integrating waste as a resource in the production cycle via closed-loop processes. China has been at the forefront of developments in this field which aim to reduce, reuse and recycle materials in the economy. Following a direction in the 13th Five Year Plan, NDRC elaborated a Leading Plan for a Circular Economy in 2016-2020. Industry is at the heart of the Circular Economy, and well-designed policies within this framework could help to reduce demand for resources needed to produce industrial products, reinforce incentives for recycling, and accelerate the transition to a more efficient and greener sector. For example, greater recycling of steel could facilitate wider use of less environmentally damaging production technologies and reduce emissions from the sector[11]. Another example is the further development of eco-industrial parks (EIP) that bring together firms or clusters of industries that are complementary and in which the by-products or residuals of one enterprise are used as a resource input by another enterprise, with mutual economic and environmental benefits. China has been piloting EIP projects since the early 2000s (under the Ministry of Environmental Protection, the Ministry of Commerce and the Ministry of Science and Technology).

OECD countries have adopted laws requiring industrial and other plants to disclose information about their releases of pollutants to the environment. Amongst other things, this makes industrial plants more accountable to local communities, improves monitoring of pollutant releases, and strengthens the basis for policy development and evaluation. In the US, this took the form of the Toxics Release Inventory (established in 1986), and in the EU, the Pollutant Release and Transfer Register (fully implemented in 2009). The OECD supports the development and implementation of PRTRs by developing technical guidelines and examining how PRTRs could help monitor progress towards achieving some of the Sustainable Development Goals[12]. A recent OECD review of the PRTR that China established in 2011 suggests that there could be mutual benefits if China participated in the OECD's work on PRTRs (Hasegawa et al., 2016).

Stricter enforcement of environmental laws can both improve environmental conditions and support the restructuring of the industry sector

Despite the efforts of the central government to strengthen environmental policies, the impact and enforcement of laws need to be strengthened. Inadequate enforcement of environmental laws has effectively provided an implicit subsidy to the enterprises concerned; they have been allowed to forego the expenditures required to comply with environmental requirements. Failure to enforce environmental requirements at heavily polluting plants has also helped to postpone the exit of inefficient firms from the industry sector, exacerbating the overcapacity and poor environmental performance of the sector. As a consequence, less polluting firms have suffered a disadvantage.

One of the main factors in weak environmental enforcement has been the role that provinces and sub-national authorities have played in impeding environmental law enforcement. Provinces and local authorities have primary responsibility for environmental enforcement. At the same time, local enterprises play a key role in meeting economic targets and generating a major part of local governments' revenues. There is a clear conflict of interest. For a long time, many local governments

[11]Currently more than 90% of Chinese steel is produced using Basic Oxygen Furnaces (BOF), and only 6% using Electric Arc Furnaces (EAF). EAFs generate lower emissions than BOF, though the extent to which this is the case will depend upon the relative carbon-intensity of the electricity supply mix. In addition, unlike BOF, they can process scrap steel. However, EAFs account for only 25% of steel production. Various factors impede the greater use of EAF in China, including low levels of recycling and the low price of coal.

[12] For further information, see http://www.oecd.org/chemicalsafety/pollutant-release-transfer-register/

prioritised economic over environmental policy objectives and used their oversight of local Environmental Protection Bureaus to protect local enterprises from actions to secure their compliance with environmental laws. The Chinese government has sought to address this issue by further strengthening the role of the achievement of environmental and economic targets in the performance management and career development of local leaders.

While these new measures have helped to improve compliance with environmental requirements, it was recognised that further measures were needed. Thus, the 2014 new Environmental Protection Law strengthened penalties for environmental violations, including by restricting access to credit and tax breaks. There is evidence that it has helped to achieve stricter enforcement in some provinces. Nevertheless, in 2016, the Central Government sent environmental inspection teams to Provinces to assess how well they were enforcing environmental laws and regulations. These teams have considerable influence and the goal is to inspect all Provinces at least once by the end of 2017. A first round of inspections has revealed some serious breaches and resulted in the application of sanctions, including fines, detention and Party disciplinary punishment (Box 4).

Box 4. **China's Review of Provinces' Environmental Enforcement 2016-17**

The environmental enforcement teams sent to provinces by the central government have substantial powers. Usually a Vice Minister of the Ministry of Environmental Protection acts as Vice Chief Inspector of the team. Inspections generally last for one month. Two rounds of inspections were completed in 16 provinces/municipalities in 2016.

The inspection teams interview local governments and cadres, conduct visits and spot checks, and respond to information provided by the public. Some of the key findings included: some key construction projects had not undergone an EIA before construction began; some cities that had not completed an evaluation of their social and economic development received an excellent grade for their performance; nature reserve areas have been sacrificed for urban development; and some companies were found falsifying pollution data. A total of 33000 offence reports were examined and resulted in: rectification orders for 20129 cases; fines totalling CNY440 million levied in 8500 cases; a total of 720 persons detained in 800 cases; 6307 persons were interviewed, 6454 persons were held accountable, and many received party disciplinary punishment.

Source: Xinhua News Agency

While the environmental inspection teams are helping to identify and rectify environmental enforcement failures, they are an *ad hoc* measure. The future challenge will be to develop a systematic approach to environmental enforcement. OECD experience suggests that this should involve developing an appropriate mix of three main activities:

- *Compliance promotion* – activities that encourage compliance but do not involve sanctions for non-compliance; e.g. information dissemination, technical assistance, and regulatory and financial incentives. The preparation of customized permits provides opportunities for regulators to explain the necessity and benefits of compliance. A significant challenge is how to communicate with small- and medium-sized enterprises that are subject to general binding rules. Many OECD countries have found that using communication tools that emphasize the economic benefits of compliance are often the most effective.
- *Compliance monitoring* – collecting and analysing information on compliance status. This may be by means of governmental inspections, audits or investigations, monitoring of ambient environmental quality, self-monitoring and reporting by regulated entities, and citizen monitoring. A key challenge for governments is how to use scarce inspection resources most efficiently. Many OECD countries now use a risk-based approach that analyses several types of risk: the magnitude of the environmental risks; the potential exposure of populations or sensitive ecosystems; and risk of non-compliance based on companies' compliance history.
- *Enforcement* – actions to compel the offender to return to compliance with requirements, remediate the damage caused, and impose sanctions on the offender. Most countries follow a sequence of increasingly severe penalties which may include: informal or formal warnings;

administrative punishments; and civil or criminal legal sanctions. Many OECD countries now seek to establish financial penalties at a level that is commensurate with the financial gain resulting from non-compliance. When a plan fails to comply with environmental requirements after a reasonable time, and continues to pose a threat to health or the environment, temporary and permanent closure should be considered.

An important prerequisite for an effective environmental and enforcement regime, is a comprehensive and accurate inventory of companies subject to regulation and well-managed information flows, within and between the relevant governing bodies. EIA and permitting procedures allow new companies to be identified. However, when setting up a new system, an inventory should be made of all companies subject to regulation. The inventory should include key information such as the size of the facility, the potential risks, the pollution control measures in place, the compliance record of the company, etc.

The effectiveness and efficiency of environmental enforcement and compliance is also influenced by the institutional framework within which these activities are embedded. A key challenge is be ensure that environmental inspectorates are shielded from the undue influence of sub-national governments. The vertical environmental governance system to be introduced in 2017 to supervise and enhance law enforcement below provincial level governments marks an important step in this regard. Another institutional issue concerns the relationship between permitting and inspection in environmental regulation (Box 5). To avoid any potential conflicts of interest, many countries allocate these responsibilities to different institutions or units.

Box 5. **Separating responsibilities for permitting and inspection**

Specifying permit conditions and checking compliance with them are closely related activities. Both tasks require experts with a high level of technical skill, and typically such experts are in short supply. Combining these functions would therefore enable these scarce resources to be used efficiently. However, conflicts of interest may arise if the same officer is involved in both activities at the same plant. As a result, many countries require these tasks to be carried out by different officers at the same installation. In some of the countries examined in an OECD study (US, Russia, England and Wales, the Netherlands, and in some Environmental Protection Boards in China), permitting specialists and inspection staff operate in different units. In Finland and Scotland, permitting and inspection staffs are usually part of the same unit. The same person may even do both permitting and inspection, but the two functions are never combined for the same installation. In France, Japan, and Northern Ireland, individual inspectors carry out all regulatory functions, including permitting, inspection and enforcement. However, to prevent potential "issue blindness" and corruption, inspectorate staff are regularly rotated between sites for which they are responsible (e.g., at least every six years in France).

Source: OECD, 2009.

The more effective design and implementation of environmental policies requires a strengthening of environmental governance

The 13th Five Year Plan put an increasing emphasis on strengthening environmental governance. There are several dimensions to this challenge: the organisation of national environmental institutions; coordinating environmental policies across levels of government; coordinating environment and other policies at the national level; and the relations between government, the public and other stakeholders.

Reflecting the growing importance attached to environmental issues, the *status of the national environmental body* in China has been significantly strengthened over the last 10 years. It has evolved from the State Environmental Protection Agency to the Ministry of Environmental Protection (MEP) with a Minister that is a member of the State Council. This has helped to enhance the environmental voice within the government. However, the MEP remains small and poorly resourced with a staff of about 300. The severe shortage of resources constitutes a challenge for MEP to tackle the increasingly complex environmental issues. By way of contrast, the Environment Ministry of the Czech Republic with a population of 10.5 million has double the staff of China.

Responsibility for environmental issues at the national level is not solely the responsibility of the MEP. Environmental responsibilities are fragmented and shared among several bodies including the

Ministries of Water Resources, Land and Resources, and Agriculture, the State Oceanic Administration and the State Forestry Administration. NDRC is responsible for climate and energy efficiency policies. Environmental responsibilities are also often fragmented in OECD countries and there is no single "best practice model". As in many countries, there are opportunities to improve coordination *within* the MEP and *between* the MEP and other Ministries/agencies with environmental responsibilities. At the same time, a question remains whether the current organisation in China is optimal, particularly from the perspective of developing more coherent and integrated approaches to environmental policy in areas such as environmental permitting.

Important adjustments have also been made to optimise the governance structure of the MEP. In 2016, three new departments responsible for the management of air, water and soil environment were established, replacing the original departments of total emission control and pollution prevention. This represents a shift to a new concept of management of environmental factors. Nevertheless, a "matrix" structure remains in place for the various departments of the MEP, regulatory procedures and the management of environmental issues. Further efforts are needed to improve the information sharing and coordination across departments within the MEP (Chen 2016).

Many OECD countries have now separated policy and regulatory functions in separate institutions at the national level. Environment Ministries generally retain responsibility for policy and international environmental cooperation. Environment Agencies are often responsible for environmental information, overseeing EIA and permitting, and for environmental enforcement and compliance. An important advantage of this type of arrangement is that it helps to avoid political interference in environmental information and enforcement actions, thereby enhancing the integrity and credibility of these activities. For a long time in China, the boundary between policy and regulatory functions has been ill-defined at the national level. This needs to be optimized for the sake of clarity and efficiency in the future.

The *vertical coordination of environmental p*olicy across levels of government remains one of the most difficult challenges in Chinese environmental governance. There has been a fundamental tension between the need to create a consistent approach to environmental requirements across the Chinese territory – an environmental level playing field – and the prerogatives of provinces to enforce environmental laws and adapt them to local conditions. As explained above, there has been a conflict of interest between environmental and economic policy, and this has often resulted in failure to adequately enforce environmental requirements. The Chinese government has taken a series of measures to address these, including integrating targets of environmental quality into the performance assessment of local leaders, and using environmental inspection teams to review provinces' environmental enforcement efforts.

Further measures have also been taken to strengthen the coordination and integrity of environmental measures across different levels of government. The MEP has established six Regional Environmental Centres, each overseeing 5-6 provinces. Administratively they do not have jurisdiction over sub-national authorities. However, through dialogue and discussion they could help to make provinces more accountable for their environmental performance. Their role should be strengthened and clarified.

MEP is centralising the responsibility for monitoring. The China National Environmental Monitoring Centre, affiliated to MEP, will directly manage 1436 state-controlled air quality monitoring stations across 338 municipalities, and will replace Provincial institutions to be the first body to receive the original data. The National Monitoring Centre is also implementing a pilot programme to centralise the monitoring of surface water quality involving 2767 water monitoring stations across the country. Transferring these responsibilities from sub-national to national authorities is an important step in ensuring the quality and independence of monitoring data.

As further insights are gained from the work of environmental inspection teams in provinces, further consideration should be given to how environmental inspection should be organised, as well as the relationship between environmental permitting and inspection. In some OECD countries, national environmental authorities retain responsibility for conducting EIA and permitting for large complex plants, with sub-national authorities dealing with smaller plants. This is due to concerns that sub-

national authorities would not have the capacity, and, in some cases, the independence, to regulate the larger plants. MEP's cut of the connection between EIA agencies and environmental protection agencies at all levels is a step in the right direction.

All countries face challenges in *horizontally coordinating environmental and other policies*. Frequently policies in other sectors, including manufacturing, can work against environmental policies. Appropriate mechanisms are needed to better align policies and regulatory responsibilities. Experience from OECD countries demonstrates that the active engagement of political leaders is an essential prerequisite for good policy coordination. The adoption of shared policies – such as the concept of ecological civilisation and green development – can also provide useful strategic frameworks for policy coordination. However, they need to be complemented by cross-department mechanisms when trade-offs need to be made between policies. A lot of efforts are thus needed to strengthen communication and co-ordination across ministries and agencies working on environmental protection. At the level of the central government of the centre of government – for instance the General Office of the State Council – can be useful in this regard, as well as joint bodies involving the ministries concerned. The central parts of government can issue guidance to non-environmental ministries on how to take account of environmental issues in their work.

There are also challenges of coordinating policies horizontally at sub-national level, both within and between sub-national governments. A common challenge in many countries is when administrative boundaries and environmental systems such as river basins and air sheds do not coincide. Fundamentally, there are two types of approaches for addressing this challenge: either to establish a coordinating mechanism involving the administrative units involved in managing the environmental system, or to establish a mechanism for managing the environmental system in which administrative systems participate. Provided that the institutional obstacles can be overcome, managing environmental systems in an integrated way fosters greater efficiency and effectiveness. There is plan to set up regulatory agencies by river basin so as to strengthen cross-jurisdictional enforcement of environment law.

China's environmental governance system should also make appropriate provision for *public engagement in environmental decision making*. As China converges with OECD country income levels, public demands for a safe environment will continue to increase. Providing access to justice and encouraging public participation in environmental decision making can enhance the quality of decisions, make public decision-making on environmental issues more transparent and accountable, and strengthen public support for environmental policies and their implementation. The 2014 Environmental Law is an important step in the right direction. China is now actively making efforts towards further specialization of environmental legislation. Amongst other things, it has helped to stimulate public interest law suits against polluters. As experience accumulates with the new measures, further opportunities should be sought to involve the public in environmental decision making.

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This project conducted jointly by the DRC and the OECD aims to propose policies to help China reduce the environmental footprint of its industry while raising productivity, spurring innovation and addressing broader environmental challenges.

It analyses the specificities of some heavy industry sectors that are energy-intensive, highly polluting and plagued by overcapacity, in order to support the design of policies that create incentives for promoting greener and more efficient production capacity. It also looks at opportunities of the Next Production Revolution that can be sought to harness new technological developments for greater productivity and environmental gains.

This Policy Paper is one in a series, developed based on main findings and recommendations of the project. It examines challenges in the current environmental governance in China and provides recommendations on how to strengthen regulatory enforcement in support of the transition to a more balanced, efficient and greener growth path.

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