Delivering Environmentally Sustainable Economic Growth: The Case of China

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Summary

China has achieved miraculous economic growth over the past 30 years to become the world's second largest single-country economy. The economic boom is attributed to China's market-oriented reforms, which prioritize economic growth. However, growing the gross domestic product (GDP) at any cost has created a series of social and environmental problems. Consequently, China's economic losses due to pollution and environmental degradation accounted for 10.51 percent of gross national income in 2008, according to the World Bank.

An extensive growth model that relies on high resource input and heavy pollution is not sustainable. The Chinese government, in recent years, has begun calling for a major policy shift. Although China has significantly stepped up efforts to soften the environmental impact of economic growth, policy makers still face numerous obstacles. The goal of this paper is to evaluate China's existing sustainability strategies and policies, recent achievements, and remaining problems to generate recommendations for policy makers.

China's economic reform, specifically related to economic construction and opening, has profoundly impacted the environment. Literature suggests that economic growth and globalization do not necessarily cause environmental degradation, implying that China does not have to slow down economic growth or return to autarky in order to avoid environmental deterioration. Nevertheless, a better environment will not emerge automatically as the country becomes richer, necessitating a strategy of sustainable development. Given that sustainability as a concept is difficult to apply practically, this paper proposes the following recommendations to facilitate a pragmatic, environmentally and socially sustainable economic growth strategy:

- The policy goals of environmental protection, poverty eradication, balanced regional development, and rural development can be conflicting. The trade-offs should be explicitly addressed in a comprehensive development strategy instead of ignored.

- The "one-child" policy is an important but controversial sustainability strategy. Reproduction is a basic human right. The mandatory population control policy is not aligned with the social goal of sustainable development, and it produces detrimental unintended consequences that need to be remedied.

- China should increase its use of market-based instruments such as price, market, and other economic incentives to regulate pollution behavior. These instruments can achieve the same environmental target as the command-and-control approach but with lower costs.

- The multifold incentives to promote renewable energy—including industrial, energy, environmental, and climate change—overlap. However, the effectiveness of industrial policy in the long run is questionable because of induced trade conflicts. Stronger efforts for international policy coordination in both environmental and trade goals should be made, enhancing green innovation and the availability of renewable energy products while mitigating greenhouse gas (GHG) emissions.

- China must better enforce its current environmental codes and regulations through a strong environmental administration, perhaps upgraded to the full ministry level.

- China should promote technology policies that encourage cost-effective green innovations instead of prescribing specific green technologies to be adopted by individual firms.

- China's climate policy should focus on the specific activities with significant co-occurring benefits that can lead to economic growth, job creation, energy security, and environmental protection. China's effort in the carbon market/with carbon emissions trading will help minimize the cost of reducing GHG emissions.

- Sustainability policy making should reflect the preference of Chinese citizens for maximizing the balance between economic output and environmental quality, which is difficult to achieve without a voting mechanism. Encouraging and securing public participation in this area are therefore key components.

I. Introduction

China's economy has grown at an unprecedented speed; over the past 30 years, China has achieved a per annum double-digit growth rate. This spurt is mainly attributable to the market-oriented reform that started in 1979. New policies granted autonomy to rural households regarding land use and crop selection, increased industrial competition by encouraging non-state-owned enterprises, liberalized foreign trade and investment regulations, and relaxed price controls. These policies began to tap into the tremendous power of increased productivity.

By 2010, China had overtaken Japan as the world's second largest single-country economy. Its GDP reached $7.3 trillion U.S. dollars (USD) in 2011, roughly half the size of that of the United States (International Monetary Fund [IMF], 2012). However, because China has the world's largest population (1.3 billion by the end of 2011), its per capita GDP was only $5,400, which is miniscule compared to $48,000 in the United States. At present, China ranks only 88th in the world on this scale. Nevertheless, considering that the per capita GDP was merely $182 in 1979 when China initiated reform and began opening economically, many researchers and international organizations regard the extraordinary increase in economic growth as the "China miracle."

The Chinese government considers economic growth to be its central task, so much so that economic performance is linked to the career advancement of government officials. Incentivized by both financial rewards and political futures, policy makers have a vested interested in, and unparalleled enthusiasm for, growing the economy. Pro-growth policies have contributed to China's dramatic economic expansion. However, this rapid economic growth has created a series of social and environmental problems.

Environmental problems have been prevalent since the beginning of China's modern industrialization (Zhang, 2000). From 1958 to 1960, the "Great Leap Forward"—a collectivization campaign aimed at transforming the natural environment to achieve rapid industrialization—caused severe damage to China's environment and natural resources. Because Chairman Mao Zedong regarded steel and grain as the two pillars of the economy, an overemphasis on iron and steel production stimulated the construction of numerous backyard steel furnaces, resulting in deforestation, pollution, and waste. Likewise, the high target of grain production led to the massive construction of dams, overexploitation of groundwater, extinction of wildlife, and destruction of vegetation. Ignorance of the environmental effects of industrial growth during China's collective economy period demonstrated that pollution and ecological degradation are not uniquely capitalist or market-created phenomena.

Environmental challenges have increased dramatically in the past 30 years as China has accelerated its economic growth. The Chinese economy is heavily dependent on secondary industry, which accounted for 46.8 percent of GDP in 2010. It has the highest volume of production in the world for major industrial products, including crude steel, coal, electricity, cement, fertilizer, and woven cotton fabrics. Its crude petroleum production was ranked as fourth globally (National Bureau of Statistics of China, 2012). In addition, medium- and small-sized enterprises that have stimulated the economic boom have a low environmental performance and require a high use of raw materials. Urbanization

and transportation systems have caused the environmental quality in cities to decline. Coal mining, transportation, and combustion have also degraded the ecosystem and polluted rural and urban areas. Rapid industrial development has relied on increasing inputs of energy, natural resources, and environmental services. As a consequence, resource depletion and environmental pollution have become serious problems that require the rethinking of governmental policies.

The deterioration of the overall state of China's environment has drawn global concern. According to the most recent environmental report from the Ministry of Environmental Protection (2012), seven main river systems in China are polluted. The eutrophication of lakes and reservoirs is now a severe problem. Although 89 percent of cities complied with air quality standards, these regulations are relatively lax. More importantly, PM2.5, a fine particulate with major health consequences, was not included in the standards until 2012. Acid rain occurred in 227 cities in 2011, or 48.5 percent of all monitored cities.

Although policy makers have taken steps to improve ecological degradation in some areas, the overall quality of China's environment continues to decline. As measured by the Environmental Performance Index developed by researchers from Yale and Columbia Universities, China ranks 116 out of 132 countries (Emerson et al., 2012). Based on a recent study by the Chinese Academy for Environmental Planning, the cost of pollution and ecological degradation accounted for 3.8 percent of the national GDP in 2009.[1] These problems have led Chinese policy makers and researchers to reflect on the effects of the extensive growth model.

Realizing that this model is not sustainable, in recent years, the Chinese government has begun calling for a major policy shift. China has significantly bolstered its efforts to soften the environmental impacts of economic growth. However, it still faces numerous obstacles to sustainable development. Most of the country is in the early to middle stages of economic development and faces major natural resource and environmental constraints. Significant economic and social structural problems remain. China again finds itself at the crossroads of change, and this time, environmental and resource constraints have become pronounced. The moment is ripe to evaluate China's sustainability strategies, policies, achievements, and remaining problems. Based on the most recent economic literature on sustainable development and taking into account China's unique attributes and special needs, this paper explores a potential sustainability model and also (1) outlines economic theories and empirical findings related to economic growth, openness, and the environment; (2) evaluates China's existing sustainability strategies; (3) identifies key issues in sustainability; and (4) makes relevant policy suggestions.

II. Economic Growth, Openness, and the Environment

Economic Growth and the Environment

China's economic reform, specifically regarding economic construction, has profoundly impacted the environment. Expanded economic activities have put mounting pressure on natural resources and environmental quality. If environmental degradation is proportional to economic growth—as has been suggested by many environmental groups such as the Club of Rome—then the only way to avoid environmental disasters is to limit economic growth. If this theory is true, the future is gloomy for China's environment.

On the other hand, many economists optimistically believe in technological progress and reliance on the market. Technology has a positive impact on resource conservation and pollution abatement, which might offset the adverse consequences of population and income growth. The market mechanism dictates that the explicit or implicit price for environmental goods and services will increase as the environment continues to deteriorate. A well-functioning market can provide feedback for consumers and producers to adjust for conservation, abatement, and innovation. If this point of view is correct, China does not have to halt economic growth in order to save its environment. Reform is intended to establish a sound market economy, and economic openness enables China to access cleaner technologies at lower costs, both of which will help achieve economic growth with less adverse environmental impacts.

Economists assess the environmental impact of economic growth by scale, composition, and technique effects. Scale effect refers to the overall size of the economy, *composition* effect represents the share of dirty industries, and *technique* effect denotes the relative emissions intensity. These frameworks can model the effect of income growth on the environment, based on the signs from and magnitude of all three effects. Therefore, the net effect of economic growth depends on whether or not the composition of methods of production and outputs is immutable. In the short run, emissions are proportional to consumption, meaning that income growth causes more pollution. However, as economies become wealthier, the demand for environmental goods induces shifts in industrial structures that spur progress in technology, which consequently decreases pollution. Some economists therefore posit an inverted-U shaped relationship between economic growth and the environment, which is known as the "environmental Kuznets curve" (Grossman and Kruger, 1994).

Under this hypothesis, environmental pollution worsens in the early stage of development. But as income continues to increase beyond some threshold, economic growth will lead to environmental improvement. The environmental Kuznets curve can predict the peak of pollution and the corresponding income level. If the inverted-U relationship between income and environment always holds true, it would offer relief for China (as well as other developing countries) because environmental degradation would not monotonically increase with economic growth.

The empirical support for the environmental Kuznets curve is ambiguous (Stern, 2004). Some studies support the hypothesized cycle of pollution in the curve for certain types of pollutants such as sulfur dioxide (SO2), nitrogen oxides, lead, and sewage. In China, the total SO2 emissions peaked in 2006

at 25.89 million metric tons, which marked a per capita GDP of $2,064 USD in current prices. The same pattern is also found in water pollution. As a result of wastewater contaminants, emissions from chemical oxygen demand (COD) peaked at 14.28 million metric tons in the same year (China Statistical Yearbook, 2011). However, this pattern is not a guaranteed norm. Many other studies have rejected the inverted-U relationship for energy use, biodiversity loss, GHG emissions, and other emerging pollutant emissions. For example, China's per capita energy use has increased from 858 kg of oil equivalent in 2001 to 1,695 kg in 2009 (World Bank, 2012). As a consequence, China has overtaken the United States as the world's largest GHG emitter. It may still be too early to determine if GHG emissions do not peak. However, the trend shows that energy use and GHG emissions in China will continue to rise as income increases.

Caution is needed in relying on the environmental Kuznets curve hypothesis to solve environmental problems in economic growth. First, it implicitly assumes that the state of the environment is reversible. Although pollutant emissions, such as SO2 and those from COD, can be reduced to previous lower levels, environmental quality cannot always be restored to its original state. For example, old-growth forests were converted to farmland or industrial parks in many developing countries. Reforestation in the future cannot recreate the original ecosystem, even if the volume of timber were to be the same or greater. Even worse, the ecosystem may crash before the peak is reached, a possibility that calls for a lower emissions pathway to reduce the risk from economic growth or a revised environmental Kuznets curve. Second, economists argue that the inverted-U shaped curve may be an artifact of restrictive functional forms. The real relationship could be N-shaped or an even more flexible shape. The policy implication is that we cannot guarantee that the environmental quality will always improve once a certain level of income is reached. Third, the causality between economic growth and the environment is not well established because of concerns of omitted variables and reverse causality. For example, environmental regulation is a confounder that simultaneously affects income and emissions but is omitted in most analyses. In addition, environmental quality can be a productive input for economic growth, but the feedback is ignored. In this case, there is reciprocal causality.

Even so, the hypothesis and empirical studies of environmental Kuznets curve are useful to China's development strategies because the curve rejects the conventional wisdom that economic growth and the environment are enemies. As the Chinese economy continues to expand rapidly within the next decade, although no longer at a double-digit growth rate, the future of the environment may not be as gloomy as predicted by some environmental groups. The bottom line is that if the correct policies are implemented, China does not have to slow down economic growth in order to avoid environmental deterioration.

However, we must be cautious not to over-interpret these results. After all, there is no support for the idea that a better environment will emerge automatically as the country becomes richer (Carson, 2010). The theory underlying the environmental Kuznets curve is that the economic structure will upgrade to cleaner industries and innovation of clean technologies will occur. These changes cannot appear automatically without incentives from policy makers enacting environmental regulations. Policy, not income, will lead to a better environment. Therefore, this theory in no sense implies that government ought not to act to improve the environment.

Openness and the Environment

A key component of China's economic reform is to embrace globalization by increasing openness to international investment and trade. By creating special economic zones and offering favorable tax and policy treatment to foreign capital, China has attracted massive foreign direct investment (FDI) inflows. In 2010 alone, the received FDI reached $105.7 billion USD. As of 2011, the total FDI stock ranked seventh in the world and the largest among developing countries.[2] China's economic boom also benefits from international trade. Its exports soared, particularly after joining the World Trade Organization (WTO), transforming China into the country with the highest exports in the world.[3] Since 2003, China's dependence on foreign trade, measured by the ratio of imports and exports to GDP, has remained above 50 percent. Since openness was set as a basic national policy, it has contributed to China's economic prosperity. However, it is also blamed as a major cause of environmental degradation and resource depletion. Economic growth, openness, and the environment are interrelated. Economists generally agree that international trade and investment are positively correlated with economic growth (Frankel, 2003). The relationship between economic growth and the environment was discussed in the previous subsection; the major uncertainty lies in the relationship between openness and the environment.

Opinions are divided on whether openness is good for the environment. The "race to the bottom" hypothesis posits that international trade and investment create downward pressure on environmental regulations in host countries. As different jurisdictions compete to chase investment and raise competitiveness, they tend to lower environmental standards to reduce costs of production. The consequence is that international trade and investment will lead to deterioration of the environment. This effect may also occur at the subnational level. Local Chinese governments have great incentives to attract FDI, which is factored into governmental employees' performance reviews. Although environmental standards are set at the national level, local governments can achieve different de facto regulations by relaxing or tightening environmental enforcement. These incentives partly explain why environmental quality has significant spatial heterogeneity, even if the same environmental standard is enacted across the country. This concern is particularly worrisome for the least developed regions that lack other capacities to attract investment besides environmental quality. These regions are mostly in western China and are ecologically sensitive, which makes the possible race to the bottom effect even more detrimental.

On the contrary, the "gains from trade" hypothesis states that openness has a positive effect on the environment because international trade enables countries to attain cleaner technologies and more environmental goods in a cost-effective manner. In particular, China might benefit from the advantages of recent developments (Lin, 2010). It could assimilate the advanced scientific, technological, and managerial innovations created by developed economies since the Industrial Revolution by purchasing, copying, and improving green technologies without the costs of reinventing the wheel. According to this hypothesis, openness contributes to a better environment. To allow gains from trade to be effective, policy makers should remove trade barriers for environmental technology, goods, and services. This approach has become a hot topic in the recent U.S.-China Strategic and Economic Dialogues.

The net impact of openness on the environment hinges on which of the two theories outlined here, race to the bottom or gains from trade, has a greater impact (Frankel, 2003). Although the effects of gains

from trade are well understood, the existence of the race to the bottom effect is at the center of current debates. Race to the bottom is supported by the "pollution haven" hypothesis, which posits that dirty industries migrate from developed countries to developing countries because of lower environmental regulatory costs. The "simple factor endowment" hypothesis supports an opposite effect. Dirty industries tend to be capital intensive and developed countries have a comparative advantage in terms of the availability of capital. The dirty industries then would be located in developed countries. Yet another hypothesis states that environmental regulatory cost is only a minor determinant for the location choice of firms. Other factors such as labor, capital, legal framework, and market are more important.

The empirical literature provides no evidence that openness and international trade necessarily lead to worsened environmental problems (Antweiler, Copeland, and Taylor, 2001; Frankel and Rose, 2005). The empirical studies that test the pollution haven hypothesis are also inconclusive; the effect ranges from negative to positive, with some studies showing no effect (Jeppesen, List and Folmer, 2002). A recent paper found that the investment of equity joint ventures in China funded from non-ethnically Chinese sources is not influenced by weak environmental standards in choosing firm locations (Dean, Lovely, and Wang, 2009). These empirical results suggest that environmental regulation has a limited impact on investment decisions, and the impact of openness on the environment is not necessarily negative. These results are good news for China's economic reform: the country does not have to go back to autarky to address its environmental challenges. In some cases, openness could even be good for the environment.

The previous paragraphs evaluated the environmental impact of China's reform policies on economic growth and openness. Evidence has shown that economic reform does not necessarily lead to a worse environment. However, the analysis is not prescriptive because it does not indicate how economic growth can be coordinated with environmental goals. This question is answered in the following section.

III. The Quest For Sustainable Development

China's Sustainability Strategies

Sustainable development is a concept coined in the Brundtland Report (World Commission on Environment and Development Report, 1987) to describe development that "meets the needs of the present without compromising the ability of future generations to meet their own needs." Sustainable development covers a complex range of ideas and meanings, generally consisting of three pillars: economic growth, environmental protection, and social progress (United Nations, 1996). First, sufficient goods and services are needed to maintain a well-functioning society. Second, renewable resources should not be overexploited, and the depletion of nonrenewable resources should be adequately compensated by the investment in substitutes. Third, economic growth should fully take into account distributional equity, health, education, and political accountability.

China claims that it is one of the first developing countries to propose and implement sustainable development as a national strategy (National Development and Reform Commission [NDRC], 2012). Its effort to achieve sustainability is best summarized in the official document prepared for the 2012 United Nations Conference on Sustainable Development (Rio+20) (NDRC, 2012). China has long realized that an extensive growth model that heavily relies on capital and resource input is not sustainable. Calls for a change of development mode have been made. Some of the major advances that China has achieved in sustainable development include poverty reduction, population control, economic restructuring, transforming development patterns, incorporating environmental protection into national economic and social development planning, and implementing environmental and resource legislation and regulation. The milestones in China's journey toward sustainability are summarized in Table 1. It is worth noting that the list is far from a complete history of China's sustainability strategies and actions.

At present, China's sustainable development strategy falls under the umbrella of the Scientific Outlook on Development, originally proposed by President Hu Jintao in 2003, which is now the official guiding socioeconomic ideology for the Communist Party of China. The ideology advocates people-oriented development, whereby comprehensive, balanced, and sustainable development is a basic requirement. Among other goals, the ideology calls for harmonious development between humans and nature. To engineer such a harmonious society, the 12th Five-Year Plan outlines an action plan for resource conservation, environmental protection, energy saving, and climate change mitigation. China's determination to accelerate a transformation of its economic development pattern is a part of the global trend toward adopting an "inclusive growth model." Following the Scientific Outlook on Development, China has proposed various development models such as those based on a green economy, a circular economy, and a low-carbon economy.

Multiple problems are apparent in China's sustainability strategies. Some challenges are universal shortcomings of the sustainable development concept, but others are specific to China. First of all, the definition of sustainable development has vague and elusive elements. In particular, the recently concluded Rio+20 Conference failed to address this problem. Its final document, "The Future We Want," does not provide practical solutions but rather political rhetoric. According to the document,

any action that a country performs to improve social welfare can be counted toward sustainable development. However, the trade-offs among the economic, environmental, and social pillars are often ignored. For example, if poverty eradication is accompanied by environmental degradation, is this development pattern sustainable? At the core of the issue is that there is no agreed-upon way to measure the overall state of sustainable development. Progress in sustainability is thus susceptible to easy exaggeration.

Perhaps for political reasons, China tends to deny a conflict between social and economic goals. For example, the country has consistently rebuffed the practice of "treatment after pollution." Instead, embodied in its environmental policies, China claims that adopting the prevention principle can minimize the negative environmental impact of economic growth, which is a priority that combines prevention, control, polluter's payments, and environmental management. In reality, China's path of economic development cannot escape post-pollution treatment, because it is unrealistic to assume that economic growth can be achieved without pollution. However, maintaining a pristine environment implies either no production at all or an extremely high cleanup cost. In a functioning economy, pollution cannot be prevented, but it can be reduced to a tolerable or efficient level—-determined as the point at which the marginal cost of pollution abatement equals the marginal damage cost avoided (or the marginal benefit of pollution reduction).

China began its sustainability strategy at the very early stages of its modernization and industrialization period. However, the overall state of the environment is still deteriorating even though investment in environmental protection has increased dramatically. For this reason, in public documents, the Chinese government stresses its efforts toward pollution abatement instead of increasing environmental quality. It is easy to observe the effort, but it is very difficult to measure the effectiveness of current policies. Without reliable methods to measure and evaluate the progress of sustainable development, it is likely that the government will exaggerate achievements.

Measuring Sustainable Development

The lack of a clear system to measure sustainable development impedes the creation of effective policy solutions to environmental challenges, as the sustainable development principle is of practical use only if it can be reliably measured. At present, GDP is the most influential indicator of the strength of a nation's economy, but economists have long acknowledged its flaws and limitations in measuring well-being. Specifically, it takes into account only human-made capital. Other forms, including social and natural capital, are ignored in the conventional national accounting. Using GDP as the exclusive performance metric could spur policy makers to grow the economy at the cost of social and environmental losses. Even worse, pollution cleanup itself increases GDP, although the pollution itself represents a net loss of welfare.

To address these concerns, environmental economists have developed approaches to revise GDP to reflect the costs of environmental pollution and natural resource depletion. Hartwick (2000) provides an exhaustive review of the economic foundation for the revised measure of national income and hence the progress of sustainable development. The economic rationale of sustainability is based on the "Hartwick Rule": if all scarcity rents from resource extraction are invested in human-made capital, then a constant level of consumption can be maintained perpetually (Hartwick, 1977). Under

this rule, sustainability can be assessed by examining whether or not the total capital stock (both human-made and natural) is declining, which would therefore call for green accounting—factoring environmental costs into total expenditures.

Many empirical approaches have been proposed to establish green national accounts. One approach is the System of Environmental-Economic Accounts (SEEA) proposed by the United Nations Statistics Division. It provides a unified structure for economic and environmental accounting consistent with the System of National Accounts. The environmentally adjusted net domestic product, or the eco-domestic product (EDP), is calculated by subtracting depreciation and environmental costs from GDP (United Nations, 2003). Another approach is to use adjusted net saving (also known as genuine saving) as a proxy for sustainability, which is the method proposed by the World Bank. It is calculated as follows:

> *gross saving - debt and depreciation + education investment - cost of environmental pollution - cost of resource degradation (World Bank, 2010)*

Both green accounting frameworks have been applied to China at national and local levels.

Using the adjusted net saving approach at the national level, the World Bank reported that China's economic loss due to pollution and environmental degradation accounted for 10.51 percent of gross national income in 2008. Despite this loss, China's adjusted net saving at 35.11 percent was still the highest among all countries, thanks to its very high net national saving.[4] The green accounting framework was also applied to the local level with more detailed socioeconomic information. Two cities, Yantai City in Shangdong Province and Sanming City in Fujian Province, were selected for a case study that used genuine saving to estimate the economic loss due to urban pollution and resource depletion. It was estimated that EDP of Sanming was only 71 percent to 80 percent of its GDP during 1990–96. EDP in Yantai was about 80 percent to 87 percent of its GDP during the same period (The Task Force on Sustainable Development Indicator System, 1999). These results revealed that the costs of environmental degradation eroded a large share of economic growth. Up to the present, this has been the most comprehensive study of green GDP in China. The State Environmental Protection Administration and the National Bureau of Statistics started a pilot study of green GDP in 10 provinces and cities. However, the two departments could not settle their methodological differences. Even so, these reported environmental costs, which account for a large part of GDP, tarnished the economic achievements of the government; therefore, China decided in 2005 to indefinitely postpone publishing green GDPs.[5]

One problem of using green national accounting indicators is that environmental goods and services need to be measured in monetary values. Although economists have developed economic valuation techniques, the estimated environmental values generally come with caveats (Champ, Boyle, and Brown, 2003). The economic value of the environment is determined by individual preference that can be derived only from a stated or revealed preference approach. Its precision is lower than that of economic variables that can be measured directly. The quality of the numbers depends on the data and methods used in the econometric analysis. Furthermore, due to heterogeneous preference, economic values can be location and time specific, and valuation studies are costly and time consuming. Hence, researchers adapt information from other original research to value the environment in a

different context—the so-called "benefit transfer" method. Because no two empirical settings are exactly the same, the unobservables affecting the preference for environmental quality can lead to a wide range of errors in the benefit transfer approach. For these reasons, a single index that consists of relatively accurate GDP and environmental values with large standard errors, although seemingly straightforward for policy makers and the general public, does not deliver credible information on sustainability. Shortfalls in these various measurement indices and tools prove problematic should policy makers work to measure, as oppose to exaggerate, gains in economically and environmentally sustainable development practices.

IV. Key Issues and Policy Suggestions

Poverty and Regional Policy

China faces many conflicting goals and trade-offs in sustainable development. The most important conflict is between poverty eradication and environmental protection. The population living in poverty within rural areas numbered 122.38 million at the end of 2011 (National Bureau of Statistics of China, 2012). China hopes to reduce its poverty rate by furthering economic growth. Although some rich provinces on the east coast might have passed the worst period of environmental degradation, most regions are still on the wrong side of the environmental Kuznets curve, and further economic growth will degrade the environment even more. Poverty and environmental problems are interrelated, and the worst-case scenario is a vicious cycle: on the one hand, poverty alleviation requires economic development that puts further pressure on the fragile ecosystem; on the other hand, the environment and natural resources can be constraints on the low-income regions for emerging from poverty. For example, deforestation, overgrazing, and overdevelopment of agricultural land lead to resource degradation and increasing natural disasters, which disproportionally occur in the poor regions and reduce their developmental capacities.

A closely related conflict exists between balanced regional development and protection of ecologically sensitive areas. China's economic activity clusters on its eastern coastal zones, which receive favorable treatment from the central government in terms of financial, taxation, land-use, and FDI policies. In comparison, the economic growth in the 12 western provinces is lackluster, and many of these regions have high poverty rates. This regional unbalance spurred China to aim for more coordinated development. Since 2000, priority has been given to the western regions that are mainly inhabited by ethnic groups. Most proposed projects in the Grand Western Development Program focus on infrastructure construction, such as highways, railroads, airports, and gas pipelines. While China's "go-west" strategy boosts economic growth in these poverty-stricken areas, it may cause the transfer of industrial pollution to the western areas. The migration of dirty industries is not necessarily due to the pollution haven effect, although the demand for environmental goods is low in the underdeveloped regions. Instead, this industrial influx is mainly due to low labor costs, abundant energy and natural resources, and the massive public investment in infrastructure. Notably, the western areas are sensitive to environmental pollution and ecological degradation; therefore, balancing regional economic development and reducing poverty in these areas present high environmental risks.

The Chinese government has realized this developing problem in its western regions and has taken measures to address it by, for example, implementing the policy of returning farmland or grazing land to forest or grassland. However, this specific policy was a reaction to the environmental disasters that caused similar damage to populous and rich eastern areas. Without the spillover effect, those local environmental problems are less likely to receive treatment. Were the western regions to repeat the developmental path of the east, the risk of ecosystem crash would be high.

Another rising conflict is between urban and rural environmental protection, as pollution is the major concern in Chinese cities. In recent years, air pollution caused by coal burning and gasoline consumption has led to wide discontent among urban residents. In rural areas, the biggest problem is

ecological degradation, particularly soil erosion. The total area that is subject to water and wind erosion reached 3.6 million km2, or 37.2 percent of the total land area. Pollution has intensified in rural areas, too, caused by livestock emissions, agricultural nonpoint source pollution, residential and industrial pollution, and ecological degradation. More specifically, while reforms encouraged village and township enterprises, many of these small firms lacked pollution abatement facilities. Although new businesses create wealth in rural areas, their environmental costs are not negligible. Lacking visibility, as well as economic and political significance, rural environmental problems draw less attention from the government. Hence, policy makers have invested heavily in urban sustainability concerns, such as pollution control. In light of this prioritization, rural areas do not gain sufficient support for ecosystem restoration and environmental protection, which should be made more visible at the subnational and national levels in order for policies that address these concerns to follow.

Population Policy

Population growth is regarded as a major cause, although not the sole one, for resource depletion and environmental deterioration. Thomas Malthus raised the very first sustainability question in 1798, claiming that geometric population growth would eventually reach the limit of the carrying capacity of natural resources, resulting in the population returning to a subsistence level. The IPAT model (Ehrlich and Holden, 1971) describes connection between a rising population and the environment. The model argues that the human impact (I) on pollution equals the product of population (P); affluence (A), the level of consumption per capita; and technology (T), the cleanliness of production ($I = P \cdot A \cdot T$). The model has been widely used to determine the contribution of myriad factors on the environment. Similar is the Kaya identity, an equation for calculating total carbon emissions, used by the Intergovernmental Panel on Climate Change (IPCC). These equations show that population growth, coupled with affluence, jeopardizes the environment. Although technological progress might lead to more efficient and intensified production, it is debatable whether the induced innovation can offset the adverse impact caused by the growth in total consumption.

Population control is an important—but also a very controversial—sustainability strategy in China, although it was not initially designed to address environmental concerns. China introduced the one-child-per-couple policy in 1978 to prevent overpopulation, and it was made basic national policy in 1979. The fertility rate, measured by the average number of births per woman, has been reduced from 2.91 in 1978 to 1.6 in 2010.[6] The family planning policy is the major cause for a declining population growth rate, although the Chinese government might have exaggerated the policy effect (Hasketh, Lu, and Xing, 2005). Although facing many critics, China still regards a low fertility rate as a top priority for population control. The one-child policy is not expected to change in the next decade, and it will continue to limit the population's impact on the environment.[7]

Even though population control has been successful in reducing pressure on the environment, natural resources, and public goods, it has many unintended consequences. These include but are not limited to skewed sex ratios, an aging society, social security inviability, and human rights violations. Economists argue that a low population growth rate can be achieved in a more flexible manner without resorting to China's extreme measures. For example, establishing a sound social security system would reduce the need for family-supported financial security. Enhancing female status, education, and job opportunities would also reduce family size. Since the one-child policy has led to many social problems and the cost

of enforcement is prohibitive, China needs to reconsider its population policy. Reproduction is a basic human right. Although the mandatory population control policy may contribute to environmental protection, it is not necessarily aligned with the social goal in sustainable development.

Environmental Policy

The "invisible hand" cannot provide for sustainable development because of market imperfections and failures. Environmental degradation is caused by externalities that lead to a discrepancy between the private and social costs of production. The market's failure to adjust for unsustainability justifies the government's intervention in environmental issues. The command-and-control (CAC) approach, providing regulations for how companies should manage a pollution-creating commercial process, has been favored by China for curbing pollution. Policies that follow this model include performance- or technology-based standards and regulations. This approach is pragmatic and straightforward to set up and also deeply rooted in China's tradition of a centrally planned economy. The major disadvantage of the prescriptive CAC approach is that it requires homogeneous abatement efforts, disregarding differentiated treatment costs, and is therefore not cost-effective. In addition, it restricts technology and does not provide an incentive for firms to innovate.

One of the major CAC environmental regulations in China is the "three synchronization program," which requires pollution control facilities to be designed, installed, and operated simultaneously with the main project. It is a redundant policy to require building environmental facilities on the top of emission standards and pollution charges. This policy increases firms' costs of compliance with environmental regulation. Even worse, it adds another layer of bureaucracy and creates opportunity for rent seeking. Other CAC policies include environmental impact assessment, deadline treatment, centralized pollution control, and discharge permits. The polluting firms can even be ordered to shut down, suspend operations, merge with other firms, or shift to another business. While these policies can achieve the environmental target, they are associated with higher costs rather than more flexible mechanisms.

As China transitions to a market economy, it increasingly uses price, market, and other economic incentives to regulate pollution. Appropriately designed market-based instruments, such as pollution charges, subsidies, or tradable permits, can create the same effect as the CAC approaches at a lower cost. Additionally, the market-based approach has a lower information burden on regulators to achieve cost-effective emissions reductions, as firms are much more knowledgeable about their marginal abatement costs than is the government at large. These market-based instruments also provide incentives for firms to innovate and adopt better and cheaper environmentally friendly technology. China has implemented market-based approaches for environmental policy with myriad shortcomings based on the policy option chosen.

The earliest market-based instrument implemented in China was an effluent charge. The rule was tentatively promulgated in 1982 and finalized in 2003. It now covers four categories of pollution: wastewater, air pollution, solid and hazardous waste, and noise pollution. The system is assessed on the quantity of pollutant in the effluent. For example, 61 water pollutants and 44 air pollutants are subject to pollution charges. This policy has been shown to be effective in abating pollution and collecting funds for environmental protection. However, it has two serious problems. First, pollution fees are lower than marginal abatement and marginal damage costs. They do not create sufficient incentive for firms

to reduce pollution to the optimal level. Second, local governments can lower and even waive effluent charges in order to keep businesses or attract more investment, which results in an even lower de facto charge level. In addition, penalties for violating the standards are too low and very difficult to enforce.

China started to use tradable permits to curb pollution in late 1980s. The Interim Measures on Management of Water Pollutant Discharge Permits, promulgated in 1988, stipulate that the permits can be traded among local polluters under the guidance of local environmental protection agencies. The Law of Prevention and Control of Atmospheric Pollution revised in 2000 provides a legal basis for setting emission caps, which facilitated the launches of many pilot projects in emissions trading, particularly for sulfur dioxide emission permits. Since 2008, the wave of environmental exchanges has swept across most provinces, powered by the hopes that tradable permits could reduce the environmental cost of economic growth. The mania for building clearing houses for environmental goods and services is mainly driven by the prospect for business opportunities. These exchanges tend to forget that explicit or implicit emission caps are the fundamental requirement of emission trading. Without establishing a sound total emission target, the exchange would eventually fail.

Technology policy plays an important role in China, based on hopes that the advances in science and technology might eventually solve environmental problems. However, China faces multiple problems in its environmental technology policies. First, most environmentally sound technologies are innovated in developed countries, and there are still barriers to access. Second, China needs to build institutions that encourage innovation. However, the obstacles that discourage innovation, such as poor enforcement of intellectual property law, might also contribute to a worse environment. Third, technology is not free, and clean technology is expensive. Pollution regulations require that certain facilities employ the best available technology to curb emissions, regardless of cost-benefit analyses. Fourth, the existing laws and regulations that micromanage a firm's choice of technology are redundant, for example, the Clean Production Promotion Law and the Circular Economy Promotion Law. Although technology policy laws increase resource conservation and reduce waste discharge, their implementation is not necessarily cost effective. Therefore, China needs to focus on the policies that incubate innovations instead of prescribing specific technologies to be adopted by individual firms.

Renewable Energy Policy

China's incentive to promote renewable energy is multifold and is explicitly stressed in its recent 12th Five-Year Plan for National Economic and Social Development. First, the renewable energy policy is mainly an industrial policy with the goal of future economic growth to create jobs and wealth. Second, it is an energy policy to ensure a sustainable, diversified, and stable supply of electricity for the long term. Third, it is an environmental policy to replace polluting coal-fired power plants with clean energy. Fourth, it is also a climate policy to comply with China's pledge to reduce carbon intensity by 40–45 percent by 2020 compared to 2005, as was announced during the Copenhagen climate talks.[8] As these incentives are mostly compatible, they lead to aggressive clean energy targets.

But, even with clean energy targets, China's economic growth has dramatically increased its electricity consumption, causing myriad issues from both the proliferation of dirty energy and the transmission of renewable energy. In 2010, the country's electricity generation reached 4,228 terawatt hours (TWh), of which 81 percent is produced by thermal power (State Electricity Regulatory Commission, 2011).

China's power hungry economic growth relies heavily on coal use, causing severe environmental and health issues (The World Bank, 2007). In the context of increasing energy demand and externalities, renewable energy development has been advocated as a national strategy. In particular, the Renewable Energy Law of 2005 and its subsequent amendment in 2009 demonstrate China's long-term commitment to the renewable energy industry. The law and its supporting rules and regulations offer favorable incentives for the industry, including a reduced tax rate, favorable land use, feed-in tariff, and exemption from some regulations. As a result, investment in renewable energy greatly benefits from the special treatment from central and local governments.

With the policy support, the development of renewable energy, particularly wind energy, has taken giant leaps. Every year since 2006, China has doubled its cumulative installed capacity of wind power. In 2010, China's annual wind power installation accounted for 46 percent of global installations. As of that same year, China had installed 42 gigawatts (GW) of wind power and replaced the United States as the world's largest wind energy market in terms of cumulative capacity (Global Wind Energy Council, 2011). However, there are still many obstacles in the renewable energy industry. After a decade of rapid growth, renewable energy remains a negligible share of China's total power generation. For example, the nameplate capacity of wind-powered generators accounted for 4.4 percent of total electricity-generating capacity in 2010. The grid-connected wind power generation is even smaller, at 3.2 percent of total capacity and 1.1 percent of total generation (Zhang, 2012). Grid connection has become a major obstacle for a larger share of renewable power. The grid companies are required by law to absorb the full amount of renewable electricity whenever the grid system permits. However, the variability and intermittency of the renewable power supply make the grid less willing to purchase. Grid companies are also expected to cover the costs for renewable energy to connect to power grids. Since renewable energy producers tend to be based in remote areas and the transmission cost is high, grid companies again do not have an incentive to comply fully with absorbing the full extent of renewable energy into the grid.

The fact that renewable energy policy is primarily an industrial-targeted policy has led to many international trade controversies. For example, the requirement for homemade wind turbines mandated that 70 percent of the equipment on wind farms needs to be from domestic manufacturers. This policy, along with other government subsidies for the manufacturers of renewable energy products, has caused trade disputes between China and its many trade partners, including the United States and the European Union. The made-in-China requirement is indeed a suboptimal policy that discourages competition. However, competitors outside China might exaggerate its effect because the percentage requirement was actually rather ambiguous, leading the Chinese government to rescind it. Another controversy is that China is "dumping" clean energy products in Western countries. This is an oxymoron since the world is short of cheap clean products. As long as China can supply the world with low-cost renewable energy products, it contributes to the global sustainability target. The debate then calls for international policy coordination in both environmental and trade goals.

Trans-boundary Environmental Problems

Many environmental and natural resource problems have become international concerns because pollution and resource sharing are trans-boundary issues. These problems include global climate change, biodiversity loss, transportation of air pollutants, and common-pool resource exploitation.

The escalation of these problems has already led to international conflicts. The most recent case is the fisheries disputes between China and its East and Southeast Asian neighbors. These conflicts are not just the result of unsettled territorial and maritime disputes. They are also attributable to China's ever-increasing demand for seafood and dwindling domestic fishery resources because of poor fisheries management. In this case, sustainable resource policy can contribute to resolving emerging international conflicts. Another key trans-boundary resource conflict is the development along the Mekong River. The problem is induced by China's insatiable demand for electricity to power its rapid economic growth. Here, China's strategy to develop renewable energy and implement energy conservation will reduce its demand for hydropower from controversial and ecologically sensitive rivers.

The toughest trans-boundary environmental problem is global climate change. Because of the principle of "common but differentiated responsibility," China is not subject to the quantified emissions limitation and reduction commitment in the Kyoto Protocol. The map of global GHG emissions has changed dramatically since the protocol was negotiated. Since 2007, China has overtaken the United States to become the world's largest GHG emitter. Even worse, China's fossil fuel consumption, and hence GHG emissions, will continue to grow at an alarming rate. Without China's meaningful participation, any climate treaty will fail to limit emissions and prevent temperatures from rising to dangerous levels. Pressure has been mounting for China to engage in more active climate mitigation. In response, and as previously mentioned, China has proposed to reduce its carbon emission intensity. Although this is not a concrete emissions cap, the intensity target cannot be achieved automatically in the business-as-usual scenario. It requires China to invest significantly in lowering GHG emissions.

A major concern is that China is still at an early stage of industrialization and urbanization. GHG emission reductions will increase industrial costs and slow further economic growth. This concern is valid since China still has a large population living in poverty and in rural areas. In addition, were China to focus too heavily on global pollutants, it would crowd out its already insufficient investment in solutions to local and regional environmental problems. Air and water pollution have immediate health consequences and enjoy priority over the long-term climate change issue. Two factors can address these problems. First, many climate mitigation projects have co-occurring benefits. As discussed earlier, renewable energy development can contribute to economic growth, job creation, energy security, environmental protection, and climate mitigation simultaneously. At this stage, China can stick to climate change mitigation projects with high concurrent benefits. Even if they are not done for climate change, such benefits alone can justify its participation in these activities.

Second, market-based instruments can minimize the cost of reducing GHG emissions spurring trans-boundary conflicts. China has already had extensive experience in the carbon market through its participation in the Clean Development Mechanism (CDM). The CDM is a project-based carbon market that allows developed countries to implement offset projects in developing countries to reduce their cost of compliance with the Kyoto Protocol. China is the dominant player on the primary CDM market, hosting about half of all projects. Although it is argued that the offsets produced by CDM projects might be exaggerated (Zhang and Wang, 2011), they are successful in the sense that they help China build the institutional capacity to deal with climate change. Many carbon markets have been established to embrace the business opportunity created by the prospect of regulating GHG emissions. The carbon market and China's experience in the CDM will help reduce the mitigation cost.

Institutions and Sustainability

While economists tend to recommend optimal solutions to achieve sustainable development, the effectiveness of these solutions hinges on the strength of the institutions that implement them. The first question concerns how political regimes will affect the environmental outcome. There are numerous combinations of economic output and environmental quality, all of which have the potential to be economically efficient. The selection of environmental policies then depends on the preference of the people in a country. In a median-voter society, individual preference can be summarized by voting outcomes and reflected in policy making. But in an authoritarian regime, how does environmental policy reflect the preference of its citizens? A simple model can explain China's environmentally focused institutions. The utility of the central government is a function of economic output and social stability. Environmental pollution is a potential cause of social unrest. Individuals' utility is a function of income and pollution. If the realized combination is very different from their preference, it is likely that social unrest will occur. To maintain social stability, the central government therefore tries to reflect individuals' preferences in its decision making.

Without a voting mechanism, it is difficult for the central government to know median preference. As a result, policy making is likely to be determined only by the information that can be observed. It will be particularly influenced by pollution accidents that need immediate attention. In addition, the policies need to be implemented by local governments. Local officials are not elected, and their career advancement is determined by their capacity to fulfill the target set by the higher-level governments. Therefore, local officials have an incentive to pursue only the goals explicitly specified in the promotion formula. It is almost impossible that the weight used in the formula is consistent with individuals' preferences. In case of any inconsistency, the government's preference always leans toward faster economic growth with lower environmental standards. The government also pays disproportionately more attention to the environmental problems that are more visible. For example, air quality accounts for 20 percent in China's National Urban Environmental Assessment, which grades and ranks a city's environmental performance by a total of 100 points; there is no scientific or economic reason why air quality deserves a larger weight than all other environmental indicators.

Pollution accidents have played an important role in China's environmental policy making. In 1972, the fish harvested from the Guanting Reservoir in Beijing caused consumers to be poisoned by DDT. This event started the official Chinese effort in environmental protection. Since then, environmental events have constantly made headlines. In 2010, 420 accidents were reported nationally, in which water and air pollution accounted for about one-third of the total (National Bureau of Statistics of China, 2011). The 1998 Yangtze River floods caused thousands of deaths and left 10 million homeless, forcing China to start massive ecosystem recovery, including returning farmland to forests and returning grazing land to grassland. In 2005, the explosion of the Jilin chemical plant heavily polluted the Songhua River. This accident led to the resignation of Environmental Minister Xie Zhenhua, the first public official in China to resign over environmental problems. Although accidents can lead to remedial policy making, the health and environmental costs are prohibitive. A reliable mechanism that can create preventive policy measures is needed.

Environmental enforcement is sometimes implemented in a campaign style by local governments. These environmental campaigns shut down factories and ban driving to reduce pollution rapidly in a

particular time frame. This behavior culminated during major international events, including the 2008 Beijing Olympic Games, the 2010 Shanghai Expo, and the 2010 Guangzhou Asian Games. Although these campaigns help cities maintain a better image during the event, their contribution to long-run sustainability is questionable. The costs of these campaigns are high because the decisions to implement them were made for political reasons instead of economic considerations. In addition, this approach benefited only the few major cities that host international events. These programs cannot be replicated in other cities and sometimes have unintended consequences. For example, the driving ban based on license plate numbers may have encouraged households to buy a second car.

Overall, China has established a relatively complete code of environmental laws, regulations, and rules. However, the stringency of enforcement rather than the letter of the law determines the de facto environmental standards. Poor enforcement can partially explain the overall poor state of the environment and can be due to a lack of respect for laws or standards that have been set too high. Enforcement can be enhanced by a strong environmental administration, upgraded to the full ministry level. (See Table 2 for an institutional history of China's environmental protection agency.) Many experts suggest that the enforcement problem can be solved by strengthening the environmental regulatory power through vertical management. That is, local environmental agencies would be appointed by and responsible to higher-level environmental agencies instead of local governments. This system could be adopted through customs and taxation, reducing the influence of local governments that often regard economic growth as the top priority. Some also suggest that environmental enforcement can learn from the success of enforcing the one-child policy. Local officials will not be promoted if they fail to comply with the policy, no matter how well they perform on other measures.

1 China Network TV. 2012, February 1. *Environment and Planning Institute to Complete the 2009 Environmental and Economic Accounting*. http://jingji.cntv.cn/20120201/110218.shtml. (Translated from the original Chinese.)
2 Central Intelligence Agency. 2011. *The World Factbook: Country Comparison—Stock of Direct Foreign Investment—At Home*. https://www.cia.gov/library/publications/the-world-factbook/rankorder/2198rank.html.
3 Central Intelligence Agency. 2011. *The World Factbook: Country Comparison—Exports.* https://www.cia.gov/library/publications/the-world-factbook/rankorder/2078rank.html.
4 World Bank. 2008. *Adjusted Net Saving 2008.* http://siteresources.worldbank.org/EXTEEI/Resources/ANS_2008_by_country.xls.
5 Liu Xin. 2007, July 23. "Green GDP Data Release Encounters Resistance, May be Postponed Indefinitely." Xinhua. http://news.xinhuanet.com/fortune/2007-07/23/content_6414797.htm. (Translated from the original Chinese.)
6 World DataBank. 2010. *Fertility Rate in China.* http://databank.worldbank.org/ddp/home.do?CNO=2&Step=12&id=4.
7 Jim Yardley. 2008, March 11. "China Sticking With One-Child Policy." *New York Times*. http://www.nytimes.com/2008/03/11/world/asia/11china.html?_r=1.
8 United Nations Framework Convention on Climate Change. 2009. *Copenhagen Accord.* http://unfccc.int/meetings/copenhagen_dec_2009/items/5262.php.

References

1. Antweiler, W., B. R. Copeland, and M. S. Taylor. 2001. "Is Free Trade Good for the Environment?" *America Economic Review* 91: 877–908.
2. Arrow, K., B. Bolin, R. Costanza, P. Dasgupta, C. Folke, C. S. Hollings, B. O. Jansson, S. Levin, K. G. Maler, C. Perrings, and D. Pimentel. 1995. "Economic Growth, Carrying Capacity and the Environment." *Science* 268: 520–21.
3. Carson, R. T. 2010. "The Environmental Kuznets Curve: Seeking Empirical Regularity and Theoretical Structure." *Review of Environmental Economics and Policy* 4(1): 3–23.
4. Champ, P. A., K. J. Boyle, and T. C. Brown, eds. 2003. *A Primer on Nonmarket Valuation.* The Netherlands: Kluwer Academic Publishers.
5. Dean, J. E., M. E. Lovely, and H. Wang. 2009. "Are Foreign Investors Attracted to Weak Environmental Regulations? Evaluating the Evidence from China." *Journal of Development Economics* 90 (1): 1–13.
6. Ehrlich, P., and J. Holden. 1971. "Impact of Population Growth." *Science* 171: 1212–17.
7. Emerson, J. W., A. Hsu, M. A. Levy, A. de Sherbinin, V. Mara, D. C. Esty, and M. Jaiteh. 2012. 2012 *Environmental Performance Index and Pilot Trend Environmental Performance Index*. New Haven: Yale Center for Environmental Law and Policy. http://epi.yale.edu/downloads.
8. Frankel, J. A. 2003. "The Environment and Globalization." NBER working paper. http://www.nber.org/papers/w10090.pdf.
9. Frankel, J. A., and A. Rose. 2005. "Is Trade Good or Bad for the Environment? Sorting out the Causality." *Review of Economics and Statistics* 87: 85–91.
10. Global Wind Energy Council. 2011. "Global Wind Report: Annual Market Update 2010." http://www.gwec.net.
11. Grossman, G. M., and A. B. Krueger. 1995. "Economic Growth and the Environment." *Quarterly Journal of Economics* 110, 353–77.
12. Hartwick J. 2000. *National Accounting and Capital*. Cheltenham, UK: Elgar.
13. Hartwick, J. M. 1977. "Intergenerational Equity and the Investing of Rents from Exhaustible Resources." *American Economic Review* 67 (5): 972–74.
14. Hasketh, T., L. Lu, and Z. Xing. 2005. "The Effects of China's One-Child Family Policy after 25 Years." *New England Journal of Medicine*, 353 (11): 1171–76.
15. International Monetary Fund (IMF). World Economic Outlook Database, April 2012. http://www.imf.org/external/pubs/ft/weo/2012/01/weodata/index.aspx
16. Jeppesen, T., J. A. List, and H. Folmer. 2002. "Environmental Regulations and New Plant Location Decisions: Evidence from a Meta-analysis." *Journal of Regional Science*, 42 (1): 19–49.
17. J. Y. Lin. 2010, March 15. "China's Miracle Demystified." http://blogs.worldbank.org/africacan/china-s-miracle-demystified.
18. Ministry of Environmental Protection. 2012. *Report on the State of the Environment in China*. http://jcs.mep.gov.cn/hjzl/zkgb/ (in Chinese).
19. Ministry of Environmental Protection. 2005. *Collection of Chinese Environmental Policy Instruments.* Beijing: China Environmental Science Press.

20. National Bureau of Statistics of China. 2012, February 22. *Statistical Communiqué on the 2011 National Economic and Social Development.* http://www.stats.gov.cn/english/newsandcomingevents/t20120222_402786587.htm
21. National Bureau of Statistics of China. *China Statistical Yearbook 1996–2012.* http://www.stats.gov.cn/tjsj/ndsj/ (in Chinese).
22. National Development and Reform Commission (NDRC). 2012. *The People's Republic of China's Report on Sustainable Development.* http://www.sdpc.gov.cn/xwzx/xwtt/t20120601_483687.htm (in Chinese).
23. State Electricity Regulatory Commission. 2011. "Electricity Regulation Annual Report 2010." http://www.serc.gov.cn/ (in Chinese).
24. Stern, D. 2004. "The Rise and Fall of the Environmental Kuznets Curve." *World Development* 32: 1419–39.
25. The Task Force on Sustainable Development Indicator System. 1999. *Research Handbook on the Indicator System of Urban Sustainable Development in China—Case Studies of Sanming City and Yantai City.* Beijing: China Environmental Sciences Press.
26. United Nations. 1996. *Indicators of Sustainable Development: Framework and Methodologies.* New York: Author.
27. United Nations. 2003. *Handbook of National Accounting: Integrated Environmental and Economic Accounting.* http://unstats.un.org/unsd/envaccounting/seea2003.pdf.
28. World Bank. 2007. "Cost of Pollution in China." World Bank, East Asia and Pacific Region. http://go.worldbank.org/FFCJVBTP40.
29. World Bank. 2010. "Adjusted Net Saving." http://go.worldbank.org/3AWKN2ZOY0.
30. World Bank. 2012. *World Development Indicator.* http://data.worldbank.org/data-catalog/world-development-indicators.
31. World Commission on Environment and Development Report. 1987. *Our Common Future.* http://www.un-documents.net/ocf-ov.htm#1.2.
32. Zhang, J., and C. Wang. 2011. "Co-Benefits and Additionality of the Clean Development Mechanism: An Empirical Analysis." *Journal of Environmental Economics and Management* 62(2): 140–54.
33. Zhang, J. 2012. "Wind Power without Hot Air." Working Paper, University of California, San Diego.
34. Zhang, K., 2000. *Policies and Actions on Sustainable Development in China.* Beijing: China Environmental Science Press.

Table 1: Milestones in China's Sustainable Development Strategies

Year	Event	Significance
1972	United Nations Conference on Human Environment (the Stockholm Conference)	Initial recognition of environmental degradation in China
1973	The First National Conference on Environmental Protection	China's first national strategy on environmental protection
1979	The Environment Protection Law (Trial) was promulgated (final law signed 1989)	The start of China's environmental legislation
1982	The Sixth Five-Year Plan	The first five-year plan that incorporated environmental protection
1983	The Second National Conference on Environmental Protection	Environmental protection announced as a basic national policy
1993	Campaign of Environmental Protection	The start of environmental information disclosure to the public
1994	China's Agenda 21—White Paper on China's Population, Environment, and Development in the 21st Century (implemented in 1996)	Sustainable development set as the national strategy
1994	Establishment of the first environmental NGO, Friends of Nature	The start of public participation in environmental protection
1998	Devastating Yangtze River floods and the following farmland-to-forest project in 1999	The start of state-sponsored ecosystem recovery
2003	The Scientific Outlook on Development	Current guiding principle of economic development requiring sustainable development

Table 2: Upgrading of the Environmental Protection Agency

Year	Name	Administrative Level
1973	State Council Leading Group Office of Environmental Protection	
1982	Department of Environmental Protection under the Ministry of Urban and Rural Construction and Environmental Protection	Department
1988	National Environmental Protection Administration	Vice ministry level
1998	State Environmental Protection Administration	Ministerial level
2008	Ministry of Environmental Protection	Cabinet ministry