CONTENTS

CHAPTER ONE

Introduction

Mr. Wu is thirty-eight years old and has a doctoral degree in civil engineering from Tsinghua University. Originally from Hunan Province, he moved to Beijing, where he now manages a department in a large, state-owned building design company. He earns a good salary. He and his wife, who works in a state-owned hospital, have a five-year-old daughter. Like many young urban couples in China, they bought their condominium and car before their daughter was born so she could grow up comfortably.

Mr. Wu enjoys a much better quality of life than his parents did. Thirty years ago, the Communist Party of China would allocate jobs and dormitory housing to college graduates like Mr. Wu's parents. For most basic necessities—from grain, meat, and cooking oil to clothes, soap, and bicycles—the party distributed ration coupons.

But Mr. Wu faces challenges that his parents did not. If he doesn't reach his profit target at work, he faces income deductions. If he suffers from health problems, such as a serious cough from the terrible pollution in Beijing, the fierce competition with his colleagues forces him to stay on the job. When he goes out to dinner, he is careful about what he eats because he has read about the excessive levels of drugs and hormones fed to chickens as they're growing. At home, he must care for his parent in their retirement and plan his daughter's schooling. The nation's one-child policy creates extra anxiety for urban parents as they focus so much energy on their sole child's success. There is a limited number of elite slots in high-quality schools and colleges, and this puts heavy pressure on every child. Worried about his daughter's future, Mr. Wu might move to Canada or the United States.

Young Chinese also face very high home prices in the major cities. Ms. Feng has a graduate degree from Tsinghua University, and works at a major real estate company. She recognizes that the booming market has brought her company enormous business opportunities, but she laments the soaring house prices in Beijing. Her family rents a small, old apartment in the Xicheng District. To buy a hundred-square-meter condominium unit, they would have to save for ten or fifteen years. Ms. Feng describes her workweek as "five plus two, and white plus black"—that is, all five weekdays, both weekend days, and always late into the night. The extra hours are considered voluntary, so she does not receive overtime pay. Those who do not follow this routine lag behind in their performance evaluations and are pressured to leave.

Ms. Feng works a much longer week than would a typical worker in western Europe. Indeed, a comparison between daily life in urban China and western Europe yields striking contrasts. Urban China's material standard of living is rising, but urban pollution and stress are extreme. Western Europe's cities offer a high quality of life, and their inhabitants have ample leisure time to enjoy it.[1]

Over the last thirty years, China's economy has grown at an amazing rate of 10 percent per year, and the share of people living below the poverty line fell from 84 percent to 13 percent. There are still hundreds of millions of poor households in rural China, but hundreds of millions have also escaped poverty. The horrible famine of 1959–61 is now a distant memory, and improvements in medical care and diet have lengthened life expectancy. Over the last thirty years, the average life expectancy at birth has increased from sixty-six to seventy-three years.

Despite this progress, Chinese urbanites must reckon with the reality that the nation's standard of living is not improving as quickly as its economy is growing. Their cities suffer from limited access to health care and education as well as disastrous environmental quality.

The Chinese and Western media have published high-profile and lengthy exposés on environmental and other problems such as lead pollution in Deqing, toxic chemicals created by the mining of rare earths in Inner Mongolia, a proven decrease in life expectancy in northern China due to coal burning, fox and rat meat sold as mutton, and even thousands of dead pigs floating down the river in Shanghai—all salient examples of the costs of China's economic growth.

In early 2013 the incredible smog in northern China caught the world's attention.[2] In January 2013 the particulate matter concentration in Beijing reached levels of two, three, and even four times the public health emergency threshold of 250 micrograms per cubic meter—and up to forty times what the World Health Organization (WHO) considers a healthy level.[3] Based on one key indicator of outdoor air pollution, twelve of the twenty most polluted cities in the world are in China.[4] In 2003, 53 percent of the 341 monitored Chinese cities—accounting for 58 percent of the country's urban population—reported annual average pollution levels that exceeded the WHO's standard. One percent of China's urban population lives in cities that meet the European Union's air-quality standards.[5] One study estimates that such extreme pollution may cause twelve hundred premature deaths per year in Hong Kong alone.[6]

Another cause for concern is water pollution. According to a report by the Chinese Ministry of Environmental Protection, 57 percent of the groundwater in 198 cities was officially rated as "bad" or "extremely bad" in 2012, while more than 30 percent of the country's major rivers were found to be "polluted" or "seriously polluted."[7]

China is the world's largest emitter of greenhouse gases, and these emissions exacerbate the risk of climate change. While per capita energy consumption in China is still less than 30 percent of that in the United States, China's total energy consumption surpassed total US energy consumption in 2009. Data from the World Bank shows that China's per capita greenhouse gas emissions grew by 186 percent (to 5.2 tons per person) between 1990 and 2010, while the world's emissions grew by 16 percent (to 4.9).[8]

We've Been There

Today China faces many local environmental challenges, and an unintended consequence of its industrial production, increased motor vehicle use, and coal reliance is growing greenhouse gas emissions. In contrast, cities in the United States have enjoyed great progress toward cleaner air and water in the last forty years.

Not long ago, the cities of the West were much more polluted. Coal burning in major cities such as London and New York City created soot

that killed thousands; London's Great Smog of 1952 alone killed at least four thousand (and by some estimates, as many as twelve thousand) people as coal emissions from residential burning greatly elevated local particulate levels. Also in the mid-twentieth century, heavy manufacturing in major cities like Los Angeles, New York, and Pittsburgh (whose booming steel industry offered high-paying but dirty jobs) led to severe air and water pollution. Meanwhile, rising motor vehicle use relying on leaded gasoline caused high levels of urban lead emissions. In the 1960s and 1970s, smog in Los Angeles increased dramatically due to an increased number of vehicles traveling greater distances.

But the combination of new regulations (perhaps spurred by the horrible consequences of the Great Smog), energy efficiency gains, and rising household incomes that encouraged the substitution away from dirty fuels such as coal toward cleaner fuels such as natural gas fostered air-quality improvements for dense cities during times of growth. The birth of the environmental movement in the 1960s, often associated with the publication of Rachel Carson's *Silent Spring*, helped mobilize the growing number of educated people in US cities to work toward a cleaner environment and preserving natural capital.

In the case of vehicle emissions, effective environmental regulations in the United States have offset the growth in total annual miles driven. Vehicles built in 2015 emit 99 percent less local air pollution per mile than those built before 1975. Thus, despite continuous vehicle use growth and increased mileage, over the last several decades levels of Los Angeles smog have plummeted.[9]

Starting in the early 1960s, Pittsburgh and other Rust Belt cities lost thousands of manufacturing jobs. The silver lining was blue skies: as industrial activity declined, air and water quality sharply improved. Pittsburgh reinvented itself as an attractive city on the Allegheny and Monongahela rivers, with new firms that relied on an educated workforce benefiting from access to leading research universities such as Carnegie Mellon and the University of Pittsburgh. Boston and Chicago enjoyed similar transitions to blue skies, as did London.

The US experience offers some lessons for predicting future dynamics for China's environmental quality. While the two nations differ on many levels, the experience of cities in the United States highlights the role that

fossil fuel consumption, the scale of industrial activity, and private vehicle use play in contributing to urban pollution. A city of given population size will experience an improvement in environmental quality if its power plants and industrial boilers move away from coal, there is a transition away from heavy industries, and firms introduce new technologies that reduce emissions. The transportation sector will create fewer emissions if people drive less or if private vehicles emit less pollution per mile of driving. The two key variables here are the scale of economic activity (i.e., industrial production or total miles driven) and the pollution intensity per unit of economic activity. For a growing economy to accomplish improvement to the environment, pollution per unit of economic activity must decline faster than economic activity grows. For example, if the people of Beijing drive 100 percent more miles in the year 2015 than they did in the year 1990, aggregate vehicle emissions can only decline if emissions per mile of driving decline by more than 50 percent over this same time period. Tracing the scale and the pollution intensity of economic activity in a growing city provides a framework both for tracking pollution dynamics in a Chinese city and comparing Chinese cities' environmental performance over time.

Reasons for Hope

Will the 2013 Beijing haze be China's equivalent of the Great Smog of 1952—a catalyst for genuine environmental change?[10] There are several trends now unfolding in China that suggest that many of China's cities will experience positive environmental change in the coming decades.

Of eighty-three major Chinese cities for which we can access urban air pollution data (measured as particulate matter up to ten micrometers in size, or PM_{10}) we predict that forty-nine will experience near-term progress in curbing air pollution.

From 2001 to 2013, Beijing's annual ambient particulate levels have declined by 39 percent. This reduction in pollution has taken place at a time when Beijing's population, number of motor vehicles, and per capita income have continued to grow. An examination of PM_{10} levels across eighty-three of China's major cities over the years 2005–10 indicates

that, controlling for a city's population size and its share of employment from manufacturing, pollution is declining by 2.8 percent per year. Assuming that this past statistical relationship continues to hold, we predict that a city whose population and manufacturing share does not change over time would enjoy a 28 percent decline in PM_{10} levels over a ten-year period. While China's cities are growing in size, and city size is positively correlated with PM_{10} levels, the impact of city growth on urban pollution levels is small. A 10 percent increase in a city's population (e.g., Beijing growing by two million people) is associated with only a 1.3 percent increase in ambient PM_{10} levels.

Many Chinese urbanites are becoming increasingly aware of the threats and impositions on their quality of life, and as more people obtain higher education and better wages, their standards and demands are rising. Indeed, the pollution in Chinese cities has sparked widespread complaints and calls for a cleanup.[11] Via the Internet, the Chinese people are discussing and debating the causes and consequences of urban pollution. *Under the Dome* is a 2015 self-financed Chinese documentary film produced by Chai Jing, a former China Central Television journalist. The film, which openly criticizes state-owned energy companies, steel producers, and coal factories that are responsible for pollution, has struck a nerve in China; within three days of its release it was viewed over 150 million times on the Tencent video portal. Chen Jining, the former president of Tsinghua University and, as of February 2015, the head of China's Ministry of Environmental Protection, praised the film, comparing its significance with Carson's *Silent Spring*.[12] Over 18 percent of the world's population lives in China, and a majority of China's population now lives in cities. The quality of life for the growing urban middle class is a key determinant of political stability for the nation, the region, and the world. [13]

A Preview

In this volume we seek to understand how China's urban economic growth impacts local and global environmental challenges, and we adopt a microeconomics perspective focused on the choices made by households, firms, and various levels of the Chinese government that in aggregate impact

the environment. No rational actor actively seeks to damage the environment; instead, environmental damage often emerges as an unintended by-product of individuals' choices and firms' production decisions.

To understand how improvements in the environment could take place, we must identify the incentives that would allow Chinese cities to achieve improved environmental performance. For example, why do Chinese industrial plants use coal if burning this fuel causes so much pollution? The economic approach asks who bears the costs and who gains the benefits from such a practice. If there are social costs associated with coal burning (i.e., hazards that a factory brings to bear on the surrounding residential area), do any local government officials have an incentive to protect the residential communities, or are these officials close to the polluting firms and thus hesitant to regulate them? If such factories unintentionally elevate local air pollution, what self-protection strategies can Chinese urbanites use to protect themselves?

We have been working together on joint research projects related to China's urban development and pollution challenges since 2006. Over the years, Matthew E. Kahn has visited and lectured in China, and Siqi Zheng has been a visiting scholar at various US research universities. This international collaboration has allowed us both to more clearly see the strengths and weaknesses of our respective political and economic systems. This book is stronger than if either of us had tried to write it alone, as it yields a more balanced examination of the challenges and opportunities for China's cities.

Matt is an expert in environmental economics, a branch of applied microeconomics that seeks to understand the causes and consequences of pollution production. Siqi is an expert on the Chinese urban economy and real estate markets. In writing this book together, we seek to convey our excitement about our joint research discoveries and to bring our research to life by weaving in personal stories about life in modern urban China. Such personal observations of people like Mr. Wu and Ms. Feng allow us to explore the human element of the massive urbanization that is now unfolding.

We seek to understand the emerging quality-of-life challenges in China from a microeconomic perspective. For China's hundreds of millions of urbanites, how does pollution affect their daily quality of life? How do

their day-to-day choices in aggregate impact local and global environmental challenges? Why is their demand for a cleaner environment likely to increase over time? How will government policies influence urban environmental quality dynamics?

In chapter 2, we study the scale and the economic geography of China's massive urban industrialization. As China produces an increasing number of goods, using more electricity generated from coal, a tremendous source of pollution is its energy-intensive manufacturing sector. In 2013, 67.5 percent of China's energy was fueled by coal, compared to 20.1 percent in the United States.[14] Indeed, the total amount of China's coal production is almost equal to that of the rest of the world's nations combined. And the demand for electricity will only rise as China's urbanites grow in number and wealth. We devote careful attention to how this growth impacts quality of life and local and global environmental challenges.

Beijing, Hong Kong, and Shanghai are well known cities, but China has hundreds of other cities scattered across its 3.7 million square miles. More than one hundred of those cities has a population of over one million, and China's urban growth is just beginning; over the next thirty years, 300 million people are expected to move to China's cities. As cities take on hundreds of millions more inhabitants, the way in which they grow is changing, as is how people locate themselves and move around within the urban environment; these changes have important environmental consequences.

The Chinese government has begun to relax its internal passport system, allowing people more freedom to choose where to live. Until recently, citizens who did not have an internal passport to live and work in a specific city were denied access to that city's schools and had less access to local hospitals and retirement pensions. In late July 2014, however, China's central government announced its intention to reform the *hukou* system of internal passports. According to the announcement, "the government will remove the limits on *hukou* registration in townships and small cities, relax restrictions in medium-sized cities, and set qualifications for registration in big cities."[15] While China's leaders are not chosen by popular vote, the public will have the opportunity to reveal their preferences by where they choose to live and work—they will vote with their feet. In chapter 3, we discuss China's system of cities and present facts about the quality of life in

different Chinese cities. These details provide readers with a sense of the options that Chinese urbanites have to choose from.

Environmental challenges vary both across cities and within cities. An old saying is that the "solution to pollution is dilution." Recognizing this point, many people in the United States choose to live in suburbs, where population density is lower. Suburban living offers ample green space and cleaner air, but environmentalists counter that this lifestyle raises a household's total carbon footprint because its members drive more and use more residential electricity than they would if lived in a city. In chapter 4, we examine the trade-offs of center city versus suburban living in urban China and discuss the aggregate environmental consequences of such choices. In the United States, most growth until recently has been at the suburban fringe. Chinese cities are much denser than their US counterparts, and 80 percent of big-city households live in high-rise condominium buildings. But as China's urbanites grow wealthier, will they embrace the American way of living and working in suburbia? What are the environmental implications if such a lifestyle takes root, especially if this means that more people will be driving?

In 2010, 15.2 million new vehicles were registered in China. In a nation with rising per capita income, more people are seeking the private mobility that US urbanites take for granted. The rise of motor vehicle use in China increases local air pollution and global greenhouse gas emissions from fossil fuels. In chapter 5 we discuss emerging microeconomic trends with respect to private vehicle use in China and analyze the environmental impacts of these trends; we survey the academic literature that examines how to design effective public policies to curb the local and global environmental externalities associated with such driving.

Together, our examination of the economic geography of industrial production, population, vehicle use, and the evolving urban form of Chinese cities allows us to explore the likely dynamics of pollution across and within China's cities. By understanding the microeconomics of pollution production and its spatial distribution, we begin to see the opportunities for achieving significant environmental improvements.

Once we understand what's happening with pollution in Chinese cities, we explore the demand for a cleaner environment, using market data and new survey results. As economists, we are quite interested in how people

express their priorities in avoiding pollution and environmental risk based on how they "vote with their wallets." In 2008, for instance, in response to the reported presence of tainted milk, parents in major Chinese cities bought more than 60 percent of their milk for infants from overseas, and they paid a 33 percent price premium for it. Through this and other examples, in chapters 6 and 7 we study how the demand for reduced risk and pollution has increased over time in China's cities as urbanites have become better educated and wealthier. An examination of a day in Siqi's life in Beijing provides a revealing glimpse into how urban air pollution impacts her on a daily basis, as well as the steps she takes to protect herself and her family from the urban hazards they face.

A Day in Siqi's Life

Today is a typical winter Monday in Beijing; the temperature in the morning is always below freezing. Siqi wakes up very early and takes a look at the air pollution monitor application on her iPhone, which reports two versions of the city's air pollution index: one from the US embassy in Beijing, and the other from China's Ministry of Environmental Protection (MEP). It will be a terrible day again: the US embassy index reports a "hazardous" day, and the MEP reports that the air is "highly polluted."

Like other successful Beijing urbanites, Siqi has several protection strategies to reduce her exposure to pollution. She owns a car, and on days with heavy pollution she drives to work rather than riding her bike. There are many products on the market to protect people from air pollution; an air purifier costs US$490, and an air mask costs ninety cents. Each mask, which researchers believe reduces one's exposure to pollution by 33 percent, is effective for ten days.

Wearing a mask isn't glamorous, but exposure to thirty minutes of outdoor air on a hazy day in Beijing causes a sore throat. On highly polluted days, most people walking or riding bicycles wear masks, and Beijing's supermarkets, pharmacies, and shops are often sold out of them—especially the higher-quality 3M Particulate N95 masks, which are 88.5 percent effective in reducing exposure to the smaller $PM_{2.5}$ particles.

Siqi decides to drive her car today to protect herself from the polluted air. Her commute to Tsinghua University can take either twenty minutes by bicycle or ten minutes by car without traffic. During peak hours the trip by car takes thirty minutes, and in very bad traffic it can take an hour. To avoid traffic, she often gets to her office before 7:00 a.m. Thanks to the flexible working hours that professors enjoy, she can adjust her commute time to avoid traffic, but many of her friends aren't that lucky. Buses and subways are extremely crowded during rush hours, and the upper middle class and wealthy avoid public transit, choosing instead to drive their cars even in severe traffic. The average one-way commute in Beijing takes fifty minutes, which is much longer than the average commute in Los Angeles or New York City.

During the winter months, centralized heating warms Siqi's office to a comfortable temperature. Generating this heat contributes to urban air pollution in Beijing, as coal is the major source of energy. With centralized heating, people cannot control the indoor temperature, and sometimes it is so hot indoors that they have to open windows, leading to wasted energy and unnecessary pollution. Professors at Tsinghua University's School of the Environment and Department of Building Technology are developing a decentralized heating-control technique that will allow households to adjust the heat inflow and their indoor temperature independently. A few new residential complexes have adopted this technology, and it promises significant energy savings.

Siqi's condominium unit is 108 square meters in area, which is much smaller than the typical single-family house in the United States. It has two bedrooms, one living room, and one bathroom. Her condominium is located in a residential complex called Qing Feng Hua Jing. The complex has six high-rise residential towers that contain about one thousand housing units; it has a feel similar to that of Peter Cooper Village in Manhattan. There is some green space in the middle of the towers, where Siqi's son can run around with his friends. It is a typical residential community for most of the middle class in Chinese cities.

Siqi's husband works for a real estate development company in Beijing's central business district. He has a long daily commute that takes an hour by car each way. Sometimes he takes the subway, but the closest subway

stop is a long walk from the condominium, and after he gets off the subway it can be very difficult to find a cab, especially when there is rain or snow. He arrives home after 7:00 p.m.

Siqi's parents are in their seventies. When Siqi had her son four and a half years ago, her parents came to Beijing, and they have been living with her and her husband ever since. On days with low pollution levels they walk around the community in the morning and they take their grandson outside to play in the community yard during the day. He makes friends there, and Siqi's parents make friends with other children's grandparents. During hazy days, they avoid their morning exercise and don't let their grandson go outside, as the local newspaper advises old people, children, and those with health conditions to stay indoors. Siqi's husband bought an indoor air purifier and turns it on for the whole day, hoping to reduce the effect of the bad air on the family.

Siqi and her family look forward to the weekends, when they like to have lunch outside. Sometimes they drive several hours to visit rural areas or small towns for fun. On one weekend outing in the fall, they might drive to a small village to pick cherries at one of the small businesses run by villagers who raise apple trees, cherry trees, and vegetables; during the growing season, people from big cities come and pay a fee to pick fruit.

Despite our narrow focus on a day in Siqi's life, these stories about her generalize to some degree. All residents of Beijing face the challenge of high home prices, air pollution, and traffic. Siqi's high level of education and her occupation have provided her with the resources and the flexibility to cope with many of these quality-of-life challenges; those who are poorer or less-educated have fewer coping strategies. But money alone doesn't shield China's urban elite from stress, pollution, and traffic.

How Will the Government Respond to the Pollution Challenge?

The rise of social media, through the microblog Weibo (the Chinese version of Twitter) and through Weixin (WeChat), has enabled Chinese urbanites to express their concerns about quality of life. As city dwellers become wealthier and more educated, they are increasingly likely to value

safety and green space and thus their demand for information and political accountability will also rise.

This creates incentives for the media to cover such stories, and as a result it is playing a more active role in calling for accountability and transparency. On a foggy day in October 2011, the US embassy's particulate-matter reading ($PM_{2.5}$) was so high compared with the standards set by the US Environmental Protection Agency that it was listed as "beyond index." China's own assessment, however—based on a different standard that measured only larger particles (PM_{10})—was merely "slightly polluted." This large discrepancy was evident for several days and triggered a prominent debate in the media and on microblogs. At first Beijing officials argued that these two readings measured different-size particulates so that a direct comparison was not valid, but the public was not convinced. Later the central government stepped in and required municipalities and cities to monitor and report $PM_{2.5}$.

Will Chinese national and local governments be up to the job of addressing these concerns? The environmental degradation of Chinese cities owes much to the poor political accountability of local officials. In choosing which local officials to promote, China's central government has traditionally focused on economic growth as the main performance criterion. Local officials boosted their economies through encouraging the growth of dirty industries, and had little incentive to reduce energy consumption or protect their jurisdiction's environment.

There are several trends that encourage the Chinese central government to shift its focus. Soaring energy consumption and electricity shortages have raised domestic energy security concerns. And as the rest of the world embraces a low-carbon energy agenda, China has an incentive to carve out new export markets if it can become a technological leader in this nascent field. The government also seeks legitimacy with the Chinese people and in the international arena; by pursuing environmental improvements, it credibly signals to the international community and to the Chinese people that the Communist Party leadership cares about the quality of life of its people. Indeed, at the turn of the twenty-first century, China's central government has been gradually placing more emphasis on energy efficiency and quality-of-life targets, and we discuss these in detail in chapter 8. The Chinese government's tenth (2001–5), eleventh (2006–10), and

twelfth (2011–15) five-year plans have all set specific energy-efficiency and pollution-reduction targets, and those targets are also included in local officials' promotional criteria.[16] China has a strong, one-party, central government. The State Council appoints the governors of provinces, municipalities, and some major cities (so-called provincial-level and vice-provincial cities) directly. Provincial governments appoint the governors of prefecture-level cities. The selection and promotion process is performed by the upper level of the Chinese Communist Party Committee's personnel department. Some data used in the promotion process include performance evaluations with objective and quantitative targets, individual interviews, and qualitative assessments of capacity and potential.[17]

Environmental issues have been added to the policy agenda of many city leaders, and they have tried to meet those targets, but skeptics point out that such a rigid target-based system raises verification challenges. The new rules will be more likely to yield environmental improvements only if local leaders view such improvements as beneficial for themselves,[18] and corruption and side deals between factories and local politicians could slow any progress. Officials sometimes have a direct financial stake in factories, or personal relationships with their owners, and such relationships provide financing and connections for private firms. Since 2013 Chinese president Xi Jinping has punished officials for engaging in such corrupt practices. From the local officials' perspective, a key issue arises concerning what they perceive to be their city's "golden goose." In the past, the answer was heavy industry, but today the prospects for improvements in environmental performance are enhanced if local leaders increasingly prioritize high-tech industries and the service and tourism sector.

Local leaders will be more likely to pursue a green agenda if such investments dovetail with their vision for their cities' future; for example, a mayor who wants to increase local tourism has strong incentives to keep the local beaches clean. In the language of economics, there are certain policies and regulations that are "incentive compatible." In 2007, three researchers who study this concept were awarded the Nobel Prize in economics; their research provides clues about how the Chinese central government can devise the "rules of the game" to incentivize local leaders to invest more effort in protecting the environment even though these leaders have considerable discretion with respect to their day-to-day choices.

In chapter 9 we explore the key idea that self-interested local leaders are more likely to act in the public interest if they believe that citizens can hold them accountable. A key issue is whether Chinese national and local government officials have strong incentives to address green challenges, and it is something we explore in detail.

China's urban growth has contributed significantly to global climate change. In 2012, China produced 27 percent of global carbon dioxide emissions, largely due to rising coal and gasoline consumption. In chapter 10 we explore how China's urban growth has affected its greenhouse gas production and use official statistics and the peer-reviewed literature to offer a preview of possible carbon production dynamics out to the year 2040. These results highlight that the amazing scale of China's growth will continue to increase the nation's greenhouse gas emissions unless there is significant technological change through the increased use of electric vehicles and less-expensive, renewable sources of power such as wind and solar systems. The Chinese central government has announced ambitious goals to increase the economy's energy efficiency. Whether these goals can be achieved hinges on a variety of microeconomic variables that we will discuss in the next section.

A Possible Path for Sustainable Growth

Labor economists emphasize that human capital and the development of the next generation of productive adults is the key to sustainable urban economic growth. In this book we document that much of China's past urban growth has relied on the smokestack model, an approach that yielded economic growth but also led to very high levels of local and global pollution.

At the time of this writing, in 2015, we can already observe many coastal Chinese cities experiencing a drop in air pollution. In this book we present new evidence on how many Chinese cities, and how many total urbanites, are likely to enjoy environmental improvements in the short term. Our findings build on the environmental Kuznets curve (EKC) hypothesis that suggests that an inverse-U association exists between per capita income and pollution.[19] Intuitively, this hypothesis posits that as poor cities grow

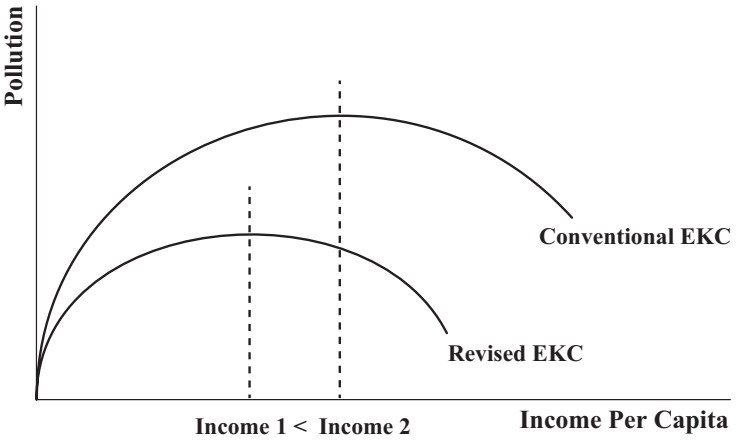

Figure 1.1 The environmental Kuznets curve: different scenarios

wealthier, such economic growth causes environmental degradation, but that as middle-income cities grow wealthier, such economic growth contributes to environmental improvements. In chapter 10 we study the intercity relationship between air pollution (measured as PM_{10}) and per capita income. We estimate that those Chinese cities whose per capita gross domestic product is greater than US$13,000 are past the turning point, so that economic growth is positively associated with improvements to the environment.

Our explanation for this statistical fact is based on several emerging trends. Chinese urbanites who reach such levels of income are increasingly well educated, and they have traveled outside of China (e.g., to Japan and the United States). Given that many adults have only one child, they seek a safe environment to raise the likelihood that that child grows up happy and healthy.

Due to China's importing world technology, China's cities can more cheaply achieve pollution emissions reduction. Figure 1.1 suggests an optimistic hypothesis that the EKC curve shifts down and in over time as the adoption of cleaner technology for cars, power generation, and winter heating means that the same level of economic production and consumption causes less pollution. We believe that this hypothesis that the EKC is shifting down and in is likely to hold true in China and to be especially

likely in those cities with younger, more educated mayors and those cities where the people are more interested in environmental issues.

Our city-level results suggest that thirty-three out of these eighty-five cities in China (where 140 million people live) are already experiencing a lowering of PM_{10}. For a decrease in pollution to take place during a time of growth means that emissions per unit of economic activity must be declining in the near future. If this inverse-U pattern exists, it will be expected that, with rising income, twenty-three of the remaining fifty-two cities will pass the income turning point by the year 2020. This means that 368 million urbanites will enjoy better air quality. The average city in this group is predicted to enjoy an annual reduction in PM_{10} of 3.4 percent over the years 2012–20. The top five cities with the largest PM_{10} declines are Dalian, Guangzhou, Ningbo, Suzhou, and Xiamen.

When people are healthy and happy they are more productive workers. Environmental quality is an essential input in producing aesthetically pleasing cities and healthy inhabitants. In this sense, blue skies and a productive, happy workforce go hand in hand. Educated urbanites will be willing to pay for products and housing in neighborhoods that offer a higher quality of life and fewer environmental and health risks. Firms will cater to this demand by designing products and neighborhoods that deliver higher-quality experiences. Urban governments will be incentivized to deliver green cities both to comply with national government objectives and to meet the demands of constituents. China's citizens and leaders are now increasingly aware that a by-product of their economic growth miracle is horrendous pollution.

Countering this optimism, however, are legitimate concerns about the global effects of China's growth. Many grant that China will take steps to protect its own public health but ask about the nation's incentive to address global challenges. China's reliance on burning coal to generate electricity and for winter heating has had substantial global environmental implications. An unintended consequence of China's current energy choices is extremely high levels of local urban pollution. The health and quality-of-life costs of such particulate pollution are borne by Chinese urbanites, and this provides a direct incentive for the people and their leaders to seek out policy solutions.

To narrow this book's focus, we chiefly study how China's urban growth impacts local environmental issues and how the evolution of local pollution challenges impacts urban growth. In turn, we investigate how China's urban growth impacts its greenhouse gas production. This is the only global environmental indicator that we examine, though we recognize that there are other relevant environmental criteria, such as mineral extraction from African nations and the overfishing of the world's oceans; as China grows wealthier, its urbanites' demand for such imports could certainly exacerbate environmental challenges. That said, our focus is on urban quality of life in China, and climate change risk (in part exacerbated by China's own greenhouse gas emissions) has a direct impact on that quality of life.

We now turn to the rise of China as an industrial urban economy. Heavy industry and coal-fired generation of electricity has been the economy's engine but, as we'll see, it has also been the main cause of China's pollution problems.

INDEX