RAND CORPORATION

ifmo
Institute for Mobility Research

THE FUTURE OF MOBILITY

Scenarios for China in 2030

Liisa Ecola, Johanna Zmud, Kun Gu, Peter Phleps, Irene Feige

The Future of Mobility

Scenarios for China in 2030

Liisa Ecola, Johanna Zmud, Kun Gu, Peter Phleps, Irene Feige

For more information on this publication, visit www.rand.org/t/rr991

As a part of the agreement under which the research described in this document was funded, RAND grants the Institute for Mobility Research a nonexclusive, royalty-free license to duplicate and distribute this publication in any medium, either commercially or noncommercially.

Library of Congress Cataloging-in-Publication Data is available for this publication.
ISBN: 978-0-8330-9035-5

Published by the RAND Corporation, Santa Monica, Calif.
© Copyright 2015 RAND Corporation
RAND® is a registered trademark.

Design: Bernhard Moosbauer, exsample.org
All photographs via 123rf.com

Limited Print and Electronic Distribution Rights
This document and trademark(s) contained herein are protected by law. This representation of RAND intellectual property is provided for noncommercial use only. Unauthorized posting of this publication online is prohibited. Permission is given to duplicate this document for personal use only, as long as it is unaltered and complete. Permission is required from RAND to reproduce, or reuse in another form, any of its research documents for commercial use. For information on reprint and linking permissions, please visit www.rand.org/pubs/permissions.html.

The RAND Corporation is a research organization that develops solutions to public policy challenges to help make communities throughout the world safer and more secure, healthier and more prosperous. RAND is nonprofit, nonpartisan, and committed to the public interest.

RAND's publications do not necessarily reflect the opinions of its research clients and sponsors.

Support RAND
Make a tax-deductible charitable contribution at www.rand.org/giving/contribute

www.rand.org

Foreword

No market in the world is as impressive not only in size but also in uncertainty about its future perspectives as China. For example, economic growth has slowed down in the past years but is still high compared with that in other regions. Are we going to see those rates stabilizing at levels close to today's rates, or will the next 20 years be shaped by a totally different economic situation in China? The gap between different possible economic future scenarios is extremely large, reflecting the tremendous insecurity in the market.

But not only the economic situation is an important pace-setter for the mobility market of the future: Environmental regulation and other regulatory policy for transportation have the potential to either further promote strong growth in the car market or hinder it. At the moment, we observe mixed signals, with some cities strongly regulating the mobility market and others still pondering such measures. The way public transport systems in urban areas will be promoted in the future will also have a tremendous impact on the way the Chinese mobility market will look in 2030.

All of these factors are much less certain than they usually are in most other large markets. The combination of high uncertainty and market size make China an ideal candidate for creating scenarios on the future of the mobility market. Doing so helps us build a spectrum of different possible development perspectives and thus enables decisionmakers in mobility companies active in the Chinese market to prepare for a variety of possible future developments.

Dr. Markus Schramm
BMW Group, Senior Vice President
Corporate Planning and Product Strategy
Member, ifmo Board of Trustees

Dr. Irene Feige
ifmo, Head of the Institute

Preface

About This Document

The future of mobility in China is important to decisionmakers. Without some ideas about how and how much the Chinese population will travel in the future, it is difficult to know whether infrastructure will be adequate, whether cars will continue to rise in popularity, and whether policies are needed to manage automobility.

Instead of trying to predict these situations, or extrapolate from existing trends, the research team on the project reported here used a scenario approach to develop two distinct alternative futures for the country. Data were based on expert opinions about the long-term future in four areas: demographics, economics, energy, and transportation supply and constraints.

The Institute for Mobility Research, known by its German abbreviation ifmo, sponsored the research reported here. ifmo has conducted several scenario exercises for Germany and previously engaged RAND to execute a scenario study for the United States (Zmud, Ecola, et al., 2013). The results of this similar study for China should be of interest to policy- and decisionmakers concerned with the long-term future of transportation.

In terms of related work, RAND and ifmo also recently published a report, *The Future of Driving in Developing Countries* (Ecola et al., 2014), that looks at long-term motorization trends in four developing countries, making predictions based on a variety of possible futures combined with the experiences of developed countries. For the Transportation Research Board, RAND has conducted three other long-term strategic studies, looking at options for adopting alternatively fueled vehicles (Sorensen et al., 2014), incorporating new technologies into the transportation system (Popper et al., 2013), and evaluating the impact that sociodemographic changes can have on travel demand (Zmud, Barabba, et al., 2014).

The RAND Transportation, Space, and Technology Program

The research reported here was conducted in the RAND Transportation, Space, and Technology Program, which addresses topics relating to transportation systems, space exploration, information and telecommunication technologies, nano- and biotechnologies, and other aspects of science and technology policy. Program research is supported by government agencies, foundations, and the private sector.

This program is part of RAND Justice, Infrastructure, and Environment, a division of the RAND Corporation dedicated to improving policy and decisionmaking in a wide range of policy domains, including civil and criminal justice, infrastructure protection and homeland security, transportation and energy policy, and environmental and natural resource policy.

Questions or comments about this report should be sent to the project leader, Liisa Ecola (Liisa_Ecola@rand.org). For more information about the Transportation, Space, and Technology Program, see http://www.rand.org/transportation or contact the director at tst@rand.org.

The Institute for Mobility Research

The Institute for Mobility Research is a research facility of the BMW Group. It deals with future developments and challenges relating to mobility across all modes of transport, with automobility being only one aspect among many. Taking on an international perspective, ifmo's activities focus on social science and sociopolitical, economic, and ecological issues, and they extend to cultural questions related to the key challenges facing the future of mobility. The work of the institute is supported by an interdisciplinary board of renowned scientists and scholars and by representatives of the BMW Group, Deutsche Bahn, Lufthansa, MAN Truck and Bus, Siemens, and the World Bank.

Contents

Summary

Research Question

What might we expect for the future of mobility in China in 2030? Responses to this question will help transportation decisionmakers in China—national, provincial, and local officials—and the private sector better prepare for the future. Long-range transportation planning involves many difficult choices, especially in an era of constrained resources. Which modes of transportation should be prioritized? Which investments should be funded? How will the pace of economic growth affect auto manufacturing and purchasing? How will economic and demographic changes affect long-distance travel? These questions are hard to answer, particularly because transportation decisionmakers must make decisions with a time horizon that extends 30 to 50 years into the future.

Although the country's mobility (how people travel from point to point) will be considerably different in 2030 from what it is today, figuring out how it will be different is a significant challenge. Some changes happen slowly, while others can take place relatively quickly. Demographic change happens relatively slowly, although the trend in China points toward rapidly slowing population growth rates and an aging population structure. Investments that change travel patterns can happen quickly; China went from no high-speed rail less than a decade ago to the world's most extensive network today. Both types of changes can dramatically affect travel demand.

Answers to our research question cannot be reliably addressed through straight-line trend analysis or improved travel demand forecast models. These approaches are lacking because the data and information needed to support long-term thinking about the future of mobility are uncertain, incomplete, evolving, or conflicting. Instead, we have applied scenario techniques, which are increasingly used to deal with the opportunities and risks associated with complex, long-term issues. As we look to 2030, multiple mobility futures are possible. The relationship between today's situation and a long-term future outcome is not linear. It is not even relevant to study the two points in time—now and then. It takes a systematic process of identifying possible, plausible futures and then understanding the paths leading to those alternative futures.

Our study, which was the result of collaboration between RAND and the Institute for Mobility Research (ifmo), focused on long-term scenarios for passenger travel, including travel by car, transit,[1] domestic air, and intercity rail. Long-term scenarios in this area are multilayered and complex, influenced by demographics, economics, energy, and transportation supply and constraints. How these forces play out over the next 15 years will depend on whether and how decisionmakers sort out and address current and upcoming challenges. Although we cannot know these outcomes in advance, we can apply scenario planning to develop plausible mobility futures that can be used to anticipate and prepare for change.

[1] *Transit* refers to all modes of intracity public transportation, including heavy rail, light rail, and bus service.

Methodology

To develop alternative scenarios of the future of mobility, we applied a process that combined expert opinion gathered in workshops, cross-impact analysis, consistency analysis, and cluster analysis. The study began with identifying four influencing areas and descriptors (variables of interest) within each area. Then RAND and ifmo staff convened four workshops, one for each influencing area: demographics, economics, energy, and transportation supply and constraints.

Six to eight subject-matter experts from government, academia, nonprofit organizations, and consulting firms were involved in each workshop, for a total of 28 people who brought considerable substantive experience in a variety of fields and disciplines. At each workshop, experts were asked to make projections for each descriptor for 2030, along with their assumptions regarding the projections and their qualitative estimates of their impact on mobility. Where there was little uncertainty and high consensus, the group identified only one projection per descriptor. Otherwise, two or three alternative projections surfaced.

We subjected the descriptors and projections to a cross-impact analysis and consistency analysis to identify relationships between the descriptors. We then put these into a computer support system, which used cluster analysis to group them into distinct scenario frameworks. This produced two scenarios: the Great Reset and Slowing but Growing. We developed the resulting scenario narratives based on the assumptions and projections that surfaced during the expert workshops. Given the importance of economic growth in each scenario, economists—both workshop experts and other RAND experts on China—vetted the economic framework for each.

The Scenarios

The scenarios provide two distinct perspectives on the future of mobility in China in 2030. Each future represents a particular trajectory to arrive at the outcome. The pace of economic growth is a major driver in both scenarios, as are environmental conditions and constraints on vehicle ownership and driving. This section provides a synopsis of each scenario.

Scenario 1: The Great Reset

In 2030, China has moved closer to the ranks of developed countries. It successfully weathered what might have been a fairly severe economic crisis through policies that introduced some measure of market-based reform and reduced reliance on personal connections in the economy. Although economic growth has slowed from previous high levels to a more modest average of 6 to 7 percent annually, it did so gradually and without major disruptions. Vehicle ownership continued to grow strongly, with about 240 vehicles per 1,000 people by 2030, even as more and more cities adopted constraints on driving to try to address growing problems of parking and congestion. Long-distance travel increased as well, even with oil prices of USD 150 per barrel. China maintained its position as the world's largest vehicle producer and was even able to increase its export share, largely based on the popularity of so-called new-energy vehicles. Urbanization continued, plateauing at rates similar to those in more-advanced economies, but so did high levels of income inequality. Finally, increased government revenues, especially from local governments' collection of property taxes, enabled the government to address some of the serious environmental problems with air and water quality.

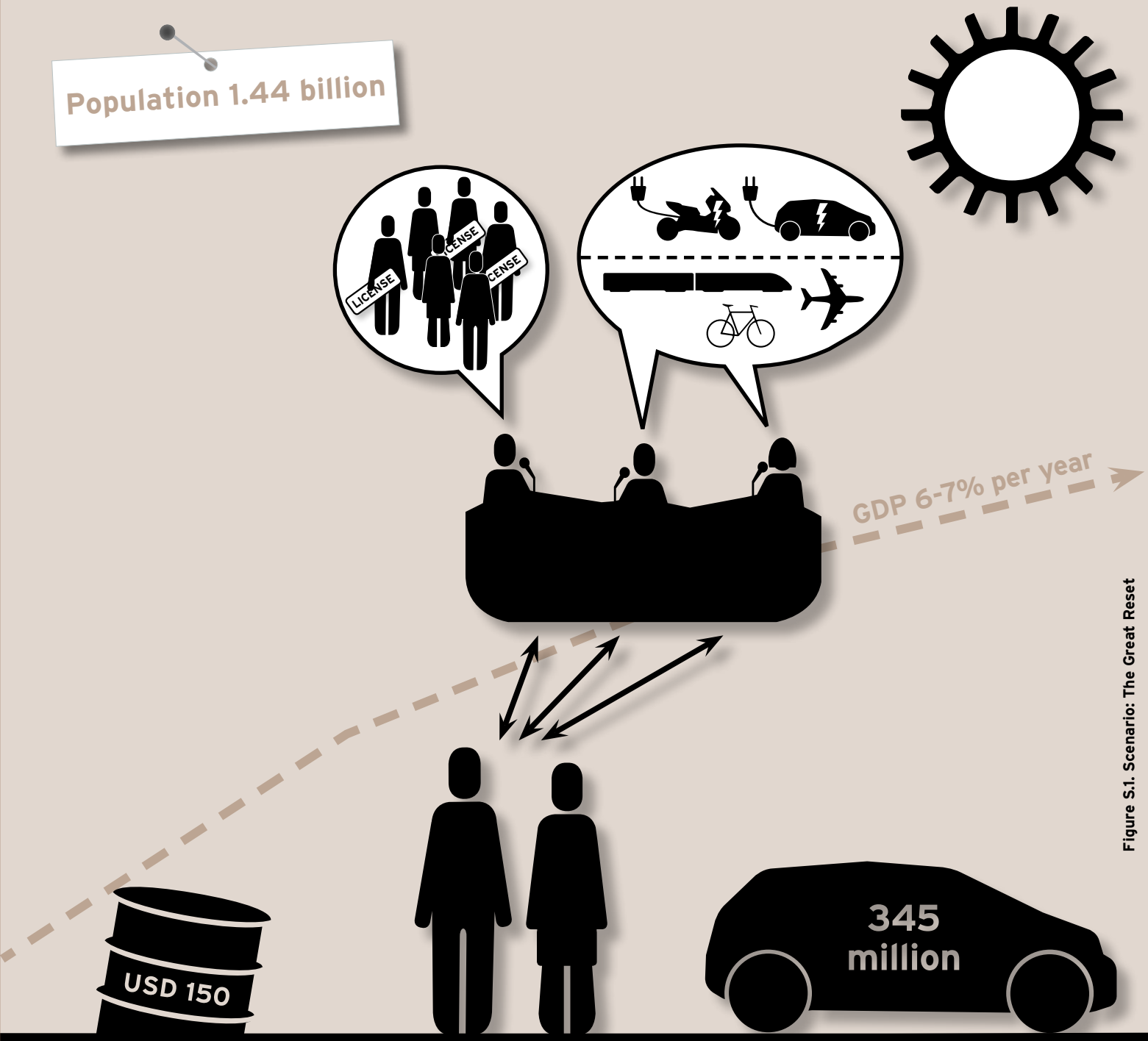


Figure S.1. Scenario: The Great Reset

The Great Reset

Market-based reform has led to continued but more-modest economic growth, with rather strong increases in vehicle ownership despite widespread constraints on driving in urban areas.

Scenario 2: Slowing but Growing

By 2030, China has experienced an economic downturn and entered a period of lower growth, averaging about 4 percent. A financial crisis based on unsustainably high levels of debt resulted in a year of very low growth and then a recovery whose gains were not necessarily widely shared. Corruption has continued to be a problem and has kept the economy from becoming more innovation-based because new firms have a hard time getting funding and international investors remain skittish. Environmental problems have continued to affect the quality of life, and lower-than-previous public revenues have impeded the ability of both the central and local governments to address them. Travel demand has continued to grow, along with the auto manufacturing industry, but at rates lower than would have been expected based on previous trends. Car ownership stands at about 185 per 1,000 people, even with oil prices remaining at USD 100 per barrel. The prevailing sentiment is that things could be better, and people try to remain optimistic that eventually they will be.

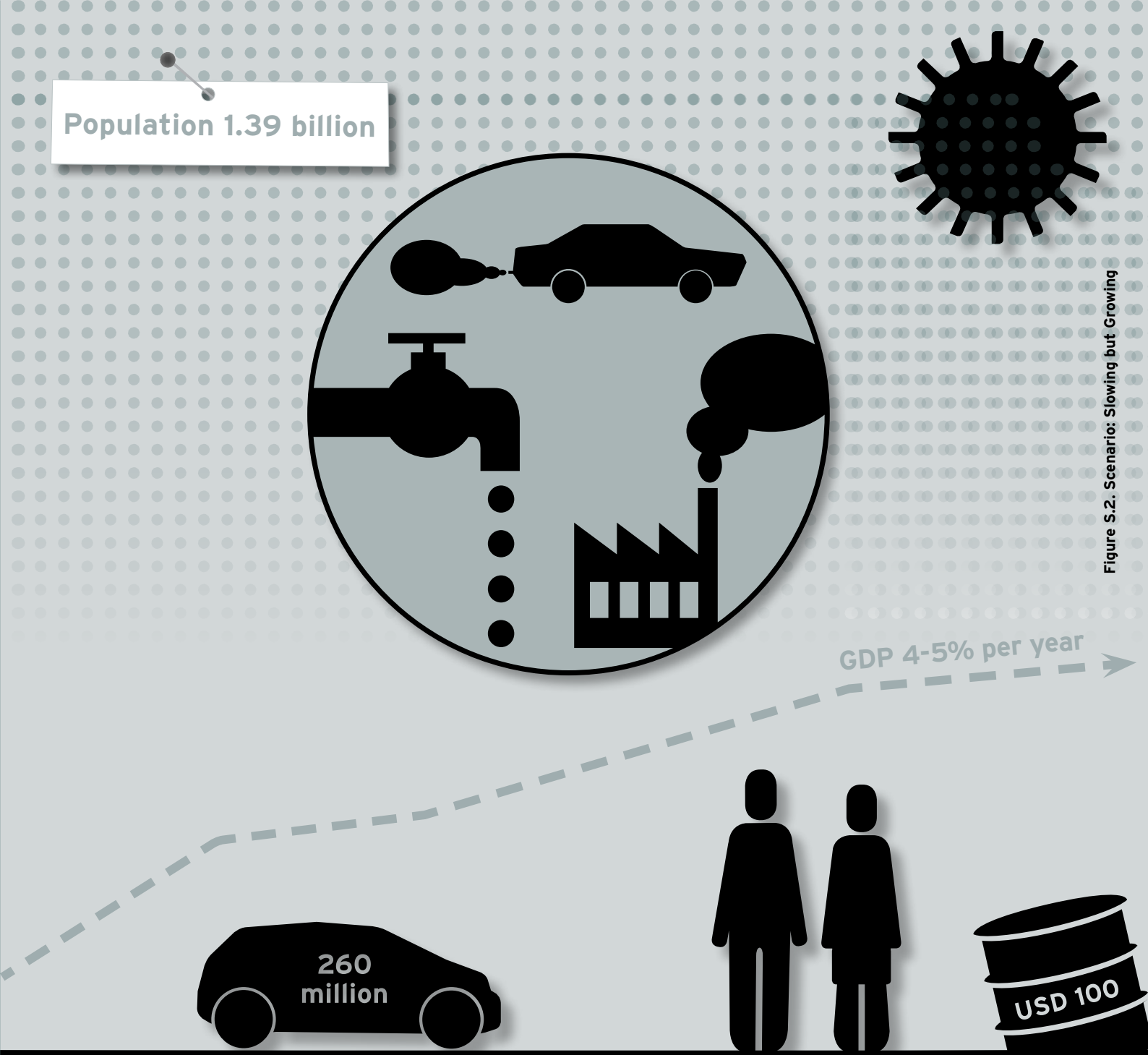


Figure S.2. Scenario: Slowing but Growing

Slowing but Growing

An economic downturn led to a period of lower but still sustained, robust growth. Environmental problems continue to affect the quality of life, and travel demand is growing more slowly than previously expected.

The Wild-Card Scenario

Acknowledging that what is plausible, believable, or imaginable today can constrain scenarios, we crafted a third wild-card scenario. In scenario planning, wild cards provoke thinking about events that break with trends and constitute paths that differ from the projections that underpin the formally developed scenarios. In this report, the wild card is based on the possibility that China experiences a major debt crisis and ensuing economic stagnation.

Implications for Decisionmakers

Our two scenarios describe different mobility futures. The scenarios are descriptive, not normative—neither is put forward as the ideal path for the future of mobility. In addition, our study did not address the likelihood of one particular outcome versus another. The scenarios are instead indicative of a range of plausibilities. By making potential long-term consequences more vivid, scenarios can support public policy by helping decisionmakers at different levels of government, as well as in the private sector, envision what the future might bring.

Our analysis revealed three driving forces as being significant in this regard: (1) the pace of economic growth, (2) the amount and type of constraints imposed on vehicle ownership and use, and (3) environmental conditions. The first and third are exogenous to transportation. Although officials can try to spur economic growth and clean up environmental degradation, success is not necessarily guaranteed; other factors come into play as well. However, the second, constraints on vehicle ownership and driving, is largely within the purview of local officials. In applying the scenarios to decisionmaking, we identified two possible approaches: (1) identifying leading indicators and (2) determining opportunities, risks, and contingencies.

Conclusions

This project created two scenarios, the Great Reset and Slowing but Growing, to illustrate the paths that might result from interconnected effects of market, policy, and consumer forces. The study identified three critical uncertainties, or driving forces, that cause one path to emerge over another: the pace of economic growth, constraints imposed on vehicle ownership and use, and environmental conditions. Of these, by far the most critical is economic growth. The potential for transportation decisionmakers to influence economic growth and environmental conditions is limited. However, they will have greater opportunity to use constraints on vehicle ownership and usage to reduce the growth in travel demand.

Acknowledgments

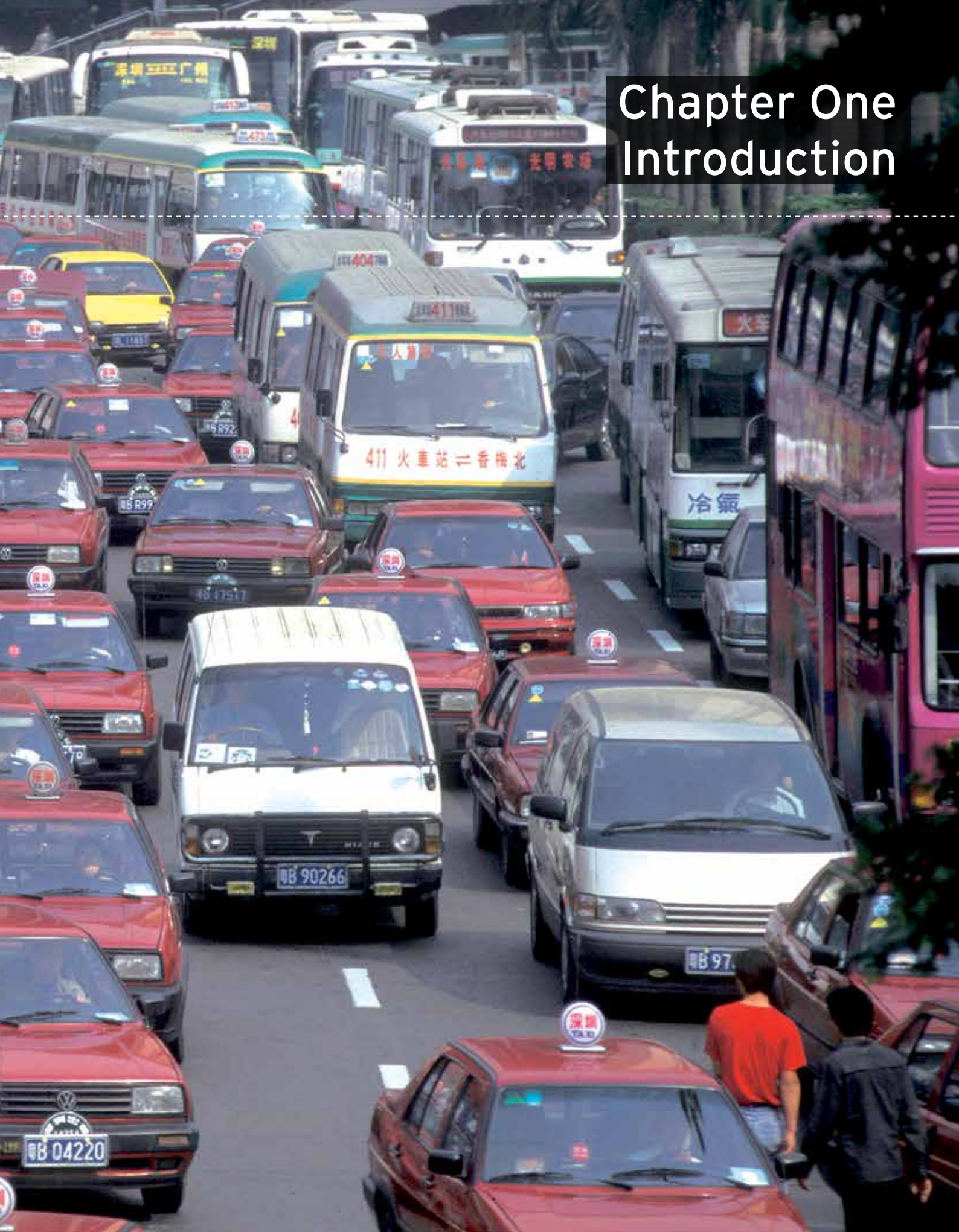
We thank the many experts outside RAND who contributed to the expert workshops. They were gracious with their time, as well as their honest opinions about future projections in their respective areas of expertise. Experts at the demographic workshop were Judith Banister of Javelin Investments; Christopher Cherry of the University of Tennessee, Knoxville (who also provided helpful information on electric-bike usage in China); C. Cindy Fan of the University of California, Los Angeles; Peilei Fan of Michigan State University; Abhas Jha of the World Bank; Ziqi Song of Utah State University; and Loraine A. West of the U.S. Census Bureau. Our economic experts were Patrick Chovanec of Silvercrest Asset Management Group; Damien Ma of the Paulson Institute; Paul Marks of Argosy International; Stephen Markscheid, an independent director; Samm Sacks of Eurasia Group; and Zhirong "Jerry" Zhao of the University of Minnesota.

We promised anonymity to our Chinese workshop participants, so we thank them here as a group. They provided valuable insights and helped us understand the current context for transportation and energy policies.

We could not have held workshops in Beijing without extensive assistance. Zhang Xiliang and Ou Xunmin of Tsinghua University identified experts and persuaded them to participate, reviewed our translated materials, and ensured that the workshops went smoothly. Jiao Liyan of Tsinghua University supported their efforts by assisting with logistics. Our subcontractor, James Kuo-Ann Chiao of International Transformation Advisory Consulting, very ably facilitated the two Beijing workshops, and Mona Han, then a student at Columbia University, served as our note taker. Mu Dan Ping, who advises RAND on doing business in China, was very helpful in identifying potential partners in China and providing general guidance on working there.

At RAND, Samuel K. Berkowitz conducted much of the research for the background paper on transportation supply and constraints, and Bonny Lin and Keith Crane contributed valuable advice about Chinese experts and the importance of adjusting some of our workshop processes to be more suitable to use in China. Howard J. Shatz and Scott W. Harold reviewed early scenario drafts. Gina Boyd prepared the reference section. Andria Tyner, formerly of RAND, handled numerous travel itineraries and reimbursements that made the workshops possible. We also thank Karen Echeverri and her team in facilities in making one of our workshops happen even as Washington, D.C., shut down for a snowstorm.

Finally, we thank David Dollar of the Brookings Institution and Scott Harold of RAND for their thoughtful review comments, which greatly improved the final report.



Chapter One
Introduction

China has grown at an astonishingly rapid pace since undertaking economic reforms in the late 1970s. That growth ushered in major changes that affect both local and long-distance travel: urbanization, higher incomes, and a building boom in transportation infrastructure across all modes. China is now the world's largest producer and consumer of passenger vehicles. Vehicle ownership remains low by the standards of developed economies, yet congestion and parking problems are so severe in most municipalities that many cities have already introduced policies to constrain vehicle ownership. The increase in travel has also contributed to the country's serious air-pollution problems, yet the government's stated plans to increase the use of electric vehicles (EVs) have fallen far short of expectations.

How these varying trends will play out over the next 15 years is of great interest to decisionmakers not only in China but all over the world. Chinese demand for oil is large enough to influence world market prices, Chinese demand and preferences for vehicles drive the plans of global auto manufacturers, and Chinese responses to climate change could measurably reduce global emissions, as well as affect the actions of other countries. However, given the rapid changes of the past few decades, past trends might not be sustainable.

This is where scenario planning becomes useful. We use the term *scenario* to refer to a plausible combination of possible long-term future developments. *Scenario planning* is the development of one or more scenarios via a methodology that incorporates multiple possible future outcomes. The contribution of scenario planning is to help us consider a wider range of potential futures than those that would be predicted from extrapolating from past trends or from a single set of projections. Either of these methods would produce a single future scenario, whereas scenario planning generally produces multiple scenarios.

The advantage to using scenarios in designing transportation policy is to foster discussion and analysis of possible outcomes that might not be obvious when using more-conventional tools, such as forecasting and travel demand modeling. Scenarios encourage transportation planners and policymakers to consider a wide range of possible, plausible futures and the paths leading to those futures. Decisions made in the short term can affect whether one scenario becomes more plausible than another, and scenarios can help identify leading indicators that can indicate which scenario has become more likely.

Study Objectives

This study applied scenario planning to answer this question: What might we expect for the future of mobility in China in 2030? We define mobility as the ability to travel from one location to another, regardless of mode or purpose. Instead of using trend analysis or quantitative forecasts to answer this question, we used scenario planning because it provides a structured method to explore the many ways in which mobility could evolve and then to examine what those possible alternative paths might imply about future mobility.

Our goal is not to predict the future—obviously, an impossible task—but to look at how various factors might affect mobility when combined in different ways. Our focus is largely on Chinese passenger travel (that is, personal travel via driving, transit, domestic air, and intercity rail). The goal is to better understand how a combination of factors can affect total mobility. For example, oil prices have a substantial effect on the amount of driving because drivers are sensitive to the price of gasoline. However, other factors that are taking place simultaneously, such as investments in public transit systems or an economic downturn, might also influence the choice to drive.

To answer this question, RAND collaborated with the Institute for Mobility Research (ifmo) to apply a methodology that distills experts' projections in a variety of areas into scenarios that form plausible and consistent stories about the future. The use of scenarios to evaluate multiple potential futures is a technique first developed by RAND researchers in the 1960s (Kahn and Wiener, 1967) and has been considerably modified and expanded in the ensuing years. Börjeson et al. (2006) provides a simple typology of the many uses for which scenarios have been developed over the years. The technique we use here would be classified as an *external explorative* scenario. *External* means that it focuses on external factors, rather than what can happen if a particular actor takes a certain action. *Explorative* means that it seeks to understand what can happen in the future, rather than what will happen or how can a certain target be reached.

Many methodologies are available to develop scenarios (as discussed in Amer, Daim, and Jetter, 2013). Cross-impact analysis is one means of developing the links between various factors, and consistency analysis is a means of ensuring that the many individual predictions that make up a scenario are internally consistent. Both of these tools can be used in qualitative, as well as quantitative, inputs.

The scenario methodology used in this project was originally developed by ifmo using a scenario framework presented in Gausemeier, Fink, and Schlake (1998). The online Risk Assessment and Horizon Scanning (RAHS) tool operationalizes the steps of the process shown in Figure 1.1. (Appendix A contains more information about RAHS.)

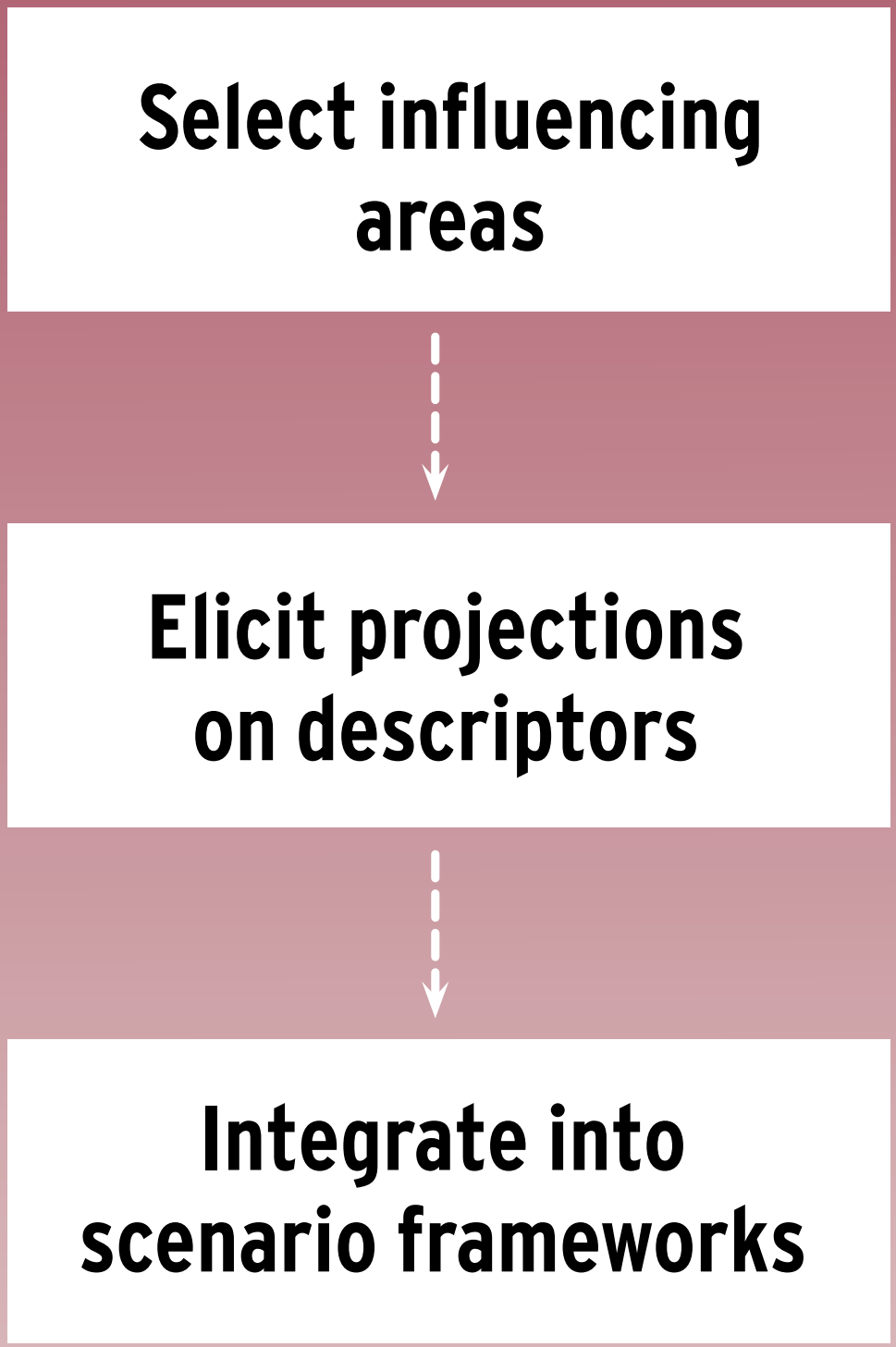
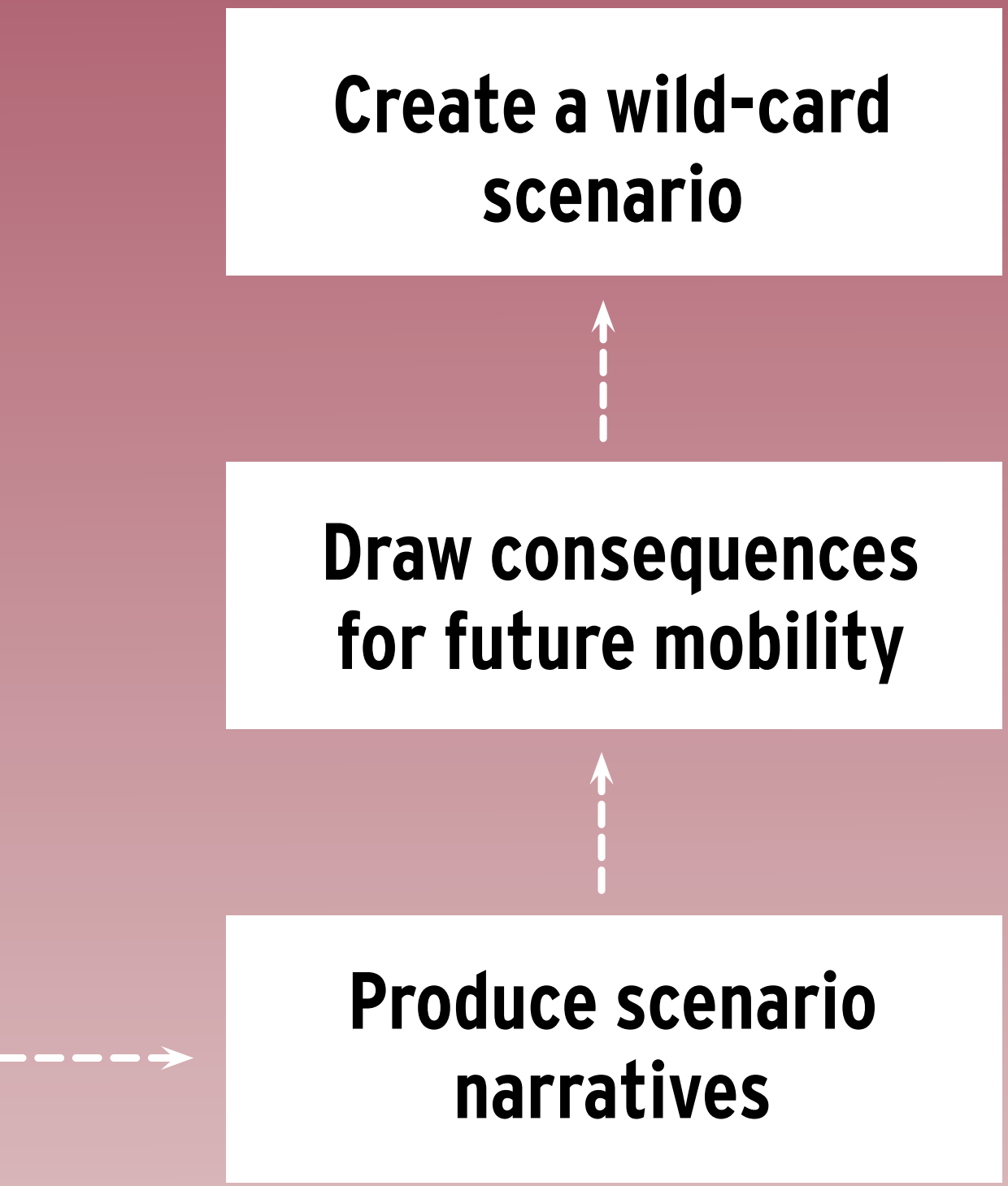


Figure 1.1. Six-Step Scenario Approach: From System Influences to Scenarios


Create a wild-card scenario
Draw consequences for future mobility
Produce scenario narratives

This study built on prior ifmo research that developed scenarios for Germany for 2020, 2025, and 2030, as well as a previous scenario report for the United States in 2030 (Zmud, Ecola, et al., 2013). In the German research, periodic updates every five years have allowed the projections in each influencing area to be confirmed or adapted based on current contexts. Long-term planning horizons for national and regional transportation planning, as well as for industry, are typically several decades. For this report, we selected 2030 as the forecast year, in part for consistency with the earlier German and U.S. work. Ideally, this report will become one of a series of reports that can be likewise updated or that use similar methodologies for other countries.

Creating the Scenarios

Our methodological approach represents a state-of-the-art scenario process while recognizing that scenarios can be developed using several different approaches. Our approach combined expert opinion, gathered via in-person workshops, with cross-impact analysis, consistency analysis, and cluster analysis using specialized computer tool support. Even though it relies more on substantive expertise than on formal research and modeling, the approach was highly empirical. Because some of the terminology might be unfamiliar, we provide definitions in Table 1.1.

Table 1.1. Key Definitions

Term	Definition	Example
Influencing area	A broad topic area that is thought to affect mobility	This study uses four: • demographics • economics • energy • transportation supply and constraints
Descriptor	A metric that represents one specific element within the influencing area	Demographics contains five descriptors: • total population • geographic distribution of population • urbanization • commute distance • household type
Projection	A prediction of the future value of a descriptor	For total population, there are two projections: • 1.39 billion • 1.44 billion

Select Influencing Areas

The scenario process begins by defining three key study parameters: (1) topic (the future of mobility), (2) geographic scope (China), and (3) time horizon (2030). The research team identified four influencing areas and specific descriptors to fit the study parameters. An influencing area is a broad topic area that is thought to affect mobility. The four in this study are demographics, economics, energy, and transportation supply and constraints.[1] These were selected based on the German and U.S. work, as well as additional background research on China. For each area, we then identified descriptors, which are metrics that represent one specific element within the influencing area. For example, among the descriptors identified for energy were the price of a barrel of oil and the percentage of vehicles in 2030 that would be hybrid or electric.

Although we developed a long list of potential descriptors, we narrowed these down based on two criteria: uncertainty and impact. In a scenario analysis, because the differentiation between certain and uncertain descriptors is based on a range of predictions, including uncertain descriptors is more important than including those that are more certain. Impact is important because we want to use factors that are more active than passive. An active descriptor influences many other descriptors; many other descriptors influence a passive descriptor. Appendix A provides a full list of the 24 descriptors. The research team produced a paper on past and current trends for all descriptors in each influencing area; Chapter Two summarizes these papers.

Elicit Projections on Descriptors

The research team held one workshop for each influencing area to gather expert opinion on projections for each descriptor. Two workshops (those on demographics and on economics) were held in the United States with American experts on China, and two workshops (those on energy and on transportation supply and constraints) were held in Beijing with Chinese experts. We defined a projection as an estimate of future possibilities informed by past and current trends. We invited six to eight prominent outside experts (RAND and ifmo staff identified American experts, whom we list in Appendix B; our partner, Tsinghua University, identified Chinese experts[2]) to attend each workshop. Prior to each workshop, each expert received the paper on trends in his or her influencing area.

---

[1] This process deliberately did not address political issues. The methodology depends on a series of projections that do not have a good way to account for an abrupt political change except through adding a wild-card scenario. We could consider this a weakness when using the method for nondemocratic countries, where such regime change is probably more likely than in Germany or the United States, where we have already used this method. Although we considered adding some discussion of political events, we ultimately opted not to because we wanted to stay focused on economic and social trends.

[2] To encourage unfettered discussion, we agreed to allow our Chinese experts to remain anonymous. Appendix B lists the institutions that they represent.

At each workshop, using facilitated discussion, we asked experts for projections for each descriptor in 2030, clarifying that we were not asking them to extrapolate from past trends but rather to consider a variety of factors that they thought might influence the descriptor. For each descriptor, the experts provided between one and three qualitative or quantitative projections. For example, we asked the energy experts to project growth in electric two-wheeled vehicles (E-2Ws), which led to estimates of high, medium, and low levels of adoption, each of which was considered plausible depending on circumstances. The number of projections depended on the degree of consensus on likely futures among the experts. We also asked the experts to provide their reasoning (or assumptions) for each projection. For example, those who projected a relatively low level of adoption cited market saturation and a continued decline in the price of other competing vehicle types, while those who projected higher adoption levels noted the low price and convenience.

Integrate into Scenario Frameworks

The research team used two distinct types of analysis—cross-impact analysis and consistency analysis—to identify the values that would group descriptors and projections into distinct scenario frameworks (for a more-detailed discussion of these analytical tools and how they compare with other analytic methodologies, see Amer, Daim, and Jetter, 2013). We first used cross-impact analysis to describe the relationships among the descriptors. The team developed a cross-impact matrix that matched each pair of descriptors across all influencing areas. The team determined whether it was plausible that either of two descriptors affected the other, using a four-point scale in which 0 indicated no influence and 3 indicated a strong influence. For example, we determined that the total population has a strong influence on urbanization, but not the other way around. In our analysis, we did not carry forward descriptor pairs that we determined to be totally independent; however, they did remain part of the final scenario frameworks. This assessment also forms the basis of analysis into how active and passive each descriptor is (see Figure A.2 in Appendix A). Active descriptors tend to be drivers of the scenario, in that changes in them are thought to produce different outcomes between scenarios.

Second, we applied consistency analysis to those pairs of descriptors in which one was found to influence the other. This analysis examined the various projections for each descriptor. RAND and ifmo staff jointly developed this consistency matrix. Each pair of projections for the two descriptors was rated on a five-point scale, from totally inconsistent (1) to strongly consistent (5). For example, strong growth in demand for air travel was deemed consistent with the lower price of oil because demand is affected by price, and higher oil prices mean more-expensive airfares. On the other hand, because the eastern region is already wealthier than the rest of the country and greater concentration of economic activity in one region is likely to lead to a concentration of wealth as well, we deemed an increasing concentration of economic output in that region to be inconsistent with a decrease in income inequality.

Then, ifmo fed these results into an online tool called the RAHS platform to group specific projections across all influencing areas. Of all the mathematically possible groupings of projections, RAHS eliminated those that contained total inconsistencies (as defined in the consistency matrix). Of those remaining, RAHS identified clusters of descriptors and projections that formed four unique and complementary scenario frameworks.

Although there is not a hard and fast limit on the number of scenarios that should be developed, selecting those that differ most meaningfully requires expert judgment. Of the four clusters produced, the research team selected two to develop further. Three of the clusters were similar across many descriptors, so we decided that only one of the three should be carried forward. We included the fourth cluster specifically because it differed so greatly from the other three. For example, it had a lower average gross domestic product (GDP) growth rate. We thought it was important to include different growth rates because, at China's stage of development, economic growth is generally an important, though hardly the only, determinant of mobility. From the group of three clusters, we selected the one that differed most from the lower-GDP-growth-rate cluster because of its different projections for total population, share of the economy in the eastern region, and domestic vehicle production. These two frameworks became the basis for the scenario narratives.

Produce Scenario Narratives

Drawing on the reasoning and assumptions that surfaced during the expert workshops, we fleshed out the two scenarios into written narratives. We called them the Great Reset and Slowing but Growing. To further validate the scenarios, we asked several RAND experts, several of the U.S. experts who attended the economic workshop, and several Chinese experts from both workshops to comment on whether they found the scenario frameworks plausible, understandable, and internally consistent. Although their ratings of the scenarios were generally positive, we used the critical feedback to ensure the relevance and sharpen the content of the scenarios.

Draw Consequences for Future Mobility

In this six-step framework, this step generally consists of developing future estimates of mobility based on empirical past trends and ratings of directional influence (that is, whether a projection would encourage higher or lower use of a mode), as well as the strength of the influence in each scenario on travel. However, the lack of reliable Chinese data on personal travel at a national level made it difficult to conduct this type of exercise, because it cannot be based on past trends. We instead discuss changes in travel demand in a more qualitative manner (e.g., strong increase versus moderate increase). We also wove in more broadly some thoughts about the prevalence of new technologies (such as advanced driver-assistance systems) and new access models (such as car-sharing) based on other drivers in each scenario.

Create a Wild-Card Scenario

The research team also developed one wild-card or low-probability scenario. Wild cards assume that certain events have broken with otherwise-foreseeable trends to move the world in an unanticipated direction. They constitute paths that differ from the projections that underpin the formally developed scenarios. The underlying assumption of this wild card originated from comments made at the four expert workshops, in which we asked the experts what events might confound the projections they had just made, as well as from internal discussions between RAND and ifmo staff.

Although multiple possible ideas for wild cards were put forward, we selected one in which China experiences a fairly severe financial crisis with long-reaching implications. The economic experts were in agreement that some type of crisis is likely but that the course of the economy following such a crisis would depend on the policy actions taken in response.

Why the Scenarios Matter

Because the two scenarios, the Great Reset and Slowing but Growing, were developed from a systematic, empirical process to identify past trends and prospective projections, they represent plausible futures in which transportation policy and planning might be conducted. These future conditions might be more or less likely and more or less desired. Still, the scenarios provide the opportunity for officials at varying levels of government, as well as stakeholders, such as transit operators and private firms in the transportation field, to assess and understand how today's decisions might play out in the future.

At one level, the scenarios can provide a valuable reality check on current strategic options and plans. Because the future is uncertain, we do not know whether one, the other, or neither scenario will actually come to be. But, to determine whether or not they will be well positioned to address associated challenges and risks, organizations can review their strategic plans or policies over the range of futures that the scenarios illustrate. The organizations' focus should be on the robustness of each strategic option (i.e., can it be delivered in a particular scenario?) and on its importance (i.e., how important is it in influencing a particular scenario outcome?).

Related to this, the scenarios facilitate out-of-the-box thinking. Multiple scenarios encourage people to consider a wider range of futures than in typical day-to-day planning, which is often based on a single set or narrow range of projections about future transportation and the factors that affect travel demand (e.g., population growth, per capita driving). They enable officials to consider atypical opportunities and risks and, by doing so, to identify a more robust set of strategic options.

One of the fundamental uses of the scenarios is to help policymakers and other decisionmakers prepare for change. We encourage officials and agencies to identify leading indicators of the changes that the scenario narratives capture and to monitor these over time. A leading indicator is typically thought of as an economic indicator that changes before the economy as a whole changes. This concept can and should be transferred to the transportation context. By monitoring leading indicators of directions in trends related to each scenario, an agency or organization can explore the questions, "Toward which scenario are we moving, and what are the implications for our policies or planning?"

Our analysis revealed three key drivers that could lead to one scenario versus the other: economic growth, constraints on cars and driving, and environmental concerns. Economic growth and environmental concerns depend on various determinants outside transportation. In addition, how our scenarios play out will depend on whether and how well transportation policymakers and other decisionmakers anticipate and address upcoming challenges related to rapid motorization.

Report Organization

We have organized the remainder of this report into seven chapters. Chapter Two provides a short description of past trends in the descriptors in each influencing area. Chapter Three discusses the key drivers that differentiate the two scenarios, as well as common projections both scenarios share. Chapter Four contains the two scenarios. Note that these are written as though we are already in 2030, looking back on developments of roughly the past two decades. For ease of comparing prices, all dollar figures are expressed in constant 2012 dollars so as to avoid making projections about inflation levels. Chapter Five contains the wild-card scenario. Chapter Six discusses the potential implications of the scenarios on different levels of government, industry, and private citizens. Finally, Chapter Seven contains our conclusions.

This report also contains two appendixes. Appendix A describes our methodology in more detail. Appendix B lists the experts who participated in each of the workshops.


Cartier

Chapter Two
Past Trends in Influencing Areas

In this chapter, we summarize past trends in each of the four influencing areas: demographics, economics, energy, and transportation supply and constraints. We drew this information from the papers that served as background materials for each workshop. The information provided in these papers, especially the historical quantitative data, helped inform the range of plausible future projections. We also discuss briefly the rationale for including each of the influencing areas.

The papers summarized in this section were drafted in 2013; we have not updated them with more-recent information because they reflect the knowledge that informed the projections.

Demographic Trends

Demographics refers to the statistical characteristics of a population. Although formal demography is generally limited to basic measures of population size and structure and their change over time, in this case, the research team cast a wider net. In addition to population, we dealt with regional geographic distribution and urbanization because these two trends have changed substantially in China in the past 20 years. In addition, these categories are closely linked to travel demand because of the income inequality that exists between rural and urban populations, as well as between different regions. Given that many of these changes have been driven by rural-to-urban migration as the country industrialized, we also included commute distance and household type. These capture the demographic dimensions of factory work, in which many workers live in dormitories colocated with their places of work and do not make conventional home-to-work commute trips.

Total Population

China's population has increased from 1.14 billion to 1.35 billion in the past two decades. The rate of growth has been slowing; from 1990 to 2000, the average annualized rate was 1.04 percent; in the following decade, the rate fell by about half, to 0.56 percent. Even at this lower rate, the total population currently increases by more than 6 million people every year (National Bureau of Statistics of China, 2012, Table 3-1).

Population change depends on three factors: births, deaths, and net migration (defined as the number of people who enter a country minus the number who depart in a given year). China's crude birth rate has fallen from 21 births per 1,000 people in 1990 to 12 in 2011. Births have fallen because China's total fertility rate has declined from 2.5 births per woman in 1990 to 1.7 in 2011 (World Bank, 2013), which is below the replacement rate of 2.1 births per woman. This decline might be due in part to China's one-child policy, adopted in 1979.[1] However, the population continued to increase because of the number of women in their child-bearing years.

The death rate has been steady during this period; each year, six or seven people per 1,000 die. Life expectancy at birth has also increased, from 69.5 years in 1990 to 75 years in 2011 (World Bank, 2013). Migration is not a major factor in population change in China. Even for the five-year period of the highest out-migration, fewer than 500,000 people left China; most years, the number was closer to 200,000 (World Bank, 2013).

[1] The policy is not universally applied; rural families are allowed to have two children in some cases, ethnic minorities are exempt, and an urban couple made up of two only children can have two children. Enforcement is also not always equally applied. In November 2013, the central government announced further relaxation, but implementation depends on local and provincial governments.

Geographic Distribution and Urbanization

To look at trends in regional population distribution, we used the four economic divisions contained in the 12th five-year plan:[2] eastern, western, central, and northeastern.[3] Since 1990, most of China's population growth has occurred in the eastern region, a trend that has been accelerating in the past decade. From 1990 to 2000, almost half of China's population growth took place in the eastern region and, from 2000 to 2010, more than 80 percent. The eastern region did not grow exclusively at the expense of the other regions. No region lost population between 1990 and 2010, and the overall balance of population between the four regions did not shift significantly during the 20-year period. The eastern region contained 34 percent of total population in 1990 and 38 percent in 2010. Each of the others saw its percentage of the overall population fall by 1 or 2 percentage points (National Bureau of Statistics of China, 2012, Table 3-1).

The percentage of the population living in census-defined urban areas has been steadily increasing. In 2011, the population became more urban than rural for the first time, with 51 percent of the Chinese population living in urban areas. These figures are based on annual national sample surveys of permanent residents, not household registration.[4] The definition of urban is administrative and not based on population density or commuting patterns. Definitions have changed over the years; the most recent change, in 2006, bases the designation of urban on population size and connection to urban infrastructure (Kamal-Chaoui, Leman, and Rufei, 2009). The annual change in urban population has been positive each year for the past two decades, peaking in 1996 at 6.1 percent. In contrast, the rural population began declining that same year and has declined every year since (National Bureau of Statistics of China, 2012, Table 3-1).

[2] The 12th five-year plan covers the period from 2011 to 2015.

[3] The provinces in each region are as follows: The eastern region contains Beijing, Tianjin, Hebei, Shandong, Jiangsu, Shanghai, Zhejiang, Fujian, Guangdong, and Hainan. The western region contains Inner Mongolia, Ningxia, Shaanxi, Chongqing, Guizhou, Guangxi, Sichuan, Yunnan, Gansu, Qinghai, Xinjiang, and Tibet. The central region contains Shanxi, Henan, Anhui, Hubei, Hunan, and Jiangxi. The northeastern region contains Heilongjiang, Jilin, and Liaoning.

[4] The household registration system, called *hukou* in Chinese, entitles a resident to certain social services in the area in which he or she lives. Many people residing in urban areas do so without registration; they are included in these population figures based on actual residence, not registration.

Commute Distance and Household Type

National data on commute distance—the distance between home and work—do not exist. To develop some partial information, we looked instead at travel data for three of China's largest cities, which included both average trip lengths and commute trip lengths. Generally, trip lengths have been increasing. Guangzhou's average trip length (for all modes) rose from 3.2 km (just less than 2 miles) in 1984 to 5 km (3.1 miles) in 2005, and the length of commute trips rose from 3.7 km (2.3 miles) to 6.3 km (3.9 miles) (Jing and Wang, 2004; Luo and Gan, 2010). For Shanghai and Beijing, the data are differentiated by mode. Trip lengths on public transit in Shanghai increased from 6.6 km (4.1 miles) in 1998 to 9.7 km (6.0 miles) in 2009; in 2009, the average car trip was just over 15 km (9.3 miles) (Zhu, 2012; Lu and Gu, 2011). Beijing's rail transit trip length more than doubled from 8 km (just less than 5 miles) in 2000 to 16.4 km (10.2 miles) in 2011 (Beijing Transportation Research Center [BJTRC], 2010; Beijing Municipal Committee of Communications, BJTRC, and World Bank, 2009). The length of a peak-hour average car trip fell from 2010 to 2011, 10.8 km (6.7 miles) to 9.3 km (5.8 miles), but this might be due to issues with data collection (BJTRC, 2010, 2011).[5]

Households are classified as either family (*jiating*) or collective (*jiti*). Family households consist of two or more related people who live in one dwelling; family households can also have only one person. Collective households are those in which multiple unrelated people live in one location, such as a factory dormitory. These designations are based on actual place of residency. According to data from three sources,[6] the proportion of family households is declining, with the most-recent figures showing about 93 to 95 percent of people living in family households, representing a decline from the late 1990s (National Bureau of Statistics of China, 1997–2002, 2004–2012).

Economic Trends

Economics is included as an influencing area because the size and growth of economic activity both help determine the amount of travel and are affected by travel. On an individual basis, income and employment are strongly correlated with travel demand. We expect China's past dynamic economic growth to affect both vehicle ownership and travel demand across all modes of transportation. In this section, we highlight national and regional economic trends, as well as income inequality, labor-force participation, the automobile industry, and investments in transportation infrastructure.

[5] We used average car trip length data from BJTRC's annual report 2010 directly but tweaked that based on the data from the 2011 report (BJTRC, 2011). The 2010 report has only one category (average trip), but the 2011 report has two categories (average trip during morning peak and average trip during evening peak). We calculated the average trip for 2011 by adding the average trip lengths during morning and evening peaks and dividing by 2. The table titles are the same in both reports ("travel time for all modes of travel during peak hours"), so, in theory, the average trip lengths for both 2010 and 2011 should focus on peak hours. However, it is not clear how BJTRC calculated the average trip length for 2010.

[6] The census is conducted once per decade (in 2000 and 2010) (National Bureau of Statistics of China, 2001–2002, 2011). The 1-percent National Population Sample Survey is usually conducted five years after the census (National Bureau of Statistics of China, 2006), and the National Sample Survey on Population Changes is conducted in the remaining years, with a sample size of less than 1 percent (National Bureau of Statistics of China, 1997–2000, 2004–2005, 2007–2010, 2012).

Economic Growth and Regional Economic Shares

We define economic growth as change in GDP. China's GDP has increased by a factor of eight, from just about 1.9 trillion Chinese yuan (CNY) in 1990 to just shy of CNY 16.6 trillion in 2011, in constant 1990 yuan (International Monetary Fund [IMF], 2013).[7] In 2011, this was the equivalent of USD 7.3 trillion in 2011 dollars (IMF, 2012). Annual percentage change in GDP has likewise been very high. With the exception of 1990, the annual percentage increase has not gone below 7.5 percent per year. Since 2001, the annualized GDP per capita growth rate has averaged 10.2 percent, slightly lower than the previous decade's average of 10.3 percent (IMF, 2012, 2013).

Much of this growth has taken place in the eastern region. Although all four regions have seen substantial growth during the study period, more than half of China's overall growth during this period took place in the eastern region, and most of that growth took place in the past decade.

As with population growth, the share of total GDP produced in the eastern region has been fairly steady: 48 percent in 1992 and 51 percent in 2011 (National Bureau of Statistics of China, 1996, 1998, 2002, 2007, 2012).

Income Inequality and Labor-Force Participation

We used a new measure, the Palma ratio, to look at income inequality. The Palma ratio is the ratio of the top 10 percent of a population's share of gross national income to the share of the poorest 40 percent.[8] In theory, a country with perfectly equal income distribution would have a Palma ratio of 0.25 because each decile (10 percent) of the population would have one-tenth of the country's income. The higher the ratio, the greater the inequality. Income inequality has risen in China since 1990. The Palma ratio was 1.25 in 1990 because the top 10 percent of the population earned about 25 percent of the country's total income, while the bottom 40 percent earned only 20 percent. This ratio reached 2.15 in 2008, when the top 10 percent earned 30 percent of total income and the bottom 40 percent earned only 15 percent (World Bank, 2013).

[7] We used IMF figures for 1990 yuan because of problems in recalculating the GDP index supplied in the China Statistical Yearbook (National Bureau of Statistics of China, 2012), which indexed all subsequent years to 1978.

[8] The term was introduced as a more easily understood metric of income inequality than the typically used Gini coefficient; see Cobham and Sumner, 2013. It is based on the observation that the share of income to the middle 50 percent is generally stable, while the other two groups see more change. The Gini coefficient for China shows a similar increase in inequality, rising from about 0.35 in 1990 to about 0.49 in 2009 (Sicular, 2013).

Labor-force participation is defined as the ratio of working adults to all adults, with adult defined as people ages 15–64. In China, this ratio has declined from 85 percent in 1990 to 76 percent in 2011. The number of workers employed in rural areas has decreased (from 477 million in 1990 to 405 million in 2011), while the number of urban ones has increased (from 170 million in 1990 to 359 million in 2011). As of 2011, there were still more rural workers than urban ones, but the lines seem to be converging (analysis of figures from National Bureau of Statistics of China, 2012, Tables 3-3 and 4-2).

Domestic Vehicle Industry and Transportation Infrastructure Investments

Total vehicle production began increasing dramatically in the 2000s; in 1990, China produced 514,000 vehicles (of which only 35,000 were passenger cars). By 2011, China produced about 18.4 million vehicles, divided more evenly between passenger cars (10.1 million) and commercial vehicles (8.3 million). China became the world's largest manufacturer of both passenger cars and commercial vehicles in 2009 (Bureau of Transportation Statistics, 2014). The automobile industry has become increasingly important in terms of output per GDP. In 1990, only 30 vehicles were produced for every CNY 100 million of GDP; by 2011, that figure was about 120.

Finally, we looked at total government spending on transportation infrastructure as a percentage of GDP. We used the category "state-holding" as a proxy for government spending across all levels (central, provincial, and local)[9] and used the figures for spending on railway transport, road transport, urban public transport, and air transport (we excluded water and pipeline transport because water transport would be mostly shipping, not passenger movement). These data show that, as a percentage of total GDP, government infrastructure spending has risen since 2004 (earlier data were not available) from 3.7 to 4.4 percent, peaking in 2009 and 2010 at 5.5 percent. These two years represent counterrecessional spending. The 5.5-percent increase in 2009 reflects both lower-than-average GDP growth and a 50-percent increase in total infrastructure spending (from CNY 265 billion to CNY 703 billion in 1990 yuan) (National Bureau of Statistics of China, 2005–2012, Table 5-14).

[9] The state-holding category includes both administrative units and various state-holding enterprises. The two other categories are "collective-holding" and "private-holding." Without further breakdowns of investment sources available, we determined that *state-holding* comes the closest to representing government investment. Our results are also in line with other work on Chinese infrastructure spending, such as Chen, Matzinger, and Woetzel, 2013.

Energy Trends

Energy is an important influencing area because the cost of gasoline and the availability and cost of alternatives affect both the number of miles and the types of vehicles people drive. This section includes background on oil price and oil consumption, the possibility of legislation or regulations to address climate change that would discourage use of certain types of transportation, and the adoption of two types of alternative vehicles: EVs and E-2Ws (both electric bicycles and scooters).

Oil Price and Consumption

The price of oil is determined on the world market.[10] Although oil prices can be measured in various ways, we used the price of one barrel of Brent crude oil, which is a major benchmark price on the world market. Oil prices were fairly steady in the 1990s, generally fluctuating between USD 20 and USD 35 per barrel, but climbed steeply in the 2000s. By 2012, after a sharp dip caused by the 2008 recession, oil prices had risen to USD 104 per barrel (World Bank, 2013).

Oil consumption has been rising rapidly in China during the past two decades, nearly tripling since 1995. In Chinese statistics, oil is typically measured in standard coal equivalent, which we converted to tons of crude oil.[11] In 1995, China consumed 163 million metric tons of crude oil, which rose to 647 million tons in 2011 (National Bureau of Statistics of China, 2012, Table 7-2). This is the equivalent of roughly 13 million barrels per day, using a conversion factor of 7.32 barrels per ton.[12] (Statistics were not consistently available for years before 1995.)

As consumption has risen, so has the percentage of oil that is imported. In 1995, China imported about 21 percent of its crude oil. By 2011, more than half of its oil was imported—56 percent. This amounted to 362 million metric tons per year, or about 7.3 million barrels per day (National Bureau of Statistics of China, 2012, undated).[13]

[10] The study focused on eliciting projections related to crude oil. Although the terms *oil* and *petroleum* are sometimes used interchangeably, we use the definition of *crude oil* that is provided by the U.S. Energy Information Administration (EIA): a mixture of hydrocarbons that exists as a liquid in natural underground reservoirs and remains liquid when brought to the surface. *Petroleum* is the broader category that includes both crude oil and refined petroleum products (such as gasoline). We use the word *oil* to mean *crude oil*.

[11] We used different sources for this section, some in short tons and some in metric tons (sometimes written as tonnes). We have kept the original terms. One metric ton = 1.102 short tonnes, so the terms are not interchangeable.

[12] The conversion factor for tons to barrels varies with the type of petroleum project. We used 7.32 barrels per ton based on EIA country conversion factors (EIA, undated).

[13] We calculated this percentage based on the ratio of imports to consumption. However, not all oil imported is consumed in country. One observer notes that imported oil might be entering a stockpile or exported as refined petroleum products (Russell, 2013).

Introduction of Effective Greenhouse-Gas Emission–Reduction Systems

The Chinese government has taken several actions in recent years to reduce greenhouse-gas (GHG) emissions and accelerate the transition to a low-carbon economy. In 2011, the State Council issued a work plan for GHG emission control (Central People's Government of the People's Republic of China, 2012a). The work plan, which is essentially a national guidance document, targets a 17-percent reduction of carbon dioxide emissions per unit of GDP by 2015 from the 2010 level and calls for comprehensive use of various control measures, including establishing a GHG emission accounting system, opening carbon emission–trading markets, and promoting extensive international cooperation (Central People's Government of the People's Republic of China, 2012a). Since the work plan was issued, progress has been made in three areas:

- First, the National Development and Reform Commission (NDRC) issued GHG emission accounting methods and reporting guidelines focusing on an initial group of ten industries (NDRC, 2013). The goal is to establish a national, local, and corporate accounting and reporting system, as well as to lay the groundwork for carbon emission–trading markets.

- Second, in 2011, the NDRC (2011) approved several pilot markets, five of which launched in 2013. In the five months after the Shenzhen market opened in 2013, the total trading volume exceeded 130,000 tons, and the price stabilized at around CNY 80 per ton (USD 31.21) (Southern Daily, 2013). The pilot markets determined their own total carbon dioxide emission targets for the 2013–2015 period, based on the emission-reduction requirements and local economic development (NDRC, 2011; Beijing Municipal Commission of Development and Reform, 2013).

- Third, a carbon tax has been proposed but not yet adopted. Because of concerns that a carbon tax might push commodity prices even higher, a relatively high inflation rate has been considered one of the biggest constraints to introducing a carbon tax. However, in 2010, the NDRC and Ministry of Finance issued a report on the Chinese carbon-tax system framework design, which proposed collecting a carbon tax beginning in 2012. One of the report's authors noted that not only would introducing a carbon tax not cause inflation; in contrast, it might produce a decline in the overall price of commodities (Daily Economic News, 2010). A Ministry of Finance official suggested in a 2013 interview that the carbon tax would focus mainly on coal, crude oil, and natural gas; that it would be introduced during 2016–2017 (China Carbon Emission Trade, 2013); and that the initial tax rate would be set to CNY 10 (USD 1.61) per ton of carbon dioxide and then gradually increased over time (Liu, 2013).

Adoption of Alternatively Fueled Vehicles

China has adopted aggressive targets for producing electric and hybrid vehicles, but it seems unlikely that they will be met on schedule. The 12th five-year plan calls for ownership of 5 million battery EVs (BEVs) and plug-in hybrid EVs (PHEVs) by 2020. However, in the third quarter of 2009, only 970 BEVs and PHEVs were registered nationwide,[14] which amounts to less than 0.02 percent of newly registered vehicles during this period (Krieger et al., 2012). Reporting suggests that the pace has not increased significantly since then. Automobile manufacturers produced 6,000 BEVs and PHEVs in 2011 and 12,500 in 2012 (China Automotive Technology and Research Center, Nissan [China] Investment Company, and Dongfeng Automobile Company, 2013). From 2011 to the first half of 2013, 24,000 new-energy vehicles (NEVs, which are defined as BEVs, PHEVs, and fuel-cell cars) were sold (Wang Tingting, 2013).

Purchase prices for such vehicles remain high even with subsidies. The central government provides CNY 60,000 (about USD 9,900) and CNY 50,000 (USD 8,260) subsidies for BEVs and PHEVs. Some local governments also provide subsidies (International Energy Agency, 2012). However, even with subsidies, the cost of EVs can still be more than double the cost of a comparable gasoline vehicle. For example, the price of a BYD E6 (a Chinese EV larger than a sedan but smaller than a sport-utility vehicle) is about CNY 230,000 (USD 37,140) after the maximum CNY 120,000 (USD 19,380) subsidy, while the price of the comparable conventional BYD F6 is just CNY 90,000 (USD 14,850) (Krieger et al., 2012).

The installation of charging infrastructure has also been slow. Although the Ministry of Science and Technology proposed constructing more than 400,000 charging piles by 2015,[15] the State Grid and the Southern Power Grid constructed only 16,000 total charging piles in 2011 (Krieger et al., 2012).

E-2W production has grown very rapidly in the past 15 years, from basically none in 1998 to almost 30 million in 2012 (Cherry, 2013). As of 2012, China had about 150 million E-2Ws in use (Sen, 2012). Another source notes that "[o]ne in five Chinese bicycles has a battery, and that ratio is likely to be higher in urban areas" (Grabar, 2013).

The E-2W category includes two broad types of vehicles: battery-powered bicycles (also called e-bikes) and electric "scooters" (also called e-scooters). E-bikes utilize both human power from pedaling and a small electric motor, while e-scooters operate entirely on electricity and tend to be larger. However, there is no hard and fast distinction between the two types of vehicles. The underlying technology is similar, and the design of the vehicles spans a continuum, making it difficult to categorize them definitively. E-bikes are less common than e-scooters; according to one survey, in 2010, only 16 percent of E-2Ws in the market were e-bikes; 26 percent were e-scooters; and 58 percent were "something in between" (Ruan et al., 2012).

[14] From the original report (Krieger et al., 2012), it is unclear whether this means 970 new registrations in that quarter or the cumulative total registered vehicles.

[15] *Charging pile* is the direct translation of the Chinese term; one pile is the same as one station in U.S. terminology—that is, an outlet for one vehicle.

Transportation Supply and Constraint Trends

This influencing area focuses on the supply of transportation, as well as constraints on vehicle ownership and driving, particularly government-enacted constraints. We focused on three broad areas: constraints on vehicle ownership and driving; nonautomobile modes of transportation; and issues specific to urban areas, including parking, availability of taxis and ride-sharing, and nonmotorized infrastructure. We could not identify national trend data for any of these areas. For the more city-specific descriptors, our background information considered conditions in four cities of different sizes: Beijing (18.8 million people), Chengdu (7.4 million), Taiyuan (4.2 million), and Jiyuan (670,000).[16] Given the lack of existing data, our background information was qualitative and, in some cases, anecdotal, rather than quantitative.

Constraints on Driving and Vehicle Ownership

The main constraints on driving are financial: Gas is relatively expensive compared with average incomes (Randall, 2013), and most intercity roads are tolled (Reja, Amos, and Hongye, 2013). Several large cities have considered road pricing, but none has yet implemented it ("Shanghai Studies Traffic Congestion Charge to Control Pollution," 2013; Bai, 2013). Beijing and Guangzhou have both experimented with regulatory restrictions, specifically odd–even restrictions (that is, only vehicles with odd-numbered license plates can drive in certain areas on certain days), but none of these applies to all areas of the city. Several restrictions have been used sporadically, such as during times of serious air pollution, during winter months, or around special events, such as party congresses, the 2008 Olympics, or major international conferences ("Beijing to Impose Odd–Even Car Ban During Heavy Pollution," 2013; Qiu, 2010; Xue and Xu, 2013).

Similarly, constraints on vehicle ownership are mostly financial. Car ownership carries insurance requirements (Ping An Insurance [Group] Company of China, undated) and various taxes: a consumption tax based on engine displacement, a value-added tax, and a purchase tax, with an additional levy of 25 percent on imported cars ("China Signals Clampdown on Foreign Car Makers," 2013). At least four large cities control vehicle ownership through limiting the number of license plates available, either through lottery or auction. Those cities with auctions (including Shanghai and Guangzhou) charge an additional fee as well (Yu, 2013; "Shanghai Car Plate Auction Hits New High," 2012; "Shanghai Puts Cap on License Plates," 2013; "Guangzhou to Allocate New Car Plates Through Auction," 2012).

Public Transit, Interurban Rail, and Domestic Air

Many Chinese cities provide both bus and rail transit. Whereas, a decade ago, only major cities had urban rail systems, several dozen urban areas now either have such systems in place or are in the process of planning and building them. By 2012, 270 km (167.8 miles) were being added annually ("China to Restore Confidence in High-Speed Trains," 2012). Fares are generally considered affordable. Bus rapid transit (BRT) has been built in more than a dozen cities (Zeng, 2013).

[16] These correspond to the four tiers of cities, a widely used categorization that has no official definition. The tier of a city depends broadly on size, with first-tier city population exceeding 10 million and fourth tier generally less than 1 million.

The main focus in interurban rail in the past decade has been high-speed rail (HSR). The country had no HSR in 2007; by 2013, it had more than 10,000 km (6,213.7 miles) ("High-Speed Railways," 2013). The HSR network currently reaches more than 100 cities and carries more than 2 million people daily, or roughly one-third of China's total rail traffic ("High-Speed Railways," 2013). HSR already transports nearly twice as many passengers as the country's domestic airline industry does (Bradsher, 2013).

Domestic air travel has risen steadily in the past decade, from 87 million trips in 2003 to 354 million in 2012. In all but two years, annual growth has exceeded 5 percent. Beijing, Shanghai, and Guangzhou have by far the busiest airports in China, measured in both passenger traffic and flights (together, they account for almost one-third of all passengers in China), but growth is highest in western Chinese airports (Civil Aviation Administration of China, 2013; CAPA Centre for Aviation, 2013).

Parking, Taxis and Car-Sharing, and Nonmotorized Infrastructure

In all but the smaller cities, parking is a major problem. Most cities have far more vehicles registered than legal parking spaces, and, anecdotally, attempts to build more parking are not keeping up with demand. One result is high levels of illegal parking, part of which is likely caused by low fines. In Beijing, for example, although the police issue more than 5,000 illegal parking tickets per day, the fine is only CNY 200 (about USD 32) and no points are deducted from the driver's license (Beijing Evening News, 2013; Beijing Bureau of Transportation Management, undated). A second result is high costs for legal spaces; in Taiyuan, a parking space in some residential areas can cost as much as CNY 100,000 (USD 16,150), which is about the cost of a car (Taiyuan Daily, 2014).

Taxis are already in widespread use, although many taxis operate illegally (in Beijing, for example, illegal taxis outnumber the 66,000 official taxis ["Beijing Taxi Troubles Tackled in CASS Report," 2012; Xinhua News, 2014]). Mobile apps to summon taxis are spreading quickly (Custer, 2013; Millward, 2013). Car-sharing began in China only in the past few years, but there are already various types of systems in place, including peer-to-peer car-sharing (Prabu, 2013) and car-sharing with an all-EV fleet (Rogowsky, 2013; China Jiangsu Online, 2013).

More information was available about bicycling infrastructure than for walking. All four cities have introduced bicycle-sharing systems (*China Daily*, 2013; *China Daily*, 2010; Central People's Government of the People's Republic of China, 2012b; Henan Provincial Department of Transportation, 2013), and Beijing has developed new regulations and guidelines to encourage bicycling (for example, by banning parking in bicycle lanes and incorporating bicycles into transportation planning) (*China Daily*, 2013). The cities are also expanding greenway systems that allow both bicycling and walking (Chengdu Business News, 2010; Taiyuan News, 2013).

Chapter Three
Key Drivers and Common Projections

The two scenarios outline different possible paths to explain how mobility might develop in China through 2030. In this chapter, we highlight two important items that helped shape the scenarios: key drivers and common projections. Key drivers are those developments that cause major shifts in how the future unfolds and ultimately distinguish between the two scenarios. Other projections differ between the two scenarios, but the differences are not as large or as important. Common projections are projections that are present in both scenarios, either because the experts agreed on one projection or because both of the two selected clusters contained the same projection.

Table 3.1 summarizes all descriptors and projections for both scenarios. The shaded rows indicate those projections that differ between the two scenarios.

Table 3.1. Comparison of Projections in the Two Scenarios

DESCRIPTOR	THE GREAT RESET	SLOWING BUT GROWING
Demography		
Total population	1.44 billion (annual growth of 0.34%)	1.39 billion (annual growth of 0.18%)
Geographic distribution of population	41% of the population lives in the eastern region.	41% of the population lives in the eastern region.
Urbanization	70% of the population lives in urban areas.	70% of the population lives in urban areas.
Average commute distance	Has increased slightly	Has increased significantly
Household type	The percentage of the population living in family households has decreased slightly.	The percentage of the population living in family households has increased slightly.
Economy		
Economic growth	6–7% average annual growth	4–5% average annual growth
Share of the economy in the eastern region	50% in 2030	43% in 2030 (similar to current)
Income distribution	Income inequality continued to increase (followed by a decline after 2025).	Income inequality continued to increase (through 2030).
Labor-force participation	80% of the adult population	76% of the adult population
Domestic vehicle production	120 total vehicles per CNY 100 million in GDP (same as current)	120 total vehicles per CNY 100 million in GDP (same as current)
Percentage of GDP spent on transportation infrastructure	4% (same as current)	2%
Energy		
Oil price	USD 150 per barrel (Brent crude, in 2014 U.S. dollars)	USD 100 per barrel (Brent crude, in 2014 U.S. dollars)
Oil consumption	60% of oil consumed is imported	70% of oil consumed is imported
Introduction of effective GHG emission-reduction systems	National carbon market in place by 2020	National carbon market in place by 2020
Adoption of electric and hybrid passenger cars	30% of the total fleet is electric and hybrid passenger vehicles in 2030	20% of the total fleet is electric and hybrid passenger vehicles in 2030
Adoption of E-2Ws	10% annual increase until 2030	2% annual increase until 2030

Table 3.1. Comparison of Projections in the Two Scenarios — Continued

DESCRIPTOR	THE GREAT RESET	SLOWING BUT GROWING
Transportation supply and constraints		
Constraints on driving	Have been introduced also in second- and third-tier cities	Have barely changed; no further constraints
Constraints on vehicle ownership	Have been introduced also in second- and third-tier cities	Have barely changed; no further constraints
Convenience of public transit [a]	Has increased significantly; customized transit systems for different tiers of cities	Has increased strongly, but mainly for tier 1 cities
Convenience of interurban rail	Strong growth	Moderate growth
Demand for domestic air travel	Strong growth	Moderate growth
Parking management in urban areas	Parking has remained a major issue	The parking situation has slightly improved
Convenience of taxis and car-sharing	Black taxis [b] have been legalized, and car-sharing systems have been introduced slowly	Black taxis have been legalized, and car-sharing systems have been introduced slowly
Infrastructure for non-motorized transportation (i.e., walking and bicycling)	Has increased significantly	Has increased only slightly

[a] By *convenience*, we mean a qualitative assessment of a variety of factors that, when taken together, increase the ease and desirability of using transit. These include more bus stops and rail stations, more-frequent service, higher speeds, better provision of information (e.g., being able to know in real time when the next vehicle is arriving), affordable fares, and the quality of the vehicles. We used *convenience* instead of *demand* because we were interested in the factors that might encourage people to ride transit, not demand itself.

[b] Black taxis are taxis that operate illegally.

Key Drivers

Although similarities between the two scenarios exist, the key drivers that cause one path to emerge over another are the important elements for anticipating and preparing for change. We identify key drivers partly through the information in Figure A.2 in Appendix A, which shows how active or passive each descriptor is. An active descriptor influences many other descriptors, while many descriptors influence a passive descriptor. Active descriptors are therefore more important in influencing the entire system. Additionally, in the process of writing the scenario narratives based on linking the descriptors and the reasons for the projections, we identified an additional driver with high uncertainty—environmental conditions—that played a dominant role in distinguishing the scenarios from each other. The future development of these three selected key drivers will strongly affect other descriptors in the scenarios. Table 3.2 summarizes the three key drivers.

Table 3.2. Key Drivers with High Uncertainty in Future Development

	SCENARIO	
Key Driver	**The Great Reset**	**Slowing but Growing**
Economic growth	High	Moderate
Constraints on driving and vehicle ownership	Widespread in cities	Only in tier 1 cities
Environmental conditions	Improve	Worsen

For China, the three most-active descriptors are urbanization, economic growth, and the introduction of GHG emission-reduction systems. However, for urbanization and GHG emission-reduction systems, our experts were in strong agreement about a single future projection: an urbanization rate of about 70 percent and adoption of GHG regulations by 2020. These constitute common projections, and we discuss them in the following section.

Economic Growth

Economic growth, the second most highly active descriptor in the system, received very different projections. Because of its influence on motorization and both intra- and intercity travel demand, we consider this a key driver of future mobility in China.

The experts agreed that China's historically high GDP growth rates would decrease by 2030; most observers agree that no country can sustain double-digit growth rates indefinitely. However, that rate might slow slightly or significantly. Indeed, in the past few years, China's GDP growth has declined to between 7 and 9 percent. The question for these scenarios is whether growth stabilizes at a higher rate or a lower one (still high by international standards, but well below past rates).

Economic growth depends on many factors, only some of which are under direct government control. Higher growth could occur as a result of a successful shift to consumption-driven growth, a reduction in corruption, reform of the *hukou* system, or policies to allow more competition among companies (as opposed to propping up state-owned enterprises). On the other hand, lower growth might result from turmoil in the financial markets as a result of extremely high levels of debt, continuing trends of low labor productivity, or a lack of a safety net for both retirement and health care that discourages consumption. Political unrest (especially if unemployment increases) or demands for higher environmental quality (which was, to some extent, sacrificed in the interest of increasing GDP) could hinder the government's ability to encourage and steer growth.

Constraints on Driving and on Vehicle Ownership

A second key driver is constraints on driving and on vehicle ownership. Although these were separate descriptors in the analysis, we combine them here because they both represent attempts to use regulations or channel market forces to dampen the amount of personal car ownership and the use of cars. Both were rated fairly active. Chinese cities have been far more assertive in developing such restrictions than cities in other developed countries have (with the exception of Singapore, whose vehicle ownership constraints, adopted several decades ago, were used as a model by Chinese cities), and these might well have a substantial effect on motorization and driving that would lead to very different mobility outcomes.

These constraints already exist to a limited extent in several of the largest cities, and the question is whether the enormous problems with congestion, air pollution, and lack of parking that led to the adoption of such policies in first-tier cities might spread to second- and third-tier cities. These cities might look to their larger neighbors and develop similar policies if they are shown to be effective.

There are two sources of uncertainty with regard to this driver. The first is whether the policies succeed where they are already implemented. They might be less effective if people find ways around them, if they are not strictly enforced, or if they are watered down over time. (For example, Beijing has a black market in license plates, which can be legally obtained only through a lottery that began in 2011 [Song, 2014]). The second is whether cities will have the political will to implement them. In an atmosphere of general political discontent, such a policy might become a flashpoint for protests. Although the need for such policies might become more pronounced with higher economic growth, such growth might also mean that residents feel as though their desires for increased mobility and status are being thwarted.

Environmental Conditions

The third driver is environmental conditions, which we did not include in our initial set of descriptors but rather identified in the process of writing the scenario narratives. Participants at several of the workshops discussed the impact of environmental conditions intensively as a reason for certain projections, especially in the demographic and economic areas. We think that environmental conditions in China might play a key role in influencing some of the descriptors. For example, prolonged drought might influence internal migration, which could affect the percentage of population living in the eastern region. Extremely low air quality could discourage business owners from locating factories and offices in certain cities, which could affect the proportion of the economy generated in the eastern region.

Second, although the extent of environmental degradation has become more apparent over time, the trajectory of these conditions is uncertain. For example, rainfall patterns could affect whether droughts become more severe; climate change, whose influence is highly uncertain, might, in turn, affect rainfall. Third, both political and economic considerations might affect environmental conditions through regulations, public pressure, and spending on measures to clean up polluted land, air, and water.

Common Projections

Although the overall focus of scenario planning is identifying alternative future developments, different scenarios often share some common projections. This can happen because the expert panel provides only one (relatively certain) projection for a specific descriptor or because the cluster analysis that underpins the scenario-building process determined that one projection would fit both scenarios. This section presents those projections that are common to both scenarios. Because their probabilities can be regarded as rather high, the value of these factors is significant.

We present the factors in this section from the standpoint of 2030.

Geographic Distribution of Population

The proportion of the Chinese population living in the eastern region has grown to just over 40 percent. This continues the previous trend, in which population has grown more quickly in the regions containing the cities with the greatest economic opportunities. The infrastructure is good, incomes are higher than in other parts of the country, and exports remain important, so it has been difficult to shift manufacturing activity westward, given that the ports are so well-developed in the east.

Urbanization

China continued urbanizing rapidly, from a base of about half the population living in urban areas in the early 2010s to about 70 percent doing so by 2030. The pace of growth in the urban population slowed from its previous rate of 4 percent annually, but the numbers kept rising as people continued to flock to urban areas for better job opportunities. The government encouraged this trend as it sought to steer the economy toward more consumption-based growth, which tends to require more urban consumers. China is now about where most developed countries stand with regard to urbanization; geographically large countries tend to top out at about 70 to 80 percent urbanized (United Nations, 2014).

The urbanization patterns differ slightly between the two scenarios. In the Great Reset, previous growth patterns have continued to swell the tier 1 and 2 cities even further, especially as reform of the *hukou* system gave migrants in those areas better access to schools, housing, and medical care. In Slowing but Growing, a higher proportion of urban growth has taken place in medium and smaller cities because the difference in wages between the larger and smaller cities is less pronounced and migrants are more likely to go to cities closer to their current residences.

Income Distribution

Income inequality, already high by world standards in the early 2010s, continued to increase. Rural populations were left behind in terms of economic growth, and unskilled labor had relatively little bargaining power given that people kept flocking to cities to work in factories. Although there have been attempts to reform a system that resulted in a small number of people being extraordinarily wealthy, the government has continued to rely on their support and the rich have continued to get richer. However, in the Great Reset, as a tighter labor market and better wage gains helped shift some bargaining power to employees, in addition to more public transparency, inequality peaked in 2025 and has declined modestly since, although still at levels higher than in the 2010s. In Slowing but Growing, the increase continues.

Domestic Vehicle Production

The domestic vehicle industry has grown in the past decade, but fairly consistently with overall economic growth. The industry has long been the world's largest, hardly surprising because China also remains the world's largest purchaser of vehicles. However, the industry has never sprinted past overall economic growth, in large part because a relatively small percentage of vehicles are exported. Therefore, domestic purchasing power limits the industry to some extent.

Greenhouse-Gas Emission Controls

By 2020, the central government had implemented fairly far-reaching policies designed to reduce GHG emissions. These began with pilot programs in the early 2010s and will be enshrined in the 13th five-year plan. The main mechanism is a carbon-trading market, which the government has backed up with subsidies to clean-energy technologies and requirements for each ministry. In terms of enforcement, provincial and local officials will be evaluated on their ability to meet emission-reduction targets (the same way they have long been evaluated on meeting economic growth targets). The push came from public demands for environmental cleanup, a realization that degraded environmental conditions were affecting quality of life and thus the party's legitimacy, a change in the attitudes of the business community, and a desire to be viewed as a leader in the international community.

Automobility Without Ownership

Over time, shared modes began to operate more effectively. Many Chinese cities had long harbored illegal taxis, but local governments began to bring them into the fold of regulated taxis through a combination of incentives and stiffer penalties. The actual number of taxis has remained roughly constant. In addition, car-sharing was introduced in quite a few cities and grew steadily in popularity. Although the intrinsic status of car ownership remained, car-sharing also gives people who cannot afford to own a car the ability to rent a luxury vehicle should the occasion require it.


上车站台
PLATFORM FOR GETTING ON THE BUS
下车站台
7-2274

Chapter Four
The Scenarios

In this chapter, we present the scenarios, the Great Reset and Slowing but Growing. However, many of the seeds of future developments were already shown by 2014, when we drafted the scenarios, so both scenarios, as well as the wild-card scenario, begin from the origins described in this chapter. As is customary in scenario writing, our vantage point is 2030, and we are looking backward to trace our steps over the past 15 years.[1] For ease of comparing prices, all dollar figures are expressed in constant 2012 U.S. dollars so as to avoid making projections about inflation levels.

[1] Where references are provided, they refer to past events or predictions by others. The remainder of the narrative is based largely on speculation at the workshops about how events might unfold over time.

Background to All Scenarios

China has experienced extremely rapid and sustained economic development over the past several decades. Beginning with the Reform and Opening Up Policy in 1978,[2] and the establishment of several Special Economic Zones in coastal cities in the early 1980s,[3] the country's overall wealth and per capita GDP grew by double digits over several decades. Much of this growth began with reforms in agriculture, which included a shift from collective land ownership to a household-based system and removal of price controls (Organisation for Economic Co-operation and Development, 2010). This freed up rural laborers to migrate from their hometowns to coastal cities with huge demands for factory labor. The pace of urbanization was enormous. China went from 300 million people in urban areas in 1990 to almost 700 million in 2011, or from about one-quarter of its residents living in cities to about half. Living standards for many have greatly increased.

Yet, by 2014, some cracks had appeared in China's economic machine. Although problems had been simmering, the response to the global financial crisis in 2008 marked a defining moment. To avoid an economic downturn caused by slowing demand for exports, China adopted a roughly USD 585 billion stimulus package (Tsuruoka, 2014), which was largely fueled by borrowing.

Although the overall level of debt was not dangerously high by the standards of developed countries, three problems became apparent. First, the debt-to-GDP ratio grew very quickly over the ensuing five-year period, from 125 percent of GDP in 2008 to 200 percent in 2013 (Casey, 2013). Municipal and corporate debt levels increased rapidly (household debt was a far smaller issue). Such rapid growth in debt is seldom sustainable.

Second, most of the growth took place in the shadow-banking system, a set of financial entities that are not regulated the same way as the banks. Shadow banking was attractive to different groups for different reasons. Many affluent households kept money in shadow banks for lack of other types of liquid investments. The stock market was risky, and regular banks offered very low interest rates. Small- and medium-sized businesses borrowed money from shadow banks because they had a difficult time getting capital from the state-run banks. Even cities turned to off-the-books entities to borrow money and lease land because they did not have adequate revenues of their own.

Third, both the central government and many cities used stimulus funds to build large amounts of infrastructure. Although spending on roads, rail, and other important infrastructure is generally a good investment, some argued that infrastructure was overbuilt, and much of it has been awaiting the increases in demand that would justify them.

[2] Reform and Opening Up (*gaige kaifang*) refers to a suite of policies adopted in 1978 that sought to modernize the economy, open China to other countries economically, and gradually liberalize Chinese society.

[3] Special Economic Zones are areas designated for special financial investment and trade policy, such as allowing direct foreign investment.

In China's case, the flip side of state overinvestment was private-sector underinvestment, meaning that private businesses could not access capital to grow, and underconsumption, meaning that most people saved their earnings rather than spending them. So, by the early 2010s, roughly half of the economy was driven by government-controlled spending,[4] not private businesses or households (Szamosszegi and Kyle, 2011).

Another major set of problems was in the housing sector. First, local governments, lacking stable sources of revenue, had turned to long-term leases of developable land. They were in a shaky position if demand for housing stagnated or fell, and, as noted above, many local governments were heavily in debt. Second, in the largest first-tier cities, housing prices had inflated by the early 2010s to levels far beyond anything affordable to an average household. In Shenzhen, for example, the ratio of the average house price to average income was almost 18 to 1 (Yi and Tan, 2013), with any ratio over 5 to 1 considered unaffordable. Although the falling prices in 2014 (Shao and Yao, 2014) might have helped resolve the affordability issue, they also meant that property developers were losing money and at risk of defaulting on their loans.

Third, despite the affordability problems, more than 20 percent of homes in urban areas were vacant (Fung, 2014). In the first-tier cities, wealthy households purchased many of the vacant units as investments, with no intention of living in them or renting them out. Housing was a desirable investment because of low interest rates on bank savings, as well as volatility in the stock market. In second- and third-tier cities, housing production was driven largely by local governments, which encouraged housing production as a source of city revenue despite lack of demand. This resulted in "ghost cities" of vacant housing, vacant shopping malls, and vacant office towers.

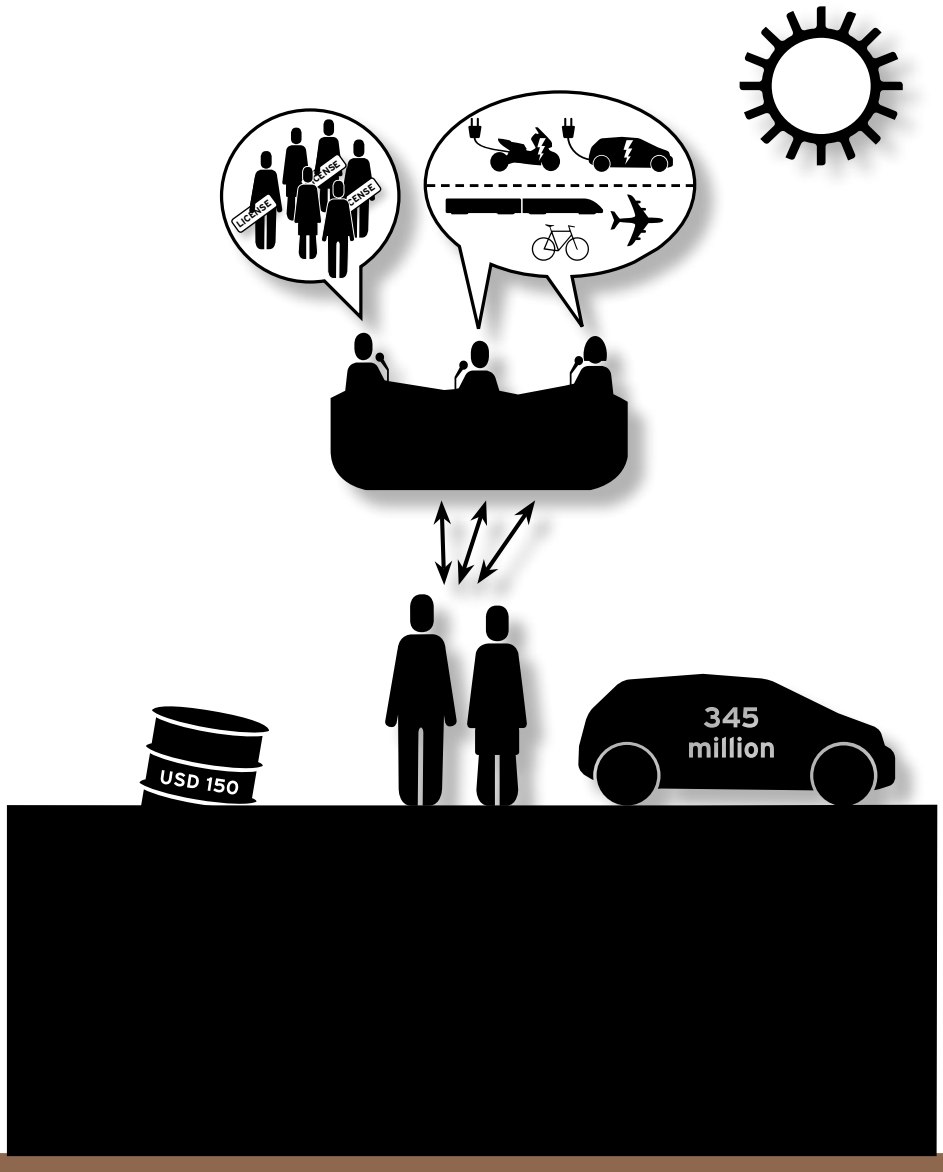
In addition to these economic difficulties, long-term environmental problems had surfaced. Air and water pollution had reached dangerous levels. Air pollution contributed to 1.2 million premature deaths in 2010 (Goodell, 2014). Sixty percent of groundwater was too polluted to drink (Chang, 2014). Water reserves in the northeast were declining rapidly; the water table under the North China Plain (which includes Beijing) has dropped 1,000 ft. (about 300 m) since the 1970s ("All Dried Up," 2013), and the region might run out of groundwater within the next ten years, by 2040 (Yardley, 2007). Soil contamination remained a serious problem as well; a report released in spring 2014 found that nearly 20 percent of all farmland was contaminated (Wong, 2014).

[4] Government-controlled spending includes that by state-owned enterprises and entities that the state indirectly controls (Szamosszegi and Kyle, 2011, p. 1).

Scenario 1: The Great Reset

Overview

In 2030, China has moved closer to the ranks of developed countries. It successfully weathered what might have been a fairly severe economic crisis through policies that introduced some measure of market-based reform and reduced reliance on personal connections in the economy. Although economic growth has slowed, it did so gradually and without major disruptions. Vehicle ownership continued to grow strongly, even as more and more cities adopted constraints on driving to try to address growing problems of parking and congestion. Long-distance travel increased as well. China maintained its position as the world's largest vehicle producer and even increased its export share, largely because of the popularity of NEVs. Urbanization continued, plateauing at rates similar to those of more-advanced economies. Finally, increased government revenues made it possible to address some of the serious environmental problems with air and water quality.



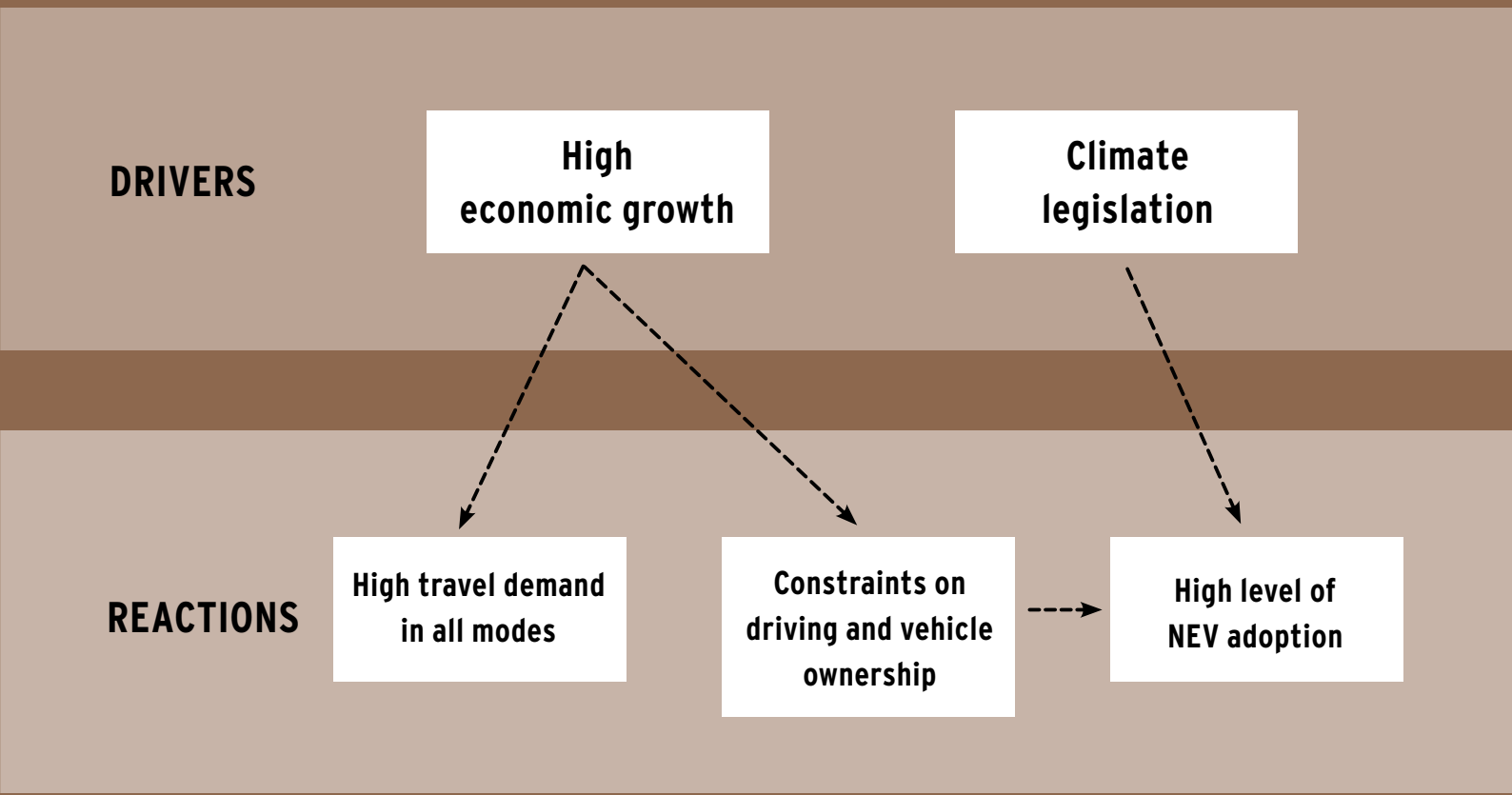


Figure 4.1. The Great Reset Scenario: Key Drivers and Reactions

Reforms Shift Growth from Government to Businesses and Households

Several early reforms set the stage for this controlled slowdown in economic growth. One was liberalizing the deposit interest rate, which injected more market-based competition into state banking and led to more-efficient allocation of capital. Smaller firms could get loans that previously flowed largely to state-owned enterprises. This reform also generated higher returns on household savings, meaning that middle-class and wealthy people were willing to keep their savings in regulated banks as opposed to shadow banks. A related reform was to allow Chinese residents to invest in international stock markets, thus giving people other venues for investment.

As part of this liberalization, the central government declined to step in when several state-owned enterprises were about to default on bonds. Observers took this as a signal that the central government was not going to continue to prop up failing companies and instead would allow banks to make more market-based decisions about lending. New banks were allowed to open as well. In addition, the amount of government spending on infrastructure began to decline as an intended result of deliberately pulling back on expensive but unproductive projects.

The Chinese Communist Party also took measures that boosted confidence in the economy and political system. As a result of liberalizing the banking system, the old corrupt practices of lending based on personal connections declined. This "cleaner" system also provided for more-aggressive protection of intellectual property rights—the laws had been on books, but now they were enforced far more vigorously—and this allowed both start-up businesses and foreign firms to function more normally, as opposed to fearing the theft of their best ideas with limited legal recourse.

Cities were allowed to implement property taxes on their own, without central government interference or permission. Although the taxes were not initially popular with residents, they provided a more stable basis of local funding and relieved cities of the financial need to continue urbanizing at sometimes-unsustainable rates. A few cities even experimented with variable-rate property taxes, taxing vacant land at higher rates to encourage compact development.

China now spends about 4 percent of its GDP on transportation projects (the same as in 2013). The investments made in the 2010s had been largely sufficient to meet the demands of urbanization at that time, and the rate fell for a few years. Now, new investments are needed to build out more key connections, refurbish those links in the system that were straining under heavy use (generally in HSR and airports), and anticipate future demand. (The creation in 2014 of both the New Development Bank by China, India, Russia, Brazil, and South Africa and the Asian Infrastructure Investment Bank [in which China has more than half the shares] as a counterweight to the World Bank and IMF provided opportunities for Chinese firms to undertake infrastructure investment abroad but did not significantly expand the amount of infrastructure spending in China ["Why China Is Creating a New 'World Bank' for Asia," 2014; Eichengreen, 2014].)

By 2020, a comprehensive retirement system was put into place, partly as an acknowledgment that the population was aging rapidly and partly to help lower saving rates, which had remained high by international standards. Reform of the health care system began around this time as well, providing more-reliable access to doctors and hospitals at affordable rates.

The retirement system and health care reforms helped boost consumer spending because people were no longer saving to extremes to avoid poverty in old age. This brought the ratio of investment and consumer spending into a better balance. The increase in consumer spending also contributed to an increase in GDP, which saw earlier increases of roughly 7 percent annually slow to 6 percent after about 2020.

Environmental Improvements Help Reinforce the Government's Legitimacy

An important component of reform was taking China's increasingly dire environmental problems seriously, instead of trying to cover them up. By the early 2010s, the central government was already seeing worsening environmental conditions as a threat to party legitimacy that deserved serious attention, rather than a problem that could be hidden by economic growth. This realization, along with some early successes on the anti-corruption front, compelled the central government to take stringent steps to curb the worst offenders.

One place to make some immediate gains was in better enforcement of existing regulations. In the late 2010s, a scandal erupted when several massive algae blooms in one of China's most-important lakes rendered water undrinkable for weeks. Bowing to public pressure, the central government announced immediate actions to more rigorously enforce water discharge. Although there was some skepticism, the additional inspectors and high fines remained in place after the initial scare had abated. Even more importantly, the central government allocated some of the new revenue from fines to the cities for cleanup efforts, creating an incentive to hold polluters accountable. This created a new constituency for reform: local leaders who benefited from the revenue source.

A second major initiative was the climate regulations that came into effect in 2020. This initiative had three broad components. First, it extended the carbon emission–trading markets that were established in 2013 in five pilot cities to the rest of the country. A third party evaluates reductions from these markets under a monitoring, reporting, and verification protocol. Second, it created a carbon tax. Although more opposition had been expected from the private sector, the pilot programs ran very smoothly, and a national consensus emerged that environmental protection was a key priority. Finally, the central government imposed an additional tax on gasoline to encourage a shift toward NEVs.

The central government took the bold step of making GHG emission reductions part of government officials' promotion criteria, which made provincial and city leaders take the pronouncement seriously. This had initially gone into effect in early 2015 (Kuhn, 2014), but, like many pronouncements from the central government, it took a little time to make the actual changes to enforce it. Seeing them in concert with the water enforcement, people gained confidence that the reforms might be serious. Evidence that people could see backed up the party's claims. The phrase "you can't fake a blue sky" was often quoted admiringly as proof that progress was under way (Kuhn, 2014).

The new climate regulations led to noticeable improvements in air quality as coal-fired power plants were closed down. Drivers who bought cars that met the new China VI pollution control standards[5] received incentives in the form of lower registration fees (or, in those cities with auctions or lottery systems, a guaranteed registration). The combination of these measures reduced some of the smog hanging over cities.

Although the policies were important, the country was also fortunate that some of the more-dismal environmental predictions did not come to pass. Some had suggested, back in the 2010s, that the aquifer in the North China Plain might dry out if rainfall remained at historic lows. Climate change might have well aggravated the drought, but rainfall resumed normal levels and, at least for now, the aquifer can still supply drinking water to that region.

Also, although much of coastal China was and is vulnerable to sea-level rise and flooding, no such events have occurred in the past ten years. One typhoon blew in around 2020 and caused severe damage to some buildings, but this happened in a largely rural area. Some of the larger coastal cities have begun to take steps to limit building in flood plains, although progress is slow and many think that the coastal region remains at risk, regulation or not.

Population and Internal Migration Continued to Slow

Population growth continued to slow, settling at an average annual increase of 0.34 percent, so, in 2030, the total population is 1.44 billion. This modest growth, lower than in previous decades, resulted in part from latent demand from some couples to have larger families now that the one-child policy has been relaxed.

[5] China has adopted a series of pollution-control standards for vehicle fuels that have progressively lowered sulfur and particulate-matter emissions. The China VI standard, which follows China I through China V, has been under development since 2014 (U.S. Department of State, 2014).

Other demographic trends have shifted modestly as well. Labor-force participation has increased from 76 percent in 2010 to 80 percent today, partly because of provisions in the retirement reforms that required higher retirement ages. The percentage of family households has declined slightly because marriages are delayed and young singles live apart from their birth families.

Two intertwined trends that accompanied the extraordinary growth in the 1990s and 2000s have continued: income inequality and urbanization. While economic growth continued at rates many countries would envy, income inequality continued to grow as well. China's income inequality was one of the highest in the world in the early 2010s (Xie and Zhou, 2014). As incomes of the lowest 40 percent of the population stagnated, mostly in the rural areas and smaller cities, and those of the middle class increased only slightly, those of the top 10 percent continued to pull further away. This pattern held true through about 2025; the flow of rural labor to the cities means that business owners have little incentive to raise wages by very much, and workers mostly lack any bargaining power. Even where wages have increased, the rising cost of living means that many workers are not seeing their standards of living increase. However, inequality peaked in 2025; since then, it has ameliorated to some extent.

Urbanization has also continued strongly in the past 15 years. From roughly half the population living in cities in the early 2010s, the proportion is now about 70 percent. Demand for urbanization had been kept artificially low through the 2000s via the *hukou* system, but China is now at an urbanization level similar to that of mature economies. Since the 2010s, the government has changed course to actively encourage the movement to cities because urban consumers are now the backbone of the economy.

In the 1990s and 2000s, urbanization meant a continued flow of people to eastern coastal cities, but this is no longer the case. The eastern region does remain China's economic driver because these provinces successfully transitioned to a more service-based economy and manufacturing moved westward. The labor pools in eastern cities are still substantially better educated and experienced, making it harder for other regions to develop or attract the firms that would create higher-paying jobs.

However, demand for continued internal migration to the east was not as high as anticipated because the central and western regions were able to absorb many of the less-skilled jobs as the eastern region moved "up the value chain" into a more service-based and higher-wage economy. *Hukou* reform also made it easier for individual job-seekers from the countryside to migrate to cities in the central and western regions. The share of population in the east did not change much from the mid-2010s, remaining steady at about 40 percent, and the share of economic output remained unchanged at about half.

Energy Use Is Growing, but Slowly

Oil prices are high, about USD 150 per barrel in 2030. Demand from other developing countries (particularly India) has pushed prices higher, similar to China's role in the world market in the 2000s. As noted later, NEVs have made some inroads, but gasoline-powered vehicles remain the primary private mode, so demand has remained high. As noted earlier, the climate regulations included specific gasoline taxes, so gas prices were higher for both reasons.

The percentage of China's domestic oil consumption supplied by imports has continued to rise very gradually, from 55 percent in 2013 to 60 percent by 2030. High prices have also spurred some additional domestic production, which has offset what might otherwise have been higher imports. Although there are multiple sources of demand, the restrictions that many cities impose on vehicle ownership and driving affect the relatively slow rate of growth in the oil import share. Such policies were once found only in the first-tier megacities, but, with consumer spending increasing, the demand for vehicles exploded in second- and third-tier cities, and even, by the late 2020s, fourth-tier cities. In addition, the high growth in the market for NEVs meant that oil consumption in the transportation section was growing at a slower rate than the number of total kilometers traveled was.

Car Manufacturing Expands and Ownership Rises

The Chinese car industry has been expanding. In 2030, production is roughly 50 million vehicles per year, both passenger vehicles and trucks. A growing auto industry also helped other related industries (everything from car repair to advertising and component manufacturing) to prosper.

Most cars produced in China are sold in the domestic market, where many households are still purchasing their first car. The share of exports has risen from 5 to 10 percent (including both light-duty and commercial vehicles). The earliest export markets were in developing countries, where low-priced Chinese vehicles were more attractive than more-expensive American and Japanese models. Since the mid-2020s, when engineering expertise improved and safety problems were resolved, a modest share of exports has gone to the United States, Japan, and Australia.

One place where Chinese manufacturing has become competitive is in hybrids and EVs. The increased adherence to intellectual property protection helped reassure foreign manufacturers operating in China that innovations in these areas were safe to introduce. Some even think that Chinese EVs might take off in the United States, where the market is expanding because of high oil prices; thus far, though, that has not happened.

As incomes have risen, car ownership has also increased to roughly 240 vehicles per 1,000 people, far higher than in 2014 (when it was less than 100 per 1,000 people) but still below ownership levels in developed countries (Japan, for example, had just under 600 personal vehicles per 1,000 people in the 2000s). Much of the increase has taken place in second- and third-tier cities, which could still accommodate them. In the first-tier cities, the number of vehicles has continued to grow, but no longer explosively. The total passenger-vehicle fleet is about 345 million.

Constraints on Driving and Vehicle Ownership Spread Widely

Parking remains problematic: Supply long ago outstripped demand, and cars were being purchased at such a fast rate that cities could not physically keep up. In the late 2010s, several cities adopted Tokyo's "proof-of-parking" requirement that each aspiring car owner prove that he or she has an off-street parking space available before being allowed to purchase a car (Asian Development Bank, 2011). However, the wealthy always seem to manage to find places to keep their multiple vehicles, and parking enforcement is not as effective as it might be.

In response, quite a few second- and third-tier cities saw public campaigns to increase restraints on ownership. City populations pressured their leaders, who were also facing demands for better air quality, to impose various types of restrictions that mirrored the auctions and lotteries for car ownership rights that started in Beijing and Shanghai. The Shanghai model of auctioning license plates has been viewed as more effective at dampening vehicle ownership—indeed, as early as 2011, auto ownership was considerably lower in Shanghai than Beijing despite that city having higher incomes than Beijing (Kishimoto, Paltsev, and Karplus, 2012). Although several cities have tried lotteries modeled on Beijing's, these have been less effective because those with money would prefer to compete at auction. Public opinion about the lotteries remains divided, with those who favor more environmental regulation still supporting restrictions and many in the growing middle class feeling resentful that cars remain financially out of reach.

Cities also adopted constraints on driving as congestion continued to be a major problem. (Rising gas prices did little to discourage driving because, with higher incomes, those who can afford to buy cars can generally afford to drive them.) Experiments with odd–even license plates were unsuccessful, but time-of-day pricing became fairly common. Widespread intercity tolls had accustomed Chinese drivers to paying for the roads, so it was not a major leap for a third-tier city of about 2 million residents to implement in 2022 a time-of-day pricing system modeled on Singapore's Electronic Road Pricing. Every time a driver passes a certain point, the system automatically deducts a fee from a debit card inserted into a transponder in the vehicle. The fee varies with the time of day. Other cities followed. Several cities have even integrated this card with their transit system so that someone can use one account to pay for both transit fares and road charges. The revenues were used to provide more and better transit service.

Although there were discussions of cordon charges, which are charges imposed on drivers entering a central area (as has been done in Singapore and London for decades now), the sprawling nature of most Chinese cities made this impractical because they have few highly concentrated central business districts. Widely watched efforts in two other cities to institute road-use fees based on all kilometers driven were met with protests, and officials backed off.

By the early 2020s, about 40 percent of urban residents lived in areas with some type of restraint on either ownership or driving. That percentage has continued to rise and now stands at 65 percent.

The Market for New-Energy Vehicles and Telematics Grew

As policies to restrain both vehicle ownership and use were adopted in the early 2020s, China also saw an uptick in demand for EVs and hybrid vehicles. Several reasons contributed to this development: Some cities treated these vehicles more leniently than conventional vehicles, the cost differential declined as China's technology sector boomed, and the higher cost was less of a deciding factor as incomes rose. Additionally, climate regulations passed in 2020 made gasoline-powered vehicles less attractive because of the increase in gas prices that resulted.

With regard to technological change, several important developments shaped the use of cars in the past 15 years. The biggest story is that NEVs—a category that includes both hybrids and PHEVs—has grown to about 30 percent of the vehicle fleet, one of the highest percentages in the world. Because the fleet continues to grow, and first-time buyers purchase most vehicles, this percentage was easier to achieve in China than in countries with a mature vehicle market, in which the majority of purchases are replacements.

This high adoption rate was partly due to increasing government subsidies on top of falling prices for the vehicles themselves. One key innovation was a fast-charging battery whose performance did not degrade over time. Previous fast charging had been associated with far shorter battery life, requiring expensive new batteries on a regular basis. Fast charging reduced the problem of using EVs for long trips because a battery could recharge in about 20 minutes. As charging stations sprung up on the outskirts of cities and along intercity expressways, they were often colocated with rest areas and food stalls, where a driver could take a short break while his or her battery charged.

The success of the reforms helped technology innovation flourish as investors felt more confident that their intellectual property would be protected. Smaller technology-based businesses were better able to borrow money than in the early 2010s, when most capital flowed to lumbering state-owned enterprises.

Much of this effort went toward telematics, in-vehicle technologies that collect data and provide information to drivers, often in real time. In particular, as demand for parking remained high—even with constraints on vehicle ownership—parking assist–type technologies became popular, as did those that made locating legal spaces easier. These probably spread the most quickly: Drivers without them increasingly struggled to find legal spaces and paid the price in tickets as parking enforcement became a solid revenue source for some cities. Several investors also gambled big on similar technologies to reroute drivers around congestion. However, with congestion as bad as it is in many cities, routes around congested areas are hard to find, and these never gained in popularity as much as the parking locators did.

In addition, the connections between smartphones and vehicles became increasingly important. Ride-sharing services similar to the early Uber really took off in the late 2010s as constraints on vehicle ownership made purchasing a vehicle more expensive. Professional drivers provide those services because those who can afford vehicles do not need to make extra money in their downtime. Most new cars are equipped with mobile Wi-Fi hotspots so that passengers need not miss a minute of online chatting.

Although there was a flurry of activity in the mid- to late 2010s around the promise of autonomous vehicles, so far, very little commercialization has occurred. Certain advanced driver-assistance systems have become standard on many vehicles, such as brake assist and adaptive cruise control. But a combination of technological and policy problems has prevented anything resembling full autonomy. One key problem was that the sheer growth in roads because of the pace of urbanization made keeping city maps updated impossible. For another, many drivers remained concerned about potential hacking. Although a growing number of highly automated vehicles (that allow hands-free and foot-free driving in such situations as traffic jams) came to market by 2030, fully autonomous vehicles are not yet available in China. Auto manufacturers and technology firms have looked to other countries for their first autonomous-vehicle markets.

E-bikes have also continued to play a large role in transportation, and growth has been substantial. They serve as a bridge to car ownership and are especially common in rural areas, as well as outlying suburban areas of large cities. The development of battery technology for cars has also made batteries for e-bikes more efficient and longer-lasting as well, so today's e-bike has a longer life for the same purchase price as an e-bike ten years ago.

Demand for Long-Distance Travel Continues to Soar

Rising economic growth led to strong increases in demand for intercity rail and air travel. The HSR network already contained 6,800 miles of track by 2014, up from literally nothing in 2007 when the ambitious program began. Now there are about 12,500 miles of track and 2.5 million riders per day, nearly double the 1.3 million daily riders in 2012 (Y. Wang, 2013). The longest-distance routes, such as Beijing to Guangzhou, have never attracted many riders because the only slightly lower ticket price hardly makes up for the five-hour difference in travel time (the HSR trip takes eight hours, while the plane trip only three). However, between cities separated by shorter distances, ridership has continued to grow at a very healthy pace. Some discounts are provided to entice middle-class riders, but most of the riders are affluent and can afford the full price.

Although two other high-profile crashes have occurred since the 2011 train derailment in Wenzhou,[6] the emphasis on reform has led to reconstruction of track that was not built in accordance with safety standards. This higher confidence in safety, along with rising incomes, has made HSR successful.

Growth in airline travel has been equally robust. The main beneficiaries have been city pairs far enough apart that air has a definite advantage over HSR. Much of the travel is for business purposes; even though the economy continues to concentrate in the eastern coastal cities, front-office types are still visiting factories in the central and western areas. Domestic tourism has been growing steadily as well.

Use of Transit and Nonmotorized Modes Remains Strong

Higher city revenues from both property taxes and road pricing have also been available to invest aggressively in nonmotorized infrastructure. One model city instituted a successful program that increased the use of walking and bicycling. It involved three elements: a clever marketing campaign promoting the "kingdom of bicycles" as a status symbol; major investments in bicycle lanes, off-street greenways, bike-sharing, and better sidewalks; and heightened enforcement of illegal parking. In a move borrowed from Finland ("Motorist Gets £80,000 Fine for Speeding in Finland," 2013), the city tied illegal-parking fines to income, and several eye-popping fines—widely discussed on microblogs—convinced drivers that the city meant business. The city became a frequent destination for city planners looking to implement similar systems.

Planners' interest was growing in part because, even with restrictions on vehicle ownership, parking remained a major issue in many cities. Many cities lacked centrally located land on which to construct surface parking lots or even multistory garages.

[6] The July 2011 crash, the first on China's HSR system, killed 40 people and injured 192. Although the direct cause of the crash was a lightning strike on a signal box, the official investigation uncovered a history of design flaws and serious safety problems (Osnos, 2012).

Commuting times have been slowly increasing with urbanization, but the trend of factory workers living near their places of employment has also continued. Also, as part of late-2010s reforms, local governments have been less disposed to resettling residents in far-flung developments, which had so often resulted in protests. Instead, those governments paid more attention to building new developments closer to existing urbanized areas that could more easily be served with rail. The trend of building entirely new cities on greenfield sites has abated as well.

Transit has also continued to play an important role, especially in the second- and third-tier cities that benefited from major new urban transit projects, including heavy rail, light rail, and BRT. Although transit use in China has always been high by world standards, in many cities, the investments in transit have prevented additional growth in driving.

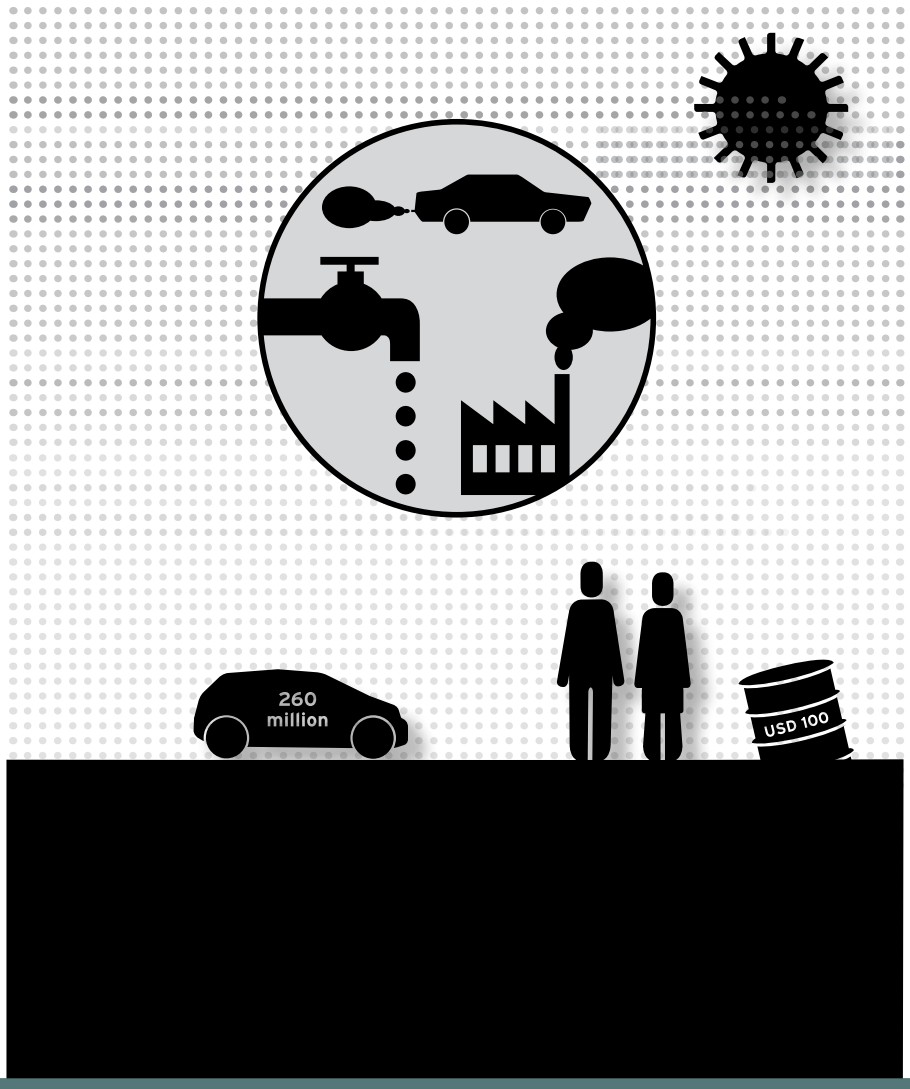
Opportunities and Challenges Lie Ahead

China has managed its way through what might have become a serious economic crisis in the 2010s and has a solid economic basis on which to build. Inequality remains a problem, and one major goal is now to spread the wealth more evenly so that more people benefit. Growth in travel demand will eventually slow now that the intercity network is built out and constraints remain on owning and driving personal vehicles. The environmental movement will likely play a larger role in the future as more Chinese people recognize that responding to environmental and climate problems means major lifestyle changes and not just regulation. In the cities, quality-of-life issues will assume a more prominent role in policy, and the cities that are best able to compete will be those that can attract new residents based on amenities and not simply jobs.

Scenario 2: Slowing but Growing

Overview

The past 15 years or so have been rocky. A financial crisis based on unsustainably high levels of debt resulted in a year with only 2 percent growth (far lower than during the global financial crisis of 2008), followed by a rebound to about 3 to 4 percent annually through the mid-2020s, and an increase to about 5 percent by 2030. However, the gains of this recovery were not widely shared, and other challenges remain. Corruption has continued to be a problem and has kept the economy from becoming more innovation-based because new firms have a hard time getting funding and international investors remain skittish. Environmental problems have continued to affect the quality of life, and declining public revenues have impeded the ability of both the central and local governments to address them. Travel demand has continued to grow, along with the auto manufacturing industry, but at rates lower than would have been expected based on previous trends. The prevailing sentiment is that things could be better, but people try to remain optimistic that eventually they will be.



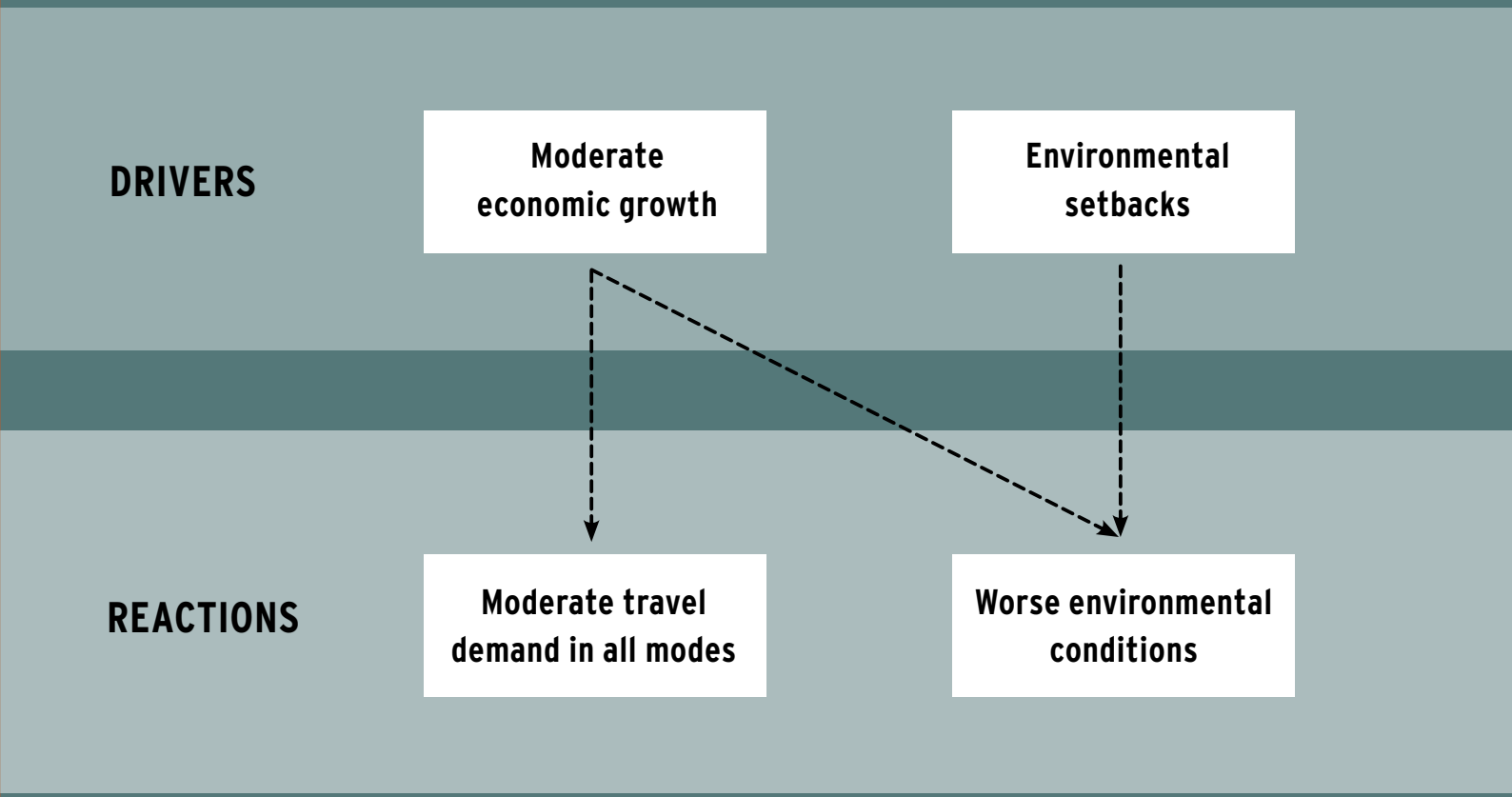


Figure 4.2. Slowing but Growing Scenario: Key Drivers and Reactions

A Financial Crisis Sparks Economic Slowdown

Although the central government signaled its intentions to make some key reforms that would have steered the economy away from a financial crisis, political pressures made such reforms difficult. Decades of cozy business relationships had created entrenched interests. Well-connected business people, especially those connected with state-owned enterprises, successfully lobbied to keep their firms afloat, on the grounds of maintaining employment and political stability, even if that required bailouts of firms that otherwise would have gone bankrupt.

Several high-profile bailouts took place in the mid-2010s, with details remaining secretive (Wang Jiamei, 2014; "China: A Question of Trust," 2014), and the shadow banks continued to operate with impunity. Although the government announced in early 2014 the formation of new banks intended to serve as competition with the four state-run banks (Das, 2014), these did not materialize, and interest rates remained at such low levels that people with serious money to invest continued to use "wealth management products" (essentially a type of shadow bank that makes loans using funds deposited by wealthy investors). Even though cities had been warned about continuing to borrow at unsustainable rates, they lacked other sources of funding for expansion and ignored the central government.

In 2017, when officials became more concerned about mounting debt, some nonperforming loans from shadow banks did go into default. There began to be a clearer signal that the government would backstop the official banks but not necessarily the shadow banks.

These defaults triggered a financial crisis, although its effects were felt most strongly in certain sectors and cities, rather than the whole country and the whole economy. In second- and third-tier cities, where there was the largest mismatch between high-profile infrastructure and housing projects and actual population growth, housing values declined quite sharply, leading to defaults by the local governments' financial vehicles that had borrowed money to build them. This led to protests in some cities, when owners realized that their main assets were worth far less than they had paid for them.

The housing-market crisis in these cities, in turn, led to declines in demand for many industrial products (such as steel and cement). The woes of real estate developers thus spread to these industries as well. The price of coal also continued the downward spiral that had its roots in the late 2000s ("China: A Question of Trust," 2014) as first-tier cities announced plans to transition to less-polluting energy sources. These sectors of the economy flat-lined for a year or two.

The state-controlled banks were able to absorb some of the losses from nonperforming loans because they had large amounts of capital available. But many of the shadow-banking entities were forced to close, and some investors lost substantial sums.

Reform Remains Difficult

The weak banking reforms were just one sign of the broader difficulties in implementing meaningful reforms against all forms of corruption. Although ambitious efforts began in the mid-2010s to root out a variety of forms of corruption, sustaining momentum proved too difficult politically. The problems of corruption proved to be more a consequence of structural incentives than of individual malfeasance, and the anticorruption campaign grew to be seen as a politically motivated rather than a sincere attempt to reduce corruption. Some corrupt business people were savvy enough to ensure that they were not targeted, thus limiting the campaign's effectiveness.

As corruption had grown to the point at which it was threatening economic efficiency, foreign investors were less willing to invest in China, especially given that other developing countries were cleaning up their own acts. Enforcement of intellectual property rights has remained weak, and several well-publicized cases involved Australian and U.S. firms going bankrupt as Chinese competitors undercut them with stolen ideas for new products. In other cases, Chinese regulatory authorities pursued Western firms on questionable charges of anticompetitive practices and other alleged illegal business activities, and the nature of the Chinese legal system made it difficult for firms to defend themselves.

Because the government did not sufficiently tackle the problem of banks making loans to less-productive industries, government spending on infrastructure continues to be high. The government still looks to infrastructure spending for a stimulus effect, although its impact is quite modest given that overcapacity plagues many sectors. However, spending on transportation infrastructure is down because environmental problems are considered more pressing. Much government spending has shifted focus, and the transportation sector receives only 2 percent of GDP.

The government also did not achieve major changes in retirement and health care policies, even though there had been some attempts to initiate such reforms. Although an initial phase of health care reform was announced in 2009, the reforms stalled. As a result, people continued to save large amounts in regular banks, which were safer but still carried low interest rates. Although people expressed concern about the safety of their bank deposits, they had few other choices for long-term savings. The overall saving rate declined as the population aged and older people drew down their savings for living expenses.

After one year with only 2 percent growth (far lower than during the global financial crisis of 2008), GDP growth rebounded to about 3 to 4 percent annually through the mid-2020s and rose to about 5 percent by 2030. This rebound was attributed to efforts undertaken after the crisis to focus more on the sectors of the economy that support growth in consumer demand. This was not immediately successful. The problems in the banking sector and what felt like a recession sufficiently spooked the Chinese population that consumer spending remained low through the early 2020s, making rebalancing the economy and getting away from reliance on investment difficult during that period. However, during the past five years, spending has improved, and the overall economy with it.

The share of the economy in the eastern region has gradually declined to about 40 to 45 percent, down from roughly half in the early 2010s. Declines in the export share of inexpensive factory goods have made fewer jobs available, and lower housing prices in other regions have lured many previous migrants back, while others who might have left for jobs on the east coast stayed put and found jobs locally. The eastern region could not shift quickly to a more white-collar economic base. Businesses in these service sectors lacked access to capital to grow, in part because reforms in the banking sector were not fully realized and smaller firms still had difficulties getting loans.

Environmental Problems Remain Incompletely Addressed

Although the government has attempted to address environmental problems seriously, such efforts have not always been successful. Sometimes, this was because the solutions were insufficient, and sometimes this was because the effects of climate change were worse than anticipated.

One major issue was water. Two of the three branches of the South–North Water Diversion Project, an ambitious plan to bring water to the northeast of the country, had opened prior to the financial crisis (Kuo, 2014; Zhao, 2014), but water supplies in the source provinces had begun to dry up as well. With GDP growth down from previous levels, increasing water prices to encourage conservation was too politically dangerous. That continued overuse of water, combined with rainfall below historical norms, made water scarce in the northeast, including Beijing. Although strict limits on water use have helped a little, they were also too little too late, and officials now anticipate that more and more people will move out of the region. Some have already begun to do so.

Activists were able to secure some meaningful changes in water-discharge enforcement, which improved water quality but did not address the issue of scarcity. These limits have dampened the previously high growth in some manufacturing industries, so they have not been universally praised.

Another issue was food safety, much of which was linked to soil contamination. After several well-publicized scandals involving tainted food, people began protesting. These drew more government response than previous demonstrations had as the government sought to hang on to its legitimacy. One response was more transparency in information related to soil pollution levels, and, by the late 2020s, many major cities had brownfield programs to clean up contaminated lands previously occupied by factories.

China did pass major climate legislation in 2020, including both an emission-trading system and a carbon tax. However, implementation of its many provisions was slow, so public could not see the anticipated effects on air quality right away, despite the enormous publicity around the law's adoption. People remained somewhat skeptical that real changes would take place. Even though government data showed improvements in air quality, many believed that the numbers were not totally reliable.

A final challenge has been the increase in severe storms along the Pearl River Delta, which have caused widespread flooding in cities on multiple occasions. Official responses have included stronger building codes—it became obvious after one flood that more people would have survived had their apartment buildings been better able to withstand the pounding winds—and more-stringent enforcement. But little has been done to advance a more permanent solution of restricting development in those areas most vulnerable to flooding.

The Population Barely Grows, but Urbanization Continues

The population in 2030 is just shy of 1.4 billion; the average growth rate since 2014 has been 0.18 percent, continuing its previous decline. At some point in the not-too-distant future, the overall population will likely begin to decline, but that point is probably five to ten years away. Despite higher incomes, people did not rush to take advantage of the liberalization of the one-child policy in the 2010s; many struggled to earn enough to provide for one child amid rising housing prices, costs of living, and competition for the best schools. Even if the fertility rate had increased, given the existing structure, the population would have continued to age.

Urbanization has continued, although the growth has been more in the inland cities than in the coastal ones. In part, this is because of the environmental problems in the northeast, and in part it is because some manufacturing jobs have shifted toward central and eastern regions.

The problem of highly unequal income distribution also continues. Although the economy has improved overall since the problems of the late 2010s, much of the gains have gone to the wealthiest 10 percent of the population. The 30 percent of the Chinese population who live in rural areas continue to seriously lag behind their urban counterparts in income. New migrants to cities have found that wages for lower-skilled work have not increased much, leaving them far behind urban workers in professional occupations. This explains how what many observers think is a respectable rate of GDP growth coexists with stubborn poverty.

Energy Prices Remain Level

Oil has remained at its 2013 price, at about USD 100 per barrel. Demand is high despite the slowdown because people have continued to buy cars, and China now imports 70 percent of its oil. Because oil is not extremely expensive, government has invested little in finding new domestic sources. The mild recession of the late 2010s has also affected demand in other developing countries (such as Brazil and India), which has kept oil prices stable.

Car Manufacturing and Ownership Grow but Not Rapidly

The car industry has been growing at a pace just below GDP growth. Total vehicle production reached 25 million in the early 2020s and has since grown to just over 35 million vehicles per year. Although vehicle ownership levels have been rising—in 2030, the total fleet size is roughly 260 million, or about 185 vehicles per 1,000 people—some observers had expected that the fleet would be even larger by now.

Domestic demand remains reasonably strong; once an urban resident reaches a certain income threshold, a car is generally the first major purchase. Also, there have been relatively few new ownership restrictions, such as auctions or lotteries for license plates. These remain in place in some first-tier cities, but the faltering economy in the late 2010s discouraged many second- and third-tier local governments from instituting additional constraints on driving and vehicle ownership. But the income gap means that car ownership is still financially out of reach for the majority of the Chinese population.

Vehicle exports (both cars and commercial vehicles) have continued to rise from about 1 million in 2012 to 3.5 million in 2030, accounting for about 10 percent of vehicle production in China. China's initial export markets were almost exclusively developing countries, especially in South America, the Middle East, and Africa. As these countries' economies grew, their demand for inexpensive Chinese vehicles did as well.

However, China has not quite unlocked the market in mature economies, in which more-advanced safety technologies and sophisticated emission controls are highly desirable and, in many cases, mandated. Chinese exports have been more successful in countries where lower prices remain the most important factor in vehicle purchase decisions. Given the difficulties of reform and the lack of more market-based incentives, Chinese manufacturers have been unable to shift to higher value-added technologies.

New-Energy Vehicles and Vehicle Technologies Still Hold Promise

Growth in EVs and hybrids has been robust, and NEVs now constitute about 20 percent of the passenger fleet. This represents an enormous increase over levels in the early 2010s, when high price tags and a lack of charging infrastructure stymied ambitious plans to increase numbers of NEVs produced. It was, of course, easier for NEVs to amass a larger share of the fleet in China than in developed countries because so many car purchases in China represented additions to the total fleet (as opposed to being replacement vehicles). Still, this share was not as high as hoped—there was an ambitious target of 30 percent of the fleet in 2030 (the well-publicized "30 in 30" campaign). However, like with past targets, the reality fell short.

Several factors contributed to the growth in NEV numbers. First, in keeping with the new climate regulations, those cities with ownership restrictions made exceptions for NEV owners to encourage people to purchase NEVs instead of conventional vehicles. Second, although the overall level of state investment in transportation infrastructure declined markedly, charging stations were a key exception to this pattern and received substantial outlays. The number of stations increased from a few tens of thousands 20 years ago to hundreds of thousands today. This public infrastructure was particularly important given that most Chinese vehicle owners cannot charge their NEVs overnight in a private space. So employer-based charging is very important, as are public stations for those who do not commute by car.

Finally, the central government pressured many cities to purchase more NEVs, such as transit buses and municipal fleet vehicles. This led to positive spillover effects as factories gained skill in producing NEVs and potential buyers became accustomed to seeing them on the roads.

The growth of in-vehicle telematics has been large, but, again, many expected it to be even larger. Constraints continue on access to online services, and vehicles are no exception. One growth area has been services that help drivers navigate congestion, which remains a serious problem in many cities. Real-time data help drivers identify less-congested routes, which is especially helpful for truck drivers and taxi services. However, as more and more drivers use them, the advantages have become smaller as more people can find those "hidden" routes.

Roadside assistance is another popular telematic service because the number of crashes remains high and people worry about being stranded on long-distance trips. The car can automatically signal its location and summon police or ambulance services. However, this capability is expensive, so it is used mostly by affluent drivers.

E-bikes—both the electric-assisted bicycles and the electric scooters, as well as everything in between—are an important mode for those urban dwellers who cannot yet afford cars. Growth has been steady, and they are seemingly everywhere. Their appeal is in making trips that are too far to walk and too inconvenient for transit. Although some cities had attempted to ban them previously, those days are over, and cities have instead tried to accommodate them with separate lanes and, in some cases, even off-street paths. Some models travel too fast to mix safely with pedestrian traffic, so a few places have three types of roadways—for cars, for e-bikes, and for totally nonmotorized traffic. But this is more of an experiment and does not seem likely to constitute a future model.

Smartphones have also enabled substantial growth in ride-sharing and car-sharing. Although owning a luxury foreign car continues to be a status symbol, for many households, the ability to access a car when needed fills an important void. Although people might still aspire to owning a car one day, these modes are quite popular for now. Some vehicle owners drive for ride-sharing services on the side to earn extra money, and, despite a few well-publicized fatal crashes and high-profile crimes, the public continues to use these services because they cannot purchase cars.

Long-Distance Travel Shows Slow, Steady Growth …

Lower annual economic growth has led to only modest growth in demand for HSR and air travel. The HSR network has been built out to about 12,500 miles of track, and it serves about 2 million riders per day, about 50 percent more daily riders than it carried in 2013. The government's continued reliance on investment meant that plans for the full HSR network were carried out, even as demand failed to reach projected levels. Most of the Chinese population still cannot afford tickets; although HSR tickets generally cost less than airline tickets, they are still more expensive than regular train tickets. Air travel has seen a similar rate of growth: steady but not spectacular. Some attribute this to China's aging population, an immense group who travel less than younger people.

One outcome of this steady growth for both HSR and air travel is that some airlines have begun working with the Ministry of Transport to carry some potential air travelers by rail instead. Such integrated air–rail service means that, even when a customer books an airline ticket, part of the trip takes place on rail through cooperation between the airline and the rail services. This has helped airlines make up revenues they might otherwise have lost to rail. The climate legislation made air travel more expensive because it is less energy-efficient than rail for long-distance travel (and both are preferable to cars).

... Along with Transit and Nonmotorized Travel

The largest cities have continued to invest in transit systems, particularly heavy rail. City officials had hoped that the investment would stimulate the economy. Although it provided only a modest boost, it has definitely increased ridership, and these expanding modern systems have attracted plenty of demand, even from so-called choice riders—that is, those who own cars but are willing to ride high-quality transit where it is available. These cities have also been active in promoting transit-oriented development, building apartment buildings and office towers within walking distance of new rail stations.

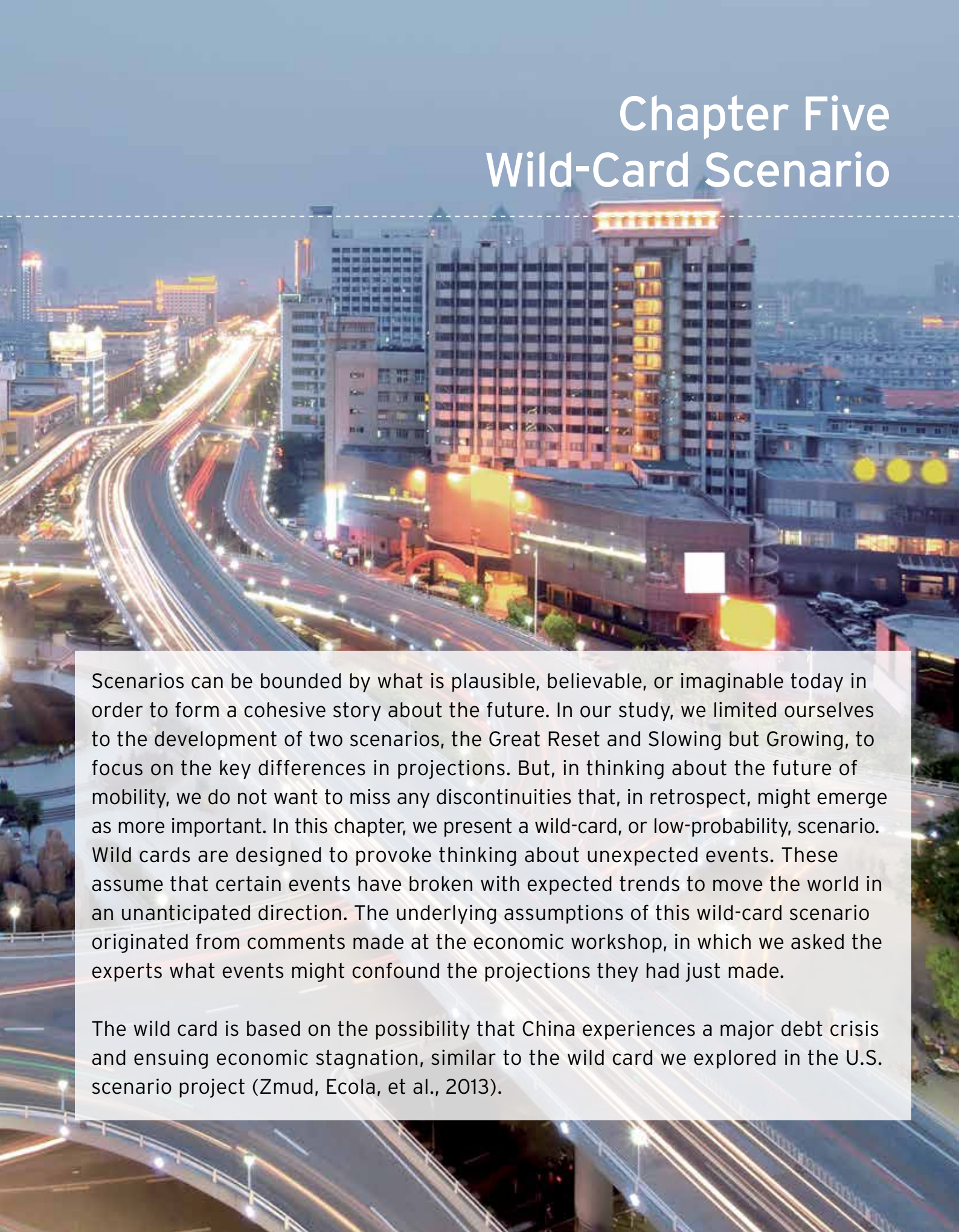
The same pattern holds true for nonmotorized infrastructure—the largest cities have made major investments that have paid off in terms of increased usage. The most successful of these made a point to increase the convenience of bike-sharing, provided off-street trails, and made streets more amenable to bicycling and walking. Between government encouragement of transit, bicycling, and walking, mode shares for cars in a few cities have even leveled off, rather than continually increasing. This has been good for air quality, although congestion is still a problem.

Other cities have made similar investments, hoping for an economic boost, but with less success. Some ambitious projects stalled in the last 2010s with the economic slowdown and crises in municipal finances, and are only now being completed. Other investments were poorly made—rail systems that were hard to access on foot from residential areas and bicycle lanes without parking enforcement that were all but impassable for cyclists. In these cities, residents still prefer to purchase and drive cars when they have the financial means, and they avoid other modes if they can.

Opportunities and Challenges Lie Ahead

After a few fairly rough years, China is well-positioned to enjoy continued growth, although of course not at the same pace as before the crisis. Environmental problems continue to be a drag on the economy, and progress toward ameliorating the more-serious problems is slow. The effects of climate change might continue to be felt in coastal areas and represent a continuing challenge because so much of the population lives near coastlines.

Chapter Five
Wild-Card Scenario



Scenarios can be bounded by what is plausible, believable, or imaginable today in order to form a cohesive story about the future. In our study, we limited ourselves to the development of two scenarios, the Great Reset and Slowing but Growing, to focus on the key differences in projections. But, in thinking about the future of mobility, we do not want to miss any discontinuities that, in retrospect, might emerge as more important. In this chapter, we present a wild-card, or low-probability, scenario. Wild cards are designed to provoke thinking about unexpected events. These assume that certain events have broken with expected trends to move the world in an unanticipated direction. The underlying assumptions of this wild-card scenario originated from comments made at the economic workshop, in which we asked the experts what events might confound the projections they had just made.

The wild card is based on the possibility that China experiences a major debt crisis and ensuing economic stagnation, similar to the wild card we explored in the U.S. scenario project (Zmud, Ecola, et al., 2013).

Debt Comes Due

The central government tried to intervene to stave off the mounting debt ratio but instead precipitated a major financial crisis.

Overleveraging Sparked a Financial Crisis

It began with an effort to curtail lending by cities, whose indebtedness had reached USD 3 trillion by 2013 (Gough, 2013). The goal was to help deleverage the indebtedness of the economy, which had reached what most observers believed was a truly unsustainable level. However, instead of solving the debt problem, the government's actions caused a full-blown financial crisis. A midsize city failed to meet a deadline for a loan payment, and the central government stuck by its 2014 statement that it would not bail out any local governments that could not meet their financial obligations (Qi, 2014). Observers had interpreted this more as a warning than a firm policy, but the city missed a payment and waited to see what would transpire.

It launched a wave of loan defaults, first by firms defaulting on loans made by the shadow-banking sector. With growth already slowing in the early 2010s, many firms were not generating enough profits to service their debts. Many firms were forced to go out of business when they could no longer hide their losses. The crisis revealed that many businesses had been taking out new loans to pay off old ones. Financially sound firms had to use profits to pay for debts rather than for expansion.

Many of these shadow bank–originated loans were short term, so they were coming due. At first, it seemed like the damage might be confined to the shadow-banking sector, but it was also revealed that, in many cases, banks were themselves setting up shadow entities to get around reserve requirements or limitations on loan recipients. The lack of transparency in the shadow-banking sector had been concealing interconnections between the state banks and shadow entities. As a consequence, state-bank balance sheets were not as strong as previously claimed.

Property values, which had already begun declining in 2014, continued falling, with two major effects. First, middle-class homeowners were furious that their main assets had lost value, and, in some cities, this expressed itself in the form of rancorous protests. Second, many of the shadow-banking loans were backed by property, so the collateral no longer covered the value of the loan. Even some state banks had exposure to the property market that was officially booked as some other type of exposure.

Growth Is Slow

China could not grow its way out of this financial crisis in the ensuing decade. After a rocky year, marked by political, as well as economic, tumult, China settled into a long, Japan-style period of deflation with GDP growth hovering around 2 to 3 percent per year. Several problems contributed to this unexpectedly sluggish growth.

First, productivity remained stagnant. Chinese productivity had been slowing even as GDP grew during the 2000s (Hoffman and Polk, 2014), in large part because lending was still targeted at state-owned enterprises at the expense of more-dynamic firms. Productivity per worker remained low, and unemployment for young college graduates remained high (having reached 13 percent in the mid-2010s [Purdy, Li, and Light, 2014]). Limits on foreign investment, which restrict the percentage of foreign ownership allowed in companies on Chinese stock exchanges, remained in place, and it was difficult for new firms to compete with entrenched state-owned enterprises.

Second, the slowdown and very slow recovery spurred protests. Protests in rural areas, predominantly over questionable land deals, had always easily been confined geographically; this time, though, students and unemployed young people joined them. Word spread quickly via online channels, which had become harder to fully censor with increasing numbers of users. The focus of the protests often seemed undefined, but an underlying theme was frustration with the shrinking of economic opportunity, with continued corruption, and with the rich getting ever richer. The unrest spooked some foreign investors, who pulled their expatriate staff from several cities and reduced the flow of investment dollars into new ventures until things calmed down, which took several years.

Third, the government had less room to maneuver financially. Slow growth meant stalled revenues, and the recent crisis constrained the ability to borrow. Weakness in the banking sector meant that the government could not increase its own spending.

Environmental Problems Fester

This third factor, lower public revenues, has meant that the central government has been unable to address some of the country's most-serious environmental problems. The main one is severe drought in the northeast. The water table had been falling rapidly for the preceding several decades, but many had placed their faith in the South–North Water Diversion Project. However, several planned sections were officially put on hold in 2019 because of lack of funding. In addition, extreme drought plagued the region in the early 2020s—essentially the beginning of desertification.

This had increasingly disastrous effects on agricultural productivity. China's already-low amount of arable land per capita became even lower, and the country had to begin importing staple foods because the harvests declined so dramatically. Food prices increased as a result, leaving less income for other consumer spending and fueling additional societal unrest.

The government was also unable to address serious water quality problems. Enforcement of existing regulations suffered as officials retired and fewer replacements were hired, so polluters had no fear of being made to pay fines or shut down. Plans to build additional treatment plants were similarly put on hold because the original plan had called for these to be built with borrowed funds as part of the massive infrastructure spending stimulus.

Flat-Lining Demand for Transportation Affects Some Modes More Than Others

The main effect on the transportation sector was stagnation in travel demand across all modes. Car ownership increased slightly, with most purchases replacing aging vehicles rather than increasing the total fleet. As a result, the economic slowdown put many of China's 170 auto manufacturers ("Chinese Dilemma," 2013) out of business.

At the national level, travel by car continued to grow, albeit slowly, and trends varied across cities. A handful of cities experienced decreases in car usage because fewer people drove to work. Although gas was not particularly expensive, some people found that riding transit was cheaper than driving and changed modes. Cities saw little need to institute new constraints on driving and ownership given that both were falling on their own. This occurred even as world oil prices fell; China had been a large source of demand, and oil prices fell as demand plunged.

Transit ridership remained about the same over time, although there was distinct variation between cities. For some, the slowdown meant unemployment, so some riders who had been commuting on transit no longer needed it. In cities that had less unemployment, ridership was up because some people sold their cars. Bicycling and walking also gained mode share because those modes are the cheapest and were a little safer with fewer cars on the road.

Long-distance travel was the most affected. Although the slowdown did not prevent the annual Lunar New Year pilgrimage to visit families—people still made those journeys, regardless of cost—fewer people were traveling long distances because many of the migrant workers had returned to their home villages more or less permanently when factory work dried up in the cities.

The other drivers of long-distance travel, business and tourism, were mixed. The rising middle class that had been clamoring for new travel experiences pulled back to focus on saving, and the hotels that had been springing up to serve them were mostly vacant. Business travel grew but at a far slower rate than previously. Few new branch offices or factories that might have required trips to scout locations or hire staff were opening, and real estate developers were no longer looking for new land to develop because they were already sitting on too much unleased inventory. Many "ghost cities" remained ghostly for years.


出站口
4站台
5站台
7站台
和谐

Chapter Six
Implications of the Scenarios

Each scenario represents a hypothetical future in which decisions that affect the transportation system might be made. The scenarios account for both the current state of affairs (because past trends informed the projections) and the various forces that might shape the state of affairs in 2030. These forces, which might be more or less likely and more or less desired, will affect mobility outcomes in the future.

As noted previously, our scenarios are descriptive and not normative. We did not seek to define a desired mobility future and then identify the path to arrive there. Instead, our scenario approach explored possible future developments with past trends as a point of departure. In other words, we tried to answer "What if?" and not "How to?" questions. These included the following:

- **What if** NEVs become an important element in the vehicle fleet?
- **What if** long-distance travel continues to grow?
- **What if** constraints on vehicle ownership and driving became far more widespread?
- **What if** auto manufacturing continues its upward trajectory and China remains the world's dominant car producer?
- **What if** economic growth falls to levels not seen in a generation?

In this chapter, we present the implications of the scenarios for transportation decisionmaking.

Implications for Transportation Policy

The Chinese urban and transportation landscape has changed rapidly in the past few decades, and further changes are likely in store. Some might be continuations of past trends, but, in many cases, it would be difficult for past trends to continue, and the country might instead see a leveling off or even a decline. The scenarios explore several combinations of these potential patterns, as well as ways in which the policy responses at different levels of government contribute to these patterns.

The Great Reset scenario assumes that, while economic growth slows from previous highs, growth remains fairly strong. The economy navigates a shift from growth fueled by government investment to reliance on consumption as the engine for growth. Car manufacturing and ownership continue to increase, even as cities try to stem the tide with additional constraints on driving and more investments in transit and nonmotorized modes of transport. The transportation network is built out both within and between cities, facilitating a substantial increase in intercity travel.

The Slowing but Growing scenario is built on the assumption of lower levels of economic growth, following a rocky transition period marked by instability. Although some past trends continue, such as expansion of auto manufacturing, the problems are more pronounced. Investments in new infrastructure have proven less productive than hoped because demand for intercity travel is not growing very quickly. Car ownership grows, albeit slowly, because many people still cannot afford to purchase vehicles. Lacking revenues, cities have not built much new infrastructure for other modes.

Analyzing the differences between the two scenarios, we can identify the key drivers that caused one path to emerge over another. Our analysis revealed three factors as being significant in this regard: (1) economic growth, (2) constraints on car ownership and driving, and (3) environmental conditions.

Economic Growth

Although economic growth will almost surely slow in China as it has for other fast-growing Asian countries in the past, the question here is how much it slows and whether the transition can be managed smoothly (the Great Reset) or is disruptive (Slowing but Growing). The central government, through its planning mechanism, sets targets for growth, but many other factors can affect growth as well: labor shortages, corruption, declines in export markets, consumer spending, and problems in the financial sector. So, although there is some leverage over this factor, controlling it is by no means fully within decisionmakers' purview.

Constraints on Car Ownership and Driving

In contrast, constraints on car ownership and driving are largely determined by policy. Some of these are market-based constraints; for example, the high cost of passenger cars might keep them financially out of reach for many. The base cost of a car depends on a range of variables, but policymakers can increase the cost by levying various types of taxes. They can and have used a mechanism seldom used in developed countries: restrictions on the number of license plates available. Constraints on driving are similarly a combination of market- and policy-driven factors. The price of gas can be an important determinant of driving, although, as China moves toward more hybrid and electric vehicles, gas prices might have a lesser impact than in a country with a predominantly gasoline-powered fleet. Road pricing (which already exists in the form of tolls) is another policy lever to influence demand.

Environmental Conditions

Environmental conditions are more like economic growth in that a variety of factors only partially under government control influence them. The key factor that the government can control is the adoption of—and even more importantly, the enforcement of—environmental regulations. In the past, regulations have been subservient to the demands of economic growth, and incentives to protect the environment have not been well-aligned with other incentives. The financial resources of city, provincial, and the central government to build the appropriate infrastructure (such as water treatment plants) can also influence environmental conditions. Although both scenarios assume that comprehensive laws to address climate change will be promulgated, there is more than one way to enact such laws. In addition, we assume that environmental problems themselves—that is, their severity and their role in shaping public opinion—might differ between the two scenarios.

Implications for Transportation Decisionmaking

Our two scenarios present transportation policymakers, planners, transportation suppliers, and private-sector users of the system with the different challenges and opportunities that they might face under one scenario versus another. This information provides a context for understanding how today's decisions, among any of these players, might play out in the future. In this section, we suggest two ways in which to apply and use the scenarios in transportation decisionmaking. Depending on who is using the scenarios, different implications for planning can be drawn.

Identifying Leading Indicators

One of the fundamental uses of scenarios is that, if considered plausible, they can help decisionmakers anticipate and prepare for change. The systematic, long-term view of different paths of mobility development supports creative but focused "what-if" thinking. As an initial step toward further action and planning, monitoring key trends in relation to each scenario is useful. Leading indicators of directions in which critical uncertainties might go can and should be discerned now and monitored over time. We can categorize them by the relative strength of their connection to demographic, economic, energy, or transportation supply and constraint issues. Considering all of the influencing areas when identifying leading indicators forces the acknowledgment of shifts in trends outside the transportation-specific domain. The purpose of this exercise is to ask, "Toward which scenario are we moving, and with what implications?"

Specific leading indicators can be developed on the basis of the key trends set out in the scenarios, supported by appropriate data sources that are monitored on a regular basis. For example, under the Great Reset scenario, potential leading indicators include adoption and effective enforcement of economic reform measures, growth in consumer spending, and gradual adoption of constraint measures on ownership and driving. Under Slowing but Growing, leading indicators include a lack of economic reforms and continuation of unsustainable debt growth, slowing of growth in car manufacturing, and lack of investment by non–first-tier cities in transit and nonmotorized modes.

Determining Opportunities, Risks, and Contingencies

Because multiple scenarios force planners to consider a wider range of futures than in typical short- to medium-term planning, scenarios serve to uncover new opportunities on the horizon and to highlight key risks. In this way, the scenarios presented in this report can be used to influence government bodies at all levels, as well as private firms, to consider a wider set of options within their planning process. Such planning typically begins with the desired end state and works backward to the current status. At every stage, the planner asks, "What must be done at the previous stage to reach this stage?" Making sense of past events and monitoring potential future developments when working in a high-pressure environment (as transportation often is) is a challenge. Scenarios enable planners to look at a wider set of opportunities and risks and therefore to identify a more robust set of strategic options.

In the Chinese context, such scenarios might be especially helpful in understanding why previous plans have not come to fruition. For example, actual NEV registrations have fallen far short of ambitious past targets for adoption. The two scenarios presented both have optimistic targets as well, but they help explain why other factors might influence the number of NEVs sold. Such factors as economic growth, special treatment of NEVs in the system of licensing restraints, and the adoption of non–ownership-based motorization are all thought to have some effect on NEV purchases. These could constitute other policy levers by which to influence NEV demand.

From the private-sector side, scenarios also point out opportunities for new markets, such as the possibility of more constraints on ownership and driving leading to markets for providing nonownership use of cars or the possibility of growth in other technologies (such as driver assistance and telematics), which could suggest a need to build more infrastructure to take advantage of these opportunities.

Finally, scenarios point to some risks based on continuing current trends. For example, there is risk in continuing current patterns of building new apartments on the outskirts based on local governments' need for revenues. In the Slowing but Growing scenario, this leads to declines in property values and a financial crisis resulting from overreliance on debt financing. Another risk is overbuilding intercity transportation infrastructure if demand does not grow strongly; this has economic consequences (wasting money that could have been spent more productively), as well as more-direct transportation consequences (lower-than-anticipated demand could result in a lack of revenues to maintain the infrastructure in a state of good repair).

Utility of the Wild-Card Scenario

Too narrow a focus, on what we can imagine today, can constrain future planning, even long-term future planning. Our scenario process, like others, followed a systematic approach of drawing out and analyzing possible future projections on a specific set of descriptors based on past and current trends. The systematic approach provides greater credibility to the scenarios, but it does constrain the scenarios to what might be plausible given current conditions.

The value of the wild-card scenario is that it escapes the condition that it must be believable today, because it represents a break in trends. Although our study identified only one such wild card, Debt Comes Due, other wild cards should be considered. These could be either positive or negative. Positive wild cards might be based on health technology breakthroughs that produce extreme longevity and declines in disability, rapid developments in autonomous-vehicle technology, or successful use of geo-engineering to address the threat of climate change. Negative wild cards could include military conflicts in Asia, a global pandemic, or destructive effects from climate change, such as a widespread refugee crisis or a sharp decline in food production.

Planners can use wild-card scenarios in the same ways they use the more-plausible scenarios. Planners can assume that those scenarios are possible, if unlikely, and test their policies against the possibility of such events coming to pass. Ideally, policies would be robust; that is, they would have positive impacts regardless of the circumstances, instead of being tailored to the likelihood of one future.

Chapter Seven
Conclusions

Our project sought to answer the question, "What might we expect for the future of mobility in China in 2030?" Knowing that the future of mobility is uncertain, we developed two scenarios, the Great Reset and Slowing but Growing. These scenarios illustrate the paths that might result from the interconnected impacts of market, policy, and consumer forces. The Great Reset describes a future in which China has successfully steered the economy toward a more sustainable path for growth and enacted constraints on vehicle ownership and driving to try to reduce their negative impacts; this results in a future of strong travel demand across all modes of transportation. Slowing but Growing describes a future of lower growth, in which incomes do not rise quickly and travel demand grows more slowly.

We applied scenario planning to this question. Scenario planning deals with opportunities and risks of complex long-term issues, such as future mobility, instead of straight-line trend analysis or improved travel demand forecast models. Not only are the data to support these latter approaches incomplete and evolving but the accuracy of long-term forecasts has also long been suspect. The relationship between today's situation and a long-term future outcome is hardly linear. It takes a systematic process, such as scenario planning, to identify possible, even plausible, futures and then explore the paths leading to these alternative futures.

The study identified three key drivers that caused one path to emerge over another: economic growth, constraints on driving and vehicle ownership, and environmental conditions. Of these, the most critical is economic growth. China's trajectory to middle-income country status and its ability to deliver a higher quality of life to an increasing number of its residents—of which mobility is one key element—depends heavily on overall growth. Although policy levers certainly influence economic growth, factors outside of decisionmakers' control, as well as constraints based on previous economic trends (such as the use of debt), could make economic growth vary widely between scenarios.

The second key driver is constraints on driving and vehicle ownership, which are present today to a modest degree but might play a large role in mobility in the future. If they become increasingly widespread, as we speculate they might if growth continues and congestion and parking scarcity reach unacceptably high levels, they could steer China toward a future in which ownership is less important than access—suggesting a major role for car-sharing services and the technologies that enable them.

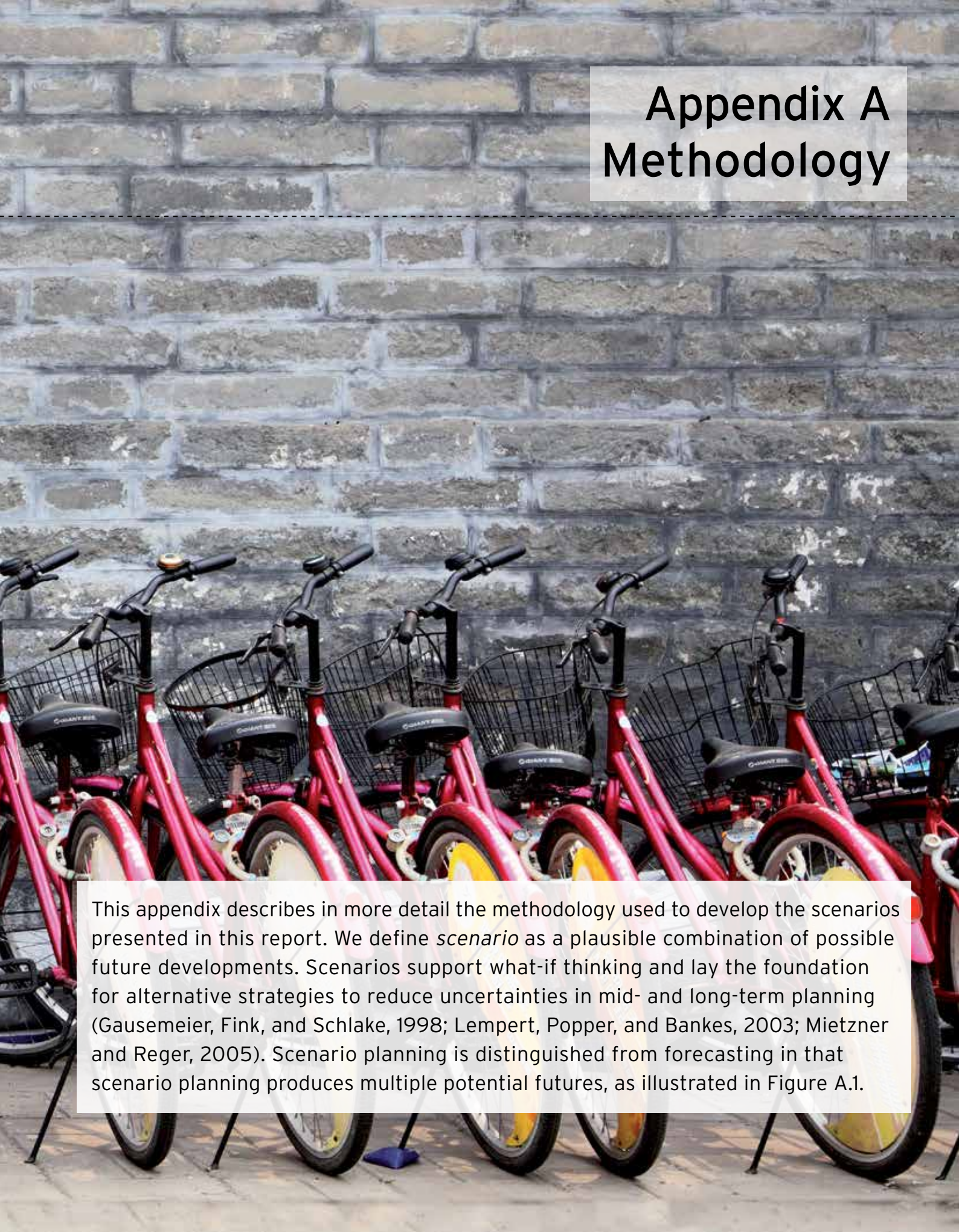
Finally, environmental conditions might play a large role in how mobility develops, through several channels. Investments to improve environmental conditions might take resources away from transportation investments, dire environmental problems (such as severe regional water shortages) might change the demand for long-distance travel, and policies to address the environment (such as climate-change regulations, which are anticipated in both scenarios) might affect travel demand through increasing fuel prices and adoption of NEVs.

What can we expect for the future of mobility in 2030? If the Great Reset scenario comes to pass, the economy is still growing enough to provide increasing opportunities; more people can afford cars, but options exist for NEVs and car-sharing; and the future is fairly comfortable. Travel demand soars, but the infrastructure can absorb new travelers. On the other hand, the Slowing but Growing scenario assumes more economic instability, lower growth into the future, and back-pedaling on reforms. Although people still travel and the domestic car industry still grows, neither does so at the rate in the Great Reset scenario.

Our wild-card scenario, which raises the specter of a major debt crisis and ensuing economic stagnation, points out that unexpected events—even those considered to be outliers—could have major effects on the future of mobility. Assuming that such events are plausible and worthy of contingency planning is important for strategic policy and planning, even though the probability of their happening is low.

By making potential long-term mobility futures more vivid, we aim to help planners and policymakers at different levels of government and in the private sector envision what the future might bring. In this way, they might better anticipate and prepare for change and, in the process, make better decisions now to affect the future of mobility in China.

Appendix A Methodology



This appendix describes in more detail the methodology used to develop the scenarios presented in this report. We define *scenario* as a plausible combination of possible future developments. Scenarios support what-if thinking and lay the foundation for alternative strategies to reduce uncertainties in mid- and long-term planning (Gausemeier, Fink, and Schlake, 1998; Lempert, Popper, and Bankes, 2003; Mietzner and Reger, 2005). Scenario planning is distinguished from forecasting in that scenario planning produces multiple potential futures, as illustrated in Figure A.1.

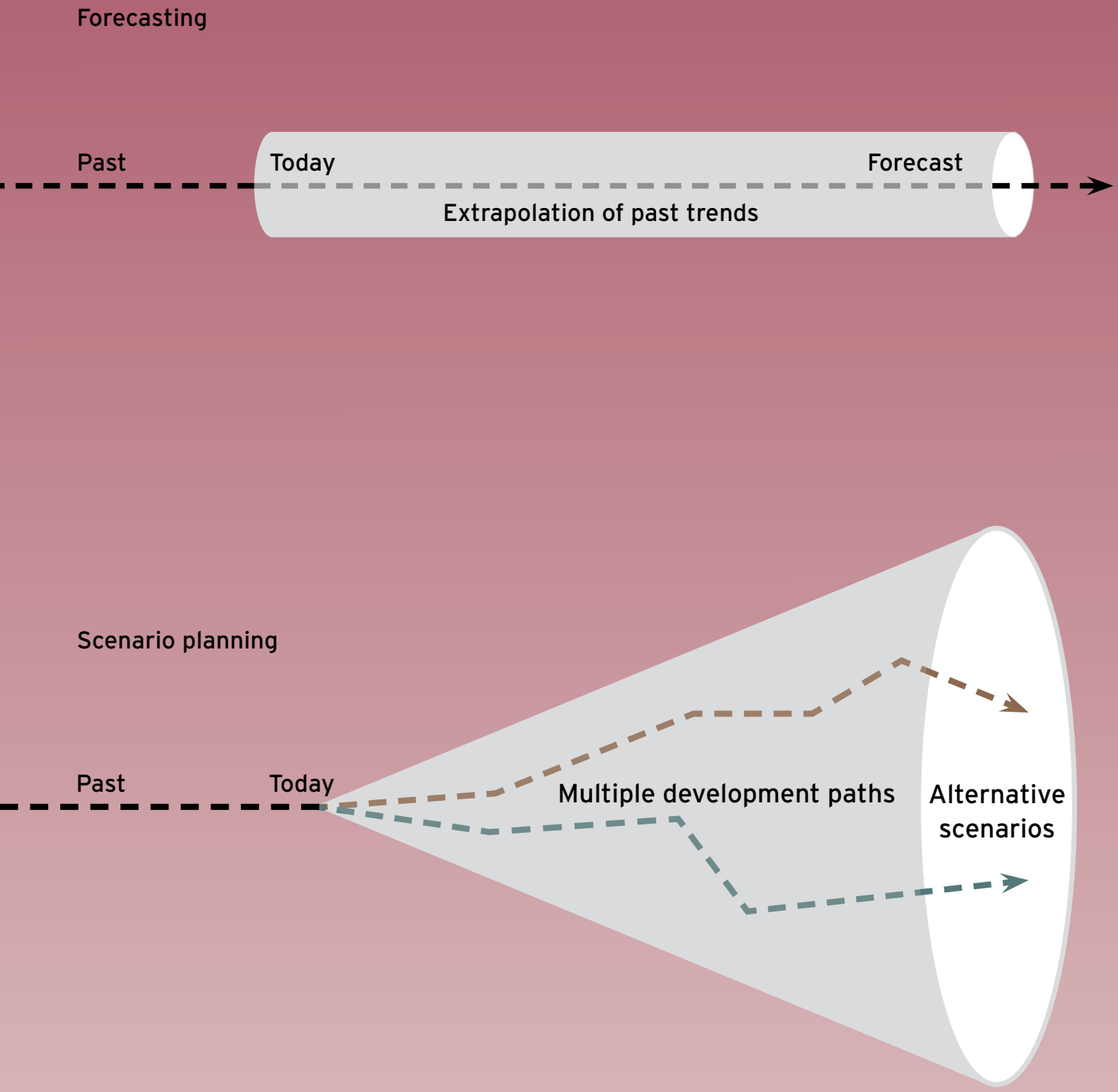


Figure A.1. Differentiating Scenarios from Forecasts

SOURCE: ifmo

Scenarios can be developed using several approaches (Mietzner and Reger, 2005). Early scenario-planning techniques focused on the solely qualitative and narrative description of different futures and mostly used intuitive approaches to arrive at these pictures and strategic statements (Kahn and Pepper, 1979). Over the years, different process steps were strengthened and formalized to address the complexity of strategic issues. Consistency analyses began to be used to measure scenario quality and relevance. Results were documented in narratives with statements relating to key indicators. Today, scenarios are developed with more-quantitative approaches that rely on multiple model runs and computer tools, which enhance the ability to cope with system complexity and make the resulting scenarios less arbitrary (see, for example, Gordon and Hayward, 1968; Kane, 1972; Gausemeier, Fink, and Schlake, 1998; Lempert, Popper, and Bankes, 2003; Bryant and Lempert, 2010; Rozenberg et al., 2012; Schweizer and Kriegler, 2012; Gerst, Wang, and Borsuk, 2013). Our methodological approach (outlined in Chapter One and presented in more detail here) is representative of a more quantitative approach to scenario development.

In the rest of this appendix, we describe each of the six steps of the scenario approach in detail.

Step 1: Select Influencing Areas

In the first step, the team identified influencing areas and descriptors relevant to building the scenarios. Influencing areas are topics germane to the scenario context. The team drew on past work on German and U.S. transportation futures, as well as additional background research on China, to identify four influencing areas: demographics, economics, energy, and transportation supply and constraints. Next, we identified descriptors within each influencing area; these were also based on prior research of the study team. We define descriptors as indicators within an influencing area; they can be quantitative or qualitative.

For each influencing area, RAND experts produced a paper documenting past trends for each descriptor over a period of 20 years, or, if data were unavailable, discussing the descriptors anecdotally. (Chapter Two presents a summary of past trends.)

Step 2: Elicit Projections on Descriptors

We held four workshops, one for each influencing area. We held workshops on demographics and on economics in the RAND Washington office in December 2013. We held workshops on energy and on transportation supply and constraints at the Wenjin Hotel near the campus of Tsinghua University in Beijing in May 2014. Six to eight outside experts participated in each workshop, for a total of 28 people (see Appendix B for a list of the U.S. experts and the affiliations of the Chinese experts). In a facilitated discussion (held in English at the U.S. workshops and in Chinese at the Beijing workshops), we asked the experts to develop a projection for each descriptor in 2030. The projection could be qualitative or quantitative. Each expert estimated his or her upper- and lower-bound projection, followed by his or her best estimate. We asked each expert to provide reasons that a certain projection might be plausible and under what conditions. We also asked each to discuss any qualitative effect on travel behavior and mode choice.

Table A.1 shows all 24 descriptors and 47 projections developed during the four workshops. For some descriptors, the experts agreed on a single projection. For example, the demographic experts agreed that urbanization would reach 70 percent in 2030. For other descriptors, participants produced multiple projections. In some cases, this was because opinions varied; in others, it was because the experts agreed that the future value of the descriptor would vary depending on other factors. For example, labor-force participation might rise if retirement ages increase or if wages decline, or remain the same as today if relaxation of the one-child policy leads to more parents staying home with children. The experts determined how many projections to produce for each descriptor.

Table A.1. Influencing Areas, Descriptors, and Projections

	DESCRIPTOR	PROJECTION
Influencing area: Demographics		
1.1	Total population	(a) 1.39 billion (0.18% per year)
		(b) 1.44 billion (0.34% per year)
1.2	Geographic distribution of population	41% of the population lives in the eastern region
1.3	Urbanization	70% of the population lives in urban areas
1.4	Commute distance	(a) Has increased slightly
		(b) Has increased significantly
1.5	Household type	(a) The percentage of the population living in family households has increased slightly
		(b) The percentage of the population living in family households has decreased slightly

Table A.1. Influencing Areas, Descriptors, and Projections — Continued

	DESCRIPTOR	PROJECTION
Influencing area: Economy		
2.1	Economic growth	(a) 2–3% average annual growth
		(b) 6–7% average annual growth
2.2	Share of the economy in the eastern region	(a) 43% (similar to current)
		(b) 50%
2.3	Income distribution	(a) Has decreased (Palma ratio of 1)
		(b) Remained equal (Palma ratio of 2)
		(c) Has increased (Palma ratio of 2.5)
2.4	Labor-force participation	(a) 76% of the adult population
		(b) 80% of the adult population
2.5	Domestic vehicle production	(a) 120 total vehicles per CNY 100 million of GDP (same as current)
		(b) 240 total vehicles per CNY 100 million of GDP
2.6.	Percentage of GDP spent on transportation infrastructure	(a) 2%
		(b) 4% (same as current)
Influencing area: Energy		
3.1	Oil price	(a) USD 100 per barrel (price in 2012 U.S. dollars)
		(b) USD 150 per barrel (price in 2012 U.S. dollars)
3.2	Oil consumption	(a) 70% of oil consumed is imported
		(b) 60% of oil consumed is imported
3.3	Introduction of effective GHG emission-reduction systems	National carbon market is in place by 2020
3.4	Adoption of electric and hybrid passenger cars	(a) 20% of the total fleet is electric and hybrid passenger vehicles
		(b) 30% of the total fleet is electric and hybrid passenger vehicles
3.5	Adoption of E-2Ws	(a) 10% annual increase until 2030
		(b) 5% annual increase until 2030
		(c) 2% annual increase until 2030

Table A.1. Influencing Areas, Descriptors, and Projections — Continued

	DESCRIPTOR	PROJECTION
Influencing area: Transportation supply and constraints		
4.1	Constraints on driving	(a) Have barely changed; no further constraints
		(b) Have been introduced in second- and third-tier cities
4.2	Constraints on vehicle ownership	(a) Have barely changed; no further constraints
		(b) Have been introduced in second- and third-tier cities
4.3	Convenience of public transit	(a) Convenience has increased significantly; customized transit systems for different tiers of cities
		(b) Convenience has increased moderately, mainly for tier 1 cities
4.4	Convenience of interurban rail	(a) Moderate growth
		(b) Strong growth
4.5	Demand for domestic air travel	(a) Moderate growth
		(b) Strong growth
4.6	Parking management in urban areas	(a) Parking has remained a major issue
		(b) The parking situation has improved slightly
4.7	Convenience of taxis and car-sharing	Black taxis have been legalized, and car-sharing systems have been introduced slowly
4.8	Infrastructure for nonmotorized transportation	(a) Has increased only slightly
		(b) Has increased significantly

Step 3: Integrate into Scenario Frameworks

We performed two types of analysis to develop the input to the scenarios. First, we conducted a cross-impact analysis between the descriptors across all influencing areas. This supported the identification of the key drivers in the system (see Gausemeier, Fink, and Schlake, 1998, for a further description of this type of analysis). We recorded the impacts that the different descriptors have on each other in a cross-impact matrix (or influence matrix) using a scale from 0 (no impact) to 3 (strong impact). For example, we determined that the total population has a strong influence on urbanization, so that relationship would be rated 3, while total population has no effect on the convenience of public transit, so that was rated 0. This exercise establishes the degree of interconnectedness among the descriptors.

The outcome of this analysis is the system diagram illustrated in Figure A.2. The higher the activity index of a descriptor, the more it influences other descriptors. For example, urbanization and economic growth affected a large number of other descriptors, so they are highly active. The higher the passivity index, the more other descriptors drive that descriptor. Many other descriptors affect oil consumption, so it is considered highly passive. A descriptor with both a high activity index and a high passivity index is strongly interconnected in the system, being driver and driven at the same time. This analysis was the basis for identifying some descriptors as key drivers.

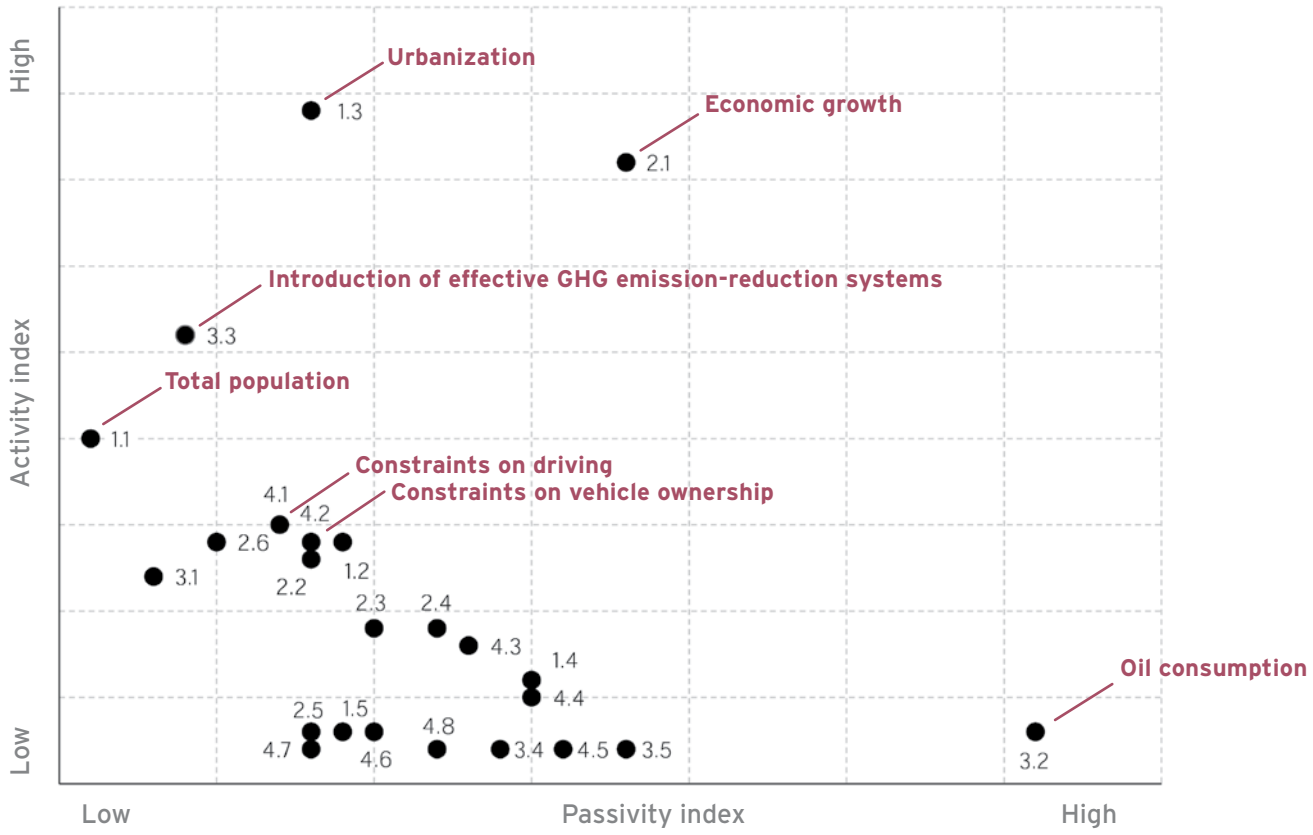


Figure A.2. System Dynamics as an Outcome of the Cross-Impact Analysis

NOTE: Numbers are cross-referenced to Table A.1.

The second type of analysis is based on consistency logic, which establishes consistency (or lack thereof) among projections across all descriptors. *Consistency* here means how well the projection of a particular row and column would "fit" and how realistic it would be for both of them to appear simultaneously. The matrix entry is a numerical value that represents the level of consistency, with 5 being totally consistent and 1 being totally inconsistent. We created a consistency matrix created using all projections for each descriptor (see extract in Figure A.3). We judged how consistent or compatible a projection in a row is with the projections in each column. For example, strong growth in demand for air travel was deemed consistent with the lower price of oil because demand is affected by price and higher oil prices mean more-expensive airfares. On the other hand, the experts deemed increasing concentration of economic output in the eastern region inconsistent with a decrease in income inequality because this region is already wealthier than the rest of the country, and greater concentration of economic activity in one region is likely to lead to a concentration of wealth as well.

		Economic growth			Share of the economy in the eastern region		Income distribution			Labor-force participation		Domestic vehicle production		Percentage of GDP spent on transportation infrastructure		Oil price	
		2-3% average annual growth	4-5% average annual growth	6-7% average annual growth	43% (similar to current)	50%	Has decreased	Remained equal	Has increased	76% of the adult population	80% of the adult population	120 total vehicles per 100 million CNY (same as current)	240 total vehicles per 100 million CNY	2%	4% (same as current)	USD 100 per barrel (real price in 2014)	USD 150 per barrel (real price in 2014)
Share of the economy in the eastern region	43% (similar to current)	3	4	2													
	50%	1	2	4													
Income distribution	Has decreased	1	3	2	2	1											
	Remained equal	3	4	3	5	2											
	Has increased	4	3	4	3	5											
Labor-force participation	76% of the adult population	1	4	2	4	3	2	3	4								
	80% of the adult population	1	2	4	3	4	4	2	2								
Domestic vehicle production	120 total vehicles per 100 million CNY (same as current)	2	5	2	3	3	2	3	4	3	3						
	240 total vehicles per 100 million CNY	1	2	5	3	3	4	2	2	3	3						
Percentage of GDP spent on transportation infrastructure	2%	1	5	2	3	3	3	3	3	3	3	3	3				
	4% (same as current)	1	2	5	3	3	3	3	3	3	3	3	3				
Oil price	USD 100 per barrel (real price in 2014)	4	5	1	3	3	3	3	3	3	3	3	3	3	3		
	USD 150 per barrel (real price in 2014)	1	1	5	3	3	3	3	3	3	3	3	3	3	3		
Oil consumption	70% of oil is imported	1	2	4	3	4	5	4	2	2	5	2	4	3	3	5	1
	60% of oil is imported	3	4	2	4	3	2	3	4	4	2	4	2	3	3	1	5

Figure A.3. Extract from the Consistency Matrix, Including Projection Pairs

NOTE: This analysis compares each pair of projections to determine whether they are consistent. We need to compare each pair only once, so the shaded cells are not used.

Rating scale

1 = Totally inconsistent
2 = Partially inconsistent
3 = Neutral or independent
4 = Consistent
5 = Strongly consistent

The consistency matrix was then fed into an online tool, the RAHS platform.[1] RAHS is a prototype of a web-based foresight platform that the Future Analysis Branch of the German Federal Ministry of Defence developed and funded to enhance external cooperation with industrial and scientific partners and thus to strengthen the methodological fundamentals of its own foresight work. Instead of providing a single software solution only for scenario development, it supports foresight projects with a variety of alternative foresight methods within a web-based online environment (Brockmann, 2012; Durst, Kolonko, and Durst, 2012). RAHS was designed based on a comprehensive scanning of internationally applied foresight methods and tools, including the Z_punkt Foresight-Toolbox, the Joint Research Centre (JRC) FOR-LEARN Online Foresight Guide, the Foresight Horizon Scanning Centre (HSC) toolkit, the European Union (EU) research project iKnow, and compilations of future research methodologies in the Millennium Project by Glenn and Gordon (2009) and Pillkahn (2007).

For this project, ifmo researchers led the use of RAHS to analyze millions of mathematically possible pairs of projections for the descriptors across all influencing areas and to eliminate the pairs deemed inconsistent in the consistency analysis that preceded this step. The exploratory scenario-construction toolbox in RAHS isolated clusters made up of homogeneous groups of descriptors and projections based on the consistency-analysis results. (More details on the application of consistency logic and cluster analysis implemented in the RAHS platform can be found in Gausemeier, Fink, and Schlake, 1998).

The RAHS output (see Table A.2) enabled the experts to identify scenarios that differ as widely as possible from each other. Of the four clusters produced, numbered 1 through 4 in Table A.2, the research team selected two to develop further. Clusters 1, 2, and 3 were similar across many descriptors, so first the team decided that only one of the three should be carried forward. Cluster 4 was included specifically because it varied so greatly from the other three. For example, cluster 4 had a lower average GDP growth rate. We thought it was important to include different growth rates because, at this stage of development, economic growth is generally an important, though hardly the only, determinant of mobility. The research team finally chose cluster 2 because its projections for total population, share of the economy in the eastern region, and domestic vehicle production differed from those in cluster 4.

[1] Although this platform is accessible online, it is only in German and requires a password to view.

Table A.2. Share of Projections Within Each Cluster

Descriptor	Projection	Cluster			
		1	2	3	4
Total population	1.39 billion (0.18% per year)	100	0	100	100
	1.44 billion (0.34% per year)	0	100	0	0
Geographic distribution of population	41% of the population lives in the eastern region	100	100	100	100
Urbanization	70% of the population lives in urban areas	100	100	100	100
Commute distance	Has increased slightly	60	87	87	0
	Has increased significantly	40	13	13	100
Household type	The percentage of the population living in family households has increased slightly	10	0	0	100
	The percentage of the population living in family households has decreased slightly	90	100	100	0
Economic growth	2–3% average annual growth	0	0	0	0
	4–5% average annual growth	0	0	0	100
	6–7% average annual growth	100	100	100	0
Share of the economy in the eastern region	43% (similar to current)	100	4	23	100
	50%	0	96	77	0
Income distribution	Has decreased	0	4	0	0
	Has remained equal	5	0	3	33
	Has increased	95	96	97	67
Labor-force participation	76% of the adult population	100	7	19	100
	80% of the adult population	0	94	81	0
Domestic vehicle production	120 total vehicles per CNY 100 million of GDP (same as current)	100	41	100	100
	240 total vehicles per CNY 100 million of GDP	0	59	0	0
Percentage of GDP spent on transportation infrastructure	2%	0	4	0	100
	4% (same as current)	100	96	100	0
Oil price	USD 100 per barrel (real price in 2014)	0	0	0	100
	USD 150 per barrel (real price in 2014)	100	100	100	0
Oil consumption	70% of oil consumed is imported	0	0	0	100
	60% of oil consumed is imported	100	100	100	0

Table A.2. Share of Projections Within Each Cluster — Continued

Descriptor	Projection	Cluster			
		1	2	3	4
Introduction of effective GHG emission-reduction systems	National carbon market is in place by 2020	100	100	100	100
Adoption of electric and hybrid passenger cars	20% of the total fleet is electric and hybrid passenger vehicles	15	13	13	100
	30% of the total fleet is electric and hybrid passenger vehicles	85	87	87	0
Adoption of E-2Ws	10% annual increase until 2030	75	100	100	0
	5% annual increase until 2030	10	0	0	0
	2% annual increase until 2030	15	0	0	100
Constraints on driving	Have barely changed; no further constraints	10	13	13	100
	Have been introduced in second- and third-tier cities	90	87	87	0
Constraints on vehicle ownership	Have barely changed; no further constraints	10	13	13	100
	Have been introduced in second- and third-tier cities	90	87	87	0
Convenience of public transit	Has increased strongly; customized transit systems for different tiers of cities	80	87	90	0
	Has increased moderately but mainly for tier 1 cities	20	13	10	100
Convenience of interurban rail	Moderate growth	100	33	74	100
	Strong growth	0	67	26	0
Demand for domestic air travel	Moderate growth	100	33	74	100
	Strong growth	0	67	26	0
Parking management in urban areas	Parking has remained a major issue	85	87	87	33
	The parking situation has slightly improved	15	13	13	67
Convenience of taxis and car-sharing	Black taxis have been legalized, and car-sharing systems have been introduced slowly	100	100	100	100
Infrastructure for nonmotorized transportation	Has increased only slightly	10	0	0	100
	Has increased significantly	90	100	100	0

Step 4: Produce Scenario Narratives

Using the two selected scenario frameworks, the research team wrote a narrative for each scenario. We developed the storylines by interlinking active and passive descriptors. We highlighted and interpreted key developments and interrelations. Thus, the scenarios describe not only the situation in 2030 but also how a situation developed step by step during that time frame. The scenarios represent a dynamic path, starting today and continuing to 2030. Using standard convention, we wrote all narratives from the vantage point of 2030.

Step 5: Draw Consequences for Future Mobility

This step generally consists of developing future estimates of mobility based empirically on past trends and ratings of directional influence (that is, whether a projection would encourage higher or lower use of a mode), as well as the strength of the influence in each scenario on travel. However, the lack of reliable Chinese data on personal travel at the national level made conducting this type of exercise difficult because it cannot be based on past trends. As such, we instead discussed changes in travel demand in a more qualitative manner (e.g., strong increase versus moderate increase). We also wove in more broadly some thoughts about the prevalence of new technologies (such as advanced driver-assistance systems) and new access models (such as car-sharing) based on other drivers in each scenario.

Step 6: Create Wild-Card Scenario

In scenario development, wild cards are highly unlikely but possible events that have a major impact on the future. They are disruptive and surprising, and they undermine the trends or developments presented in a scenario. During the workshops, we asked the experts to think about which wild cards would have a strong and sustained impact on future mobility in China. We determined that, given the importance of economic growth, we would include a wild card in which China falls into a period of sustained weak growth, which would represent a very different future.


花旗银行

Appendix B
List of Experts

Table B.1 lists the outside experts who participated in each workshop, as well as each expert's professional affiliations at the time the workshop took place. (The table does not include RAND and ifmo staff who were also present.) We held two expert workshops in the RAND Washington office in Arlington, Virginia, and two in Beijing.

Table B.1. Expert Workshop Participants

Workshop and Date	Expert	Affiliation
Demographics, December 5, 2013, Arlington, Virginia	Judith Banister	Javelin Investments
	Christopher Cherry	University of Tennessee, Knoxville
	Cindy Fan	University of California, Los Angeles
	Peilei Fan	Michigan State University
	Abhas Jha	World Bank
	Ziqi Song	Utah State University
	Loraine West	U.S. Census Bureau
Economics, December 10, 2013, Arlington, Virginia	Patrick Chovanec	Silvercrest Asset Management Group
	Damien Ma	Paulson Institute
	Paul Marks	Argosy International
	Stephen Markscheid	Independent director
	Samm Sacks	Eurasia Group
	Zhirong "Jerry" Zhao	University of Minnesota
Energy, May 28, 2014, Beijing		China Automotive Energy Research Center, Tsinghua University (two experts)
		Institute of Low-Carbon Economy, Tsinghua University
		Department of Automotive Engineering, Tsinghua University
		Economics and Technology Research Institute, China National Petroleum Corporation
		Beijing Bright Future Auto-Industry Consulting
		Southwest Jiaotong University
Transportation supply and constraints, May 30, 2014, Beijing		China Automotive Energy Research Center, Tsinghua University (two experts)
		Department of Automotive Engineering, Tsinghua University
		Shanghai City Comprehensive Transportation Planning Institute
		Beijing Jiaotong University
		China Academy of Railway Sciences
		Chinese Academy of Civil Aviation Science and Technology
		Beijing Bright Future Auto-Industry Consulting

Bibliography

"All Dried Up: Northern China Is Running Out of Water, but the Government's Remedies Are Potentially Disastrous," *Economist*, October 12, 2013. As of April 5, 2015: http://www.economist.com/news/china/21587813-northern-china-running-out-water-governments-remedies-are-potentially-disastrous-all

Amer, Muhammad, Tugrul U. Daim, and Antonie Jetter, "A Review of Scenario Planning," *Futures*, Vol. 46, February 2013, pp. 23–40.

Asian Development Bank, *Parking Policy in Asian Cities*, Manila, Philippines, 2011.

Badkar, Mamta, "Economist Warns That China's 'Bear Stearns Moment' May Strike Any Time," *Business Insider*, March 17, 2014. As of April 5, 2015: http://www.businessinsider.com/chinas-bear-stearns-moment-may-strike-2014-3

Bai Tiantian, "Beijing Mulls Vehicle Congestion Charge," *Global Times*, September 3, 2013. As of November 11, 2014: http://www.globaltimes.cn/content/808172.shtml

Beijing Bureau of Transportation Management, "道路交通安全违法行为记分标准 [Scoring criteria for road traffic safety violations]," undated.

Beijing Evening News, "北京每天5800辆车乱停挨罚 停车位供不应求 [5,800 illegally parked cars receive tickets every day in Beijing: Parking supply does not meet demand]," October 16, 2013.

Beijing Municipal Commission of Development and Reform, "北京市发展和改革委员会关于开展碳排放权交易试点工作的通知 [Beijing Municipal Commission of Development and Reform on the issuance of implementation work plan for pilot carbon emissions trading markets]," November 22, 2013. As of December 26, 2013, in Chinese: http://www.bjpc.gov.cn/tztg/201311/t7020680.htm

Beijing Municipal Committee of Communications, Beijing Transportation Research Center, and World Bank, *Research on Beijing's Public Transportation Commuting Transit Network*, July 2009.

Beijing Municipal Committee of Communications, BJTRC, and World Bank—*See* Beijing Municipal Committee of Communications, Beijing Transportation Research Center, and World Bank.

"Beijing Taxi Troubles Tackled in CASS Report," *Global Times*, December 27, 2012. As of November 11, 2014: http://www.globaltimes.cn/content/752631.shtml

"Beijing to Impose Odd-Even Car Ban During Heavy Pollution," *Telegraph*, October 17, 2013. As of November 11, 2014: http://www.telegraph.co.uk/news/worldnews/asia/china/10386738/Beijing-to-impose-odd-even-car-ban-during-heavy-pollution.html

Beijing Transportation Research Center, "2010年北京交通发展年度报告 [Beijing transportation annual report, 2010]," July 2010. As of February 18, 2015, in Chinese: http://www.bjtrc.org.cn/InfoCenter%5CNewsAttach%5C%5C58183610-583f-410d-bc03-b6acbb17f697.pdf

——, "2011年北京交通发展年度报告 [Beijing transportation annual report, 2011]," August 2011. As of February 18, 2015, in Chinese: http://www.bjtrc.org.cn/InfoCenter%5CNewsAttach%5C%5Caeb7c878-d31e-4f08-982f-3c17c717c87b.pdf

Börjeson, Lena, Mattias Höjer, Karl-Henrik Dreborg, Tomas Ekvall, and Göran Finnveden, "Scenario Types and Techniques: Towards a User's Guide," *Futures*, Vol. 38, No. 7, September 2006, pp. 723–739.

Bradsher, Keith, "Speedy Trains Transform China," *New York Times*, September 23, 2013. As of November 11, 2014: http://www.nytimes.com/2013/09/24/business/global/high-speed-train-system-is-huge-success-for-china.html

Brockmann, Kathrin, "Futures Analysis Cooperation Tool in the German Armed Forces," *Foreknowledge*, No. 4, August 2012, pp. 6–7. As of April 20, 2015: http://issuu.com/foreknowledge/docs/foreknowledge4/7?e=4348323/2968825

Bryant, Benjamin P., and Robert J. Lempert, "Thinking Inside the Box: A Participatory, Computer-Assisted Approach to Scenario Discovery," *Technological Forecasting and Social Change*, Vol. 77, No. 1, January 2010, pp. 34–49.

Bureau of Transportation Statistics, U.S. Department of Transportation, "World Motor Vehicle Production, Selected Countries (Thousands of Vehicles)," *National Transportation Statistics*, Table 1-23, updated October 2014. As of April 7, 2015: http://www.rita.dot.gov/bts/sites/rita.dot.gov.bts/files/publications/national_transportation_statistics/html/table_01_23.html

——, *National Transportation Statistics*, updated January 2015; referenced April 14, 2015. As of April 20, 2015: http://www.rita.dot.gov/bts/sites/rita.dot.gov.bts/files/publications/national_transportation_statistics/index.html

Cai Xiao, "Rail Sector Sets 200,000 km Target," *China Daily*, July 22, 2014. As of April 5, 2015: http://www.chinadailyasia.com/business/2014-07/22/content_15151103.html

CAPA Centre for Aviation, "China Airport Wrap: Beijing Still Not #1 While Western China Airports Lead Double-Digit Growth," May 20, 2013. As of November 11, 2014: http://centreforaviation.com/analysis/china-airport-wrap-beijing-still-not-1-while-western-china-airports-lead-double-digit-growth-110139

Casey, Michael J., "Has China's Debt Crisis Moment Arrived?" *Wall Street Journal*, October 23, 2013. As of April 5, 2015: http://blogs.wsj.com/moneybeat/2013/10/23/has-chinas-debt-crisis-moment-arrived/

Central People's Government of the People's Republic of China, "国务院关于印发"十二五"控制温室气体排放工作方案的通知 [Notice from the state council on issuing the work plan for greenhouse-gas emission control during the 12th five-year plan period]," January 13, 2012a. As of April 20, 2015, in Chinese: http://www.gov.cn/zwgk/2012-01/13/content_2043645.htm

——, "山西太原推广公共自行车提倡绿色出行 [Taiyuan expands public bicycle system, advocates green transportation]," September 14, 2012b. As of November 19, 2014, in Chinese: http://www.gov.cn/jrzg/2012-09/14/content_2224687.htm

Chang, Jack, "Nation's Drought Worsens Water Shortage," Associated Press, September 24, 2014.

Chen, Yougang, Stefan Matzinger, and Jonathan Woetzel, "Chinese Infrastructure: The Big Picture," *McKinsey Quarterly*, Vol. 3, 2013, pp. 8–15.

Chengdu Business News, "成都12.5公里滨江绿道 明年开始任你行 [You can use the 12.5-kilometer Chengdu Binjiang Greenway starting next year]," October 19, 2010. As of November 19, 2014, in Chinese: http://inf.315che.com/n/2010_10/131082/

Cherry, Christopher, email exchange with Liisa Ecola and Kun Gu, December 23, 2013.

"China: A Question of Trust," *Economist*, May 10, 2014. As of April 5, 2015: http://www.economist.com/news/special-report/21601622-or-not-case-may-be-question-trust

China Automotive Technology and Research Center, Nissan (China) Investment Company, and Dongfeng Automobile Company, *Annual Report on New Energy Vehicle Industry in China (2013)*, Social Science Academic Press, China, September 2013.

China Carbon Emission Trade, "碳税或将在'十三五'中期出台 [Carbon tax may be launched during the middle of the 13th five-year plan]," December 14, 2013.

China Daily, "成都二环内设10个公共自行车租赁点部分已建好 [Ten bike-share kiosks to be set up inside Chengdu's second ring road, several already completed]," December 14, 2010. As of November 19, 2014, in Chinese: http://www.chinadaily.com.cn/dfpd/2010-12/14/content_11697922.htm

——, "北京将改善自行车出行环境鼓励绿色出行 [Beijing will improve the environment for bicycle travel to encourage green transportation]," September 27, 2013. As of November 11, 2014, in Chinese: http://www.chinadaily.com.cn/hqpl/zggc/2013-09-27/content_10215914.html

China Jiangsu Online, "电动汽车也能分时租赁 [Electric vehicles can also be rented]," December 30, 2013. As of November 19, 2014, in Chinese: http://js.xhby.net/system/2013/12/30/019796586.shtml

"China Signals Clampdown on Foreign Car Makers: Commerce Ministry to Review Rules Governing Auto Pricing and Distribution," *Wall Street Journal*, August 23, 2013.

"China to Restore Confidence in High-Speed Trains," *China Daily*, May 9, 2012. As of November 11, 2014: http://www.chinadaily.com.cn/business/2012-05/09/content_15246909.htm

"Chinese Dilemma: 170 Auto Makers—Local Government Incentives Keep Small Companies Expanding Even as Beijing Tries to Encourage Industry Consolidation," *Wall Street Journal*, April 9, 2013.

Civil Aviation Administration of China, "民航机场业务量（排序）[Civil aviation airport traffic], (ranked)" 2013. As of November 19, 2014, in Chinese: http://www.caac.gov.cn/I1/K3/201303/P020130327299233850801.pdf

Cobham, Alex, and Andy Sumner, *Is It All About the Tails? The Palma Measure of Income Inequality*, Washington, D.C.: Center for Global Development Working Paper 343, 2013.

Custer, C., "Chinese City Launches Mobile Taxi App for Easy Cab Pickups," *Tech in Asia*, January 3, 2013.

Daily Economic News, "课题组专家：碳税最快明年实施 [Expert task force: Carbon tax may be implemented next year]," May 25, 2010. As of December 15, 2014, in Chinese: http://www.cfej.net/?thread-17622-1.html

Das, Satyajit, "China's Shadow Banking System," *EconoMonitor,* April 16, 2014. As of April 5, 2015: http://www.economonitor.com/blog/2014/04/chinas-shadow-banking-system/

Dunne, Timothy J., "The Global Auto Industry's Balance of Power Shifts to Emerging Markets," *CreditWeek*, September 25, 2013, pp. 12–18.

Durst, Carolin, Thomas Kolonko, and Michael Durst, "Kooperations-dilemma in der Zukunftsforschung Ein IT-basierter Lösungsansatz der Bundeswehr [Cooperation dilemma in future analysis: A web-based approach by the German Armed Forces]," *Proceedings Multikonferenz Wirtschaftsinformatik*, Braunschweig, February 29, 2012.

Ecola, Liisa, Charlene Rohr, Johanna Zmud, Tobias Kuhnimhof, and Peter Phleps, *The Future of Driving in Developing Countries*, Santa Monica, Calif.: RAND Corporation, RR-636-ifmo, 2014. As of April 6, 2015: http://www.rand.org/pubs/research_reports/RR636.html

Eichengreen, Barry, "Do the Brics Need Their Own Development Bank?" *Guardian*, August 14, 2014. As of April 20, 2015: http://www.theguardian.com/business/2014/aug/14/brics-development-bank-imf-world-bank-dollar

Fung, Esther, "More Than 1 in 5 Homes in Chinese Cities Are Empty, Survey Says," *Wall Street Journal*, June 11, 2014.

Gausemeier, Juergen, Alexander Fink, and Oliver Schlake, "Scenario Management: An Approach to Develop Future Potentials," *Technological Forecasting and Social Change*, Vol. 59, No. 2, October 1998, pp. 111–130.

Gerst, M. D., P. Wang, and M. E. Borsuk, "Discovering Plausible Energy and Economic Futures Under Global Change Using Multidimensional Scenario Discovery," *Environmental Modelling and Software*, Vol. 44, June 2013, pp. 76–86.

Glenn, Jerome C., and Theodore J. Gordon, *Futures Research Methodology, Version 3.0*, Washington, D.C.: Millennium Project, 2009. As of April 4, 2013: http://www.millennium-project.org/millennium/FRM-V3.html

Goodell, Jeff, "China, the Climate and the Fate of the Planet," *Rolling Stone*, September 15, 2014. As of April 5, 2015: http://www.rollingstone.com/politics/news/china-the-climate-and-the-fate-of-the-planet-20140915

Gordon, Theodore J., and H. Hayward, "Initial Experiments with the Cross Impact Matrix Method of Forecasting," *Futures*, Vol. 1, No. 2, December 1968, pp. 100–116.

Gough, Neil, "China Says Local-Level Debt Soars, Stirring Fear," *New York Times*, December 30, 2013. As of April 5, 2015: http://www.nytimes.com/2013/12/31/business/international/chinese-local-government-debt-up-13-in-6-months.html

Grabar, Henry, "China's Electric Bicycle Boom: Will the Fashion Last?" *China Dialogue*, September 25, 2013. As of April 20, 2015: https://www.chinadialogue.net/article/show/single/en/6372-China-s-electric-bicycle-boom-will-the-fashion-last-

"Guangzhou to Allocate New Car Plates Through Auction, Lottery," Xinhua News, July 10, 2012.

Henan Provincial Department of Transportation, "济源市加强公共自行车服务系统运行管理 [Jiyuan City improves the operations and management of the public bicycle service system]," August 22, 2013.

"High-Speed Railways: Faster Than a Speeding Bullet," *Economist*, November 9, 2013. As of November 11, 2014: http://www.economist.com/news/china/21589447-chinas-new-rail-network-already-worlds-longest-will-soon-stretch-considerably-farther-faster

Hoffman, David, and Andrew Polk, *The Long Soft Fall in Chinese Growth: Business Realities, Risks and Opportunities*, New York: Conference Board, R-1563-14-RR, October 2014.

IHS, "Global Vehicle Production to Increase by 21 Million Units by 2021; China to Account for Half of the Increment, Europe and North America to Experience Growth and Japan Production to Decline, According to IHS Automotive," May 8, 2014. As of April 5, 2015: http://press.ihs.com/press-release/automotive/global-vehicle-production-increase-21-million-units-2021-china-account-half

IMF—*See* International Monetary Fund.

International Energy Agency, *EV City Casebook: A Look at the Global Electric Vehicle Movement*, Paris: International Energy Agency, Rocky Mountain Institute, Implementing Agreement for Cooperation on Hybrid and Electric Vehicle Technologies and Programmes, and the Electric Vehicles Initiative of the Clean Energy Ministerial, 2012. As of November 20, 2014: http://www.iea.org/publications/freepublications/publication/EVCityCasebook.pdf

International Monetary Fund, World Economic Outlook Database, October 2012. As of November 20, 2014: http://www.imf.org/external/pubs/ft/weo/2012/02/weodata/index.aspx

——, "China: Gross Domestic Product, Constant Prices," last updated September 2013. As of November 20, 2014: http://www.imf.org/external/pubs/ft/weo/2013/02/weodata/weorept.aspx?sy=1990&ey=2012&scsm=1&ssd=1&sort=country&ds=.&br=1&c=924&s=NGDP_R%2CNGDP_D&grp=0&a=&pr1.x=24&pr1.y=10

Jing Guoshang and Wang Bo, "广州市居民出行特征变化趋势分析 [Analysis of trends in Guangzhou residents' travel characteristics]," *Journal of Huazhong University of Science and Technology (Urban Science Edition)*, Vol. 21, No. 2, June 2004. As of February 18, 2015, in Chinese: http://lib.cnki.net/cjfd/WHCJ200402026.html

Kahn, Herman, and Thomas Pepper, *The Japanese Challenge: The Success and Failure of Economic Success*, New York: Crowell, 1979.

Kahn, Herman, and Anthony J. Wiener, "The Next Thirty-Three Years: A Framework for Speculation," *Daedalus*, Vol. 96, No. 3, Summer 1967, pp. 705–732.

Kamal-Chaoui, Lamia, Edward Leman, and Zhang Rufei, *Urban Trends and Policy in China*, Paris: Organisation for Economic Co-operation and Development Regional Development Working Paper 2009/1, 2009. As of November 11, 2014: http://www.oecd.org/china/42607972.pdf

Kane, Julius, "A Primer for a New Cross-Impact Language: KSIM," *Technological Forecasting and Social Change*, Vol. 4, No. 2, 1972, pp. 129–142.

Kishimoto, Paul N., Sergey Paltsev, and Valerie J. Karplus, *The Future Energy and GHG Emissions Impact of Alternative Personal Transportation Pathways in China*, Cambridge, Mass.: Massachusetts Institute of Technology Joint Program on the Science and Policy of Global Change, Report 231, October 2012. As of April 5, 2015: http://dspace.mit.edu/handle/1721.1/73607

Krieger, Axel, Larry Wang, Philipp Radtke, and Christian Malorny, "Recharging China's Electric-Vehicle Aspirations," McKinsey and Company, July 2012. As of April 5, 2015: http://www.mckinsey.com/insights/energy_resources_materials/recharging_chinas_electric-vehicle_aspirations

Kuhn, Anthony, "China Agrees to Pollution Limits, but Will It Make a Difference?" *National Public Radio*, November 14, 2014. As of April 5, 2015: http://www.npr.org/blogs/parallels/2014/11/14/364001658/china-agrees-to-pollution-limits-but-will-it-make-a-difference

Kuo, Lily, "China Has Launched the Largest Water-Pipeline Project in History," *Atlantic*, March 7, 2014. As of April 20, 2015: http://www.theatlantic.com/international/archive/2014/03/china-has-launched-the-largest-water-pipeline-project-in-history/284300/

Lempert, Robert J., Steven W. Popper, and Steven C. Bankes, *Shaping the Next One Hundred Years: New Methods for Quantitative, Long-Term Policy Analysis*, Santa Monica, Calif.: RAND Corporation, MR-1626-RPC, 2003. As of April 20, 2015: http://www.rand.org/pubs/monograph_reports/MR1626.html

Liu Baoxing, "碳税征收政策或将在2017年左右出台 拟每吨二氧化碳征10元 [Carbon tax might be introduced around 2017; every ton of emitted carbon likely to be taxed at 10 yuan]," December 9, 2013. As of December 26, 2013, in Chinese: http://www.tanpaifang.com/tanshui/2013/1209/26770.html

Lu Ximing and Gu Xiaotao, "上海市第五次居民出行调查与交通特征研 [The fifth travel survey of residents in Shanghai and analysis of travel characteristics]," *Urban Transport of China*, Vol. 9, No. 5, September 2011. As of February 18, 2015, in Chinese: http://www.chinautc.com/upload/accessorychinautc/pdf/20131291481947534.pdf

Luo Dian and Gan Yonghua, "城市空间发展对居民出行特征的影响研究——以广州为例 [Study about impact of urban area development on residents' travel characteristics: A case research on Guangzhou City]," *Traffic and Transportation*, Vol. z1, 2010.

Mietzner, Dana, and Guido Reger, "Advantages and Disadvantages of Scenario Approaches for Strategic Foresight," *International Journal of Technology Intelligence and Planning*, Vol. 1, No. 2, 2005, pp. 220–239.

Millward, Steven, "Uber Takes Its Limos into Third City in China," *Tech in Asia*, December 5, 2013.

"Motorist Gets £80,000 Fine for Speeding in Finland . . . Because He's Rich," *Daily Mail*, October 13, 2013. As of April 5, 2015: http://www.dailymail.co.uk/news/article-2458711/Motorist-Anders-Wiklvf-gets-80-000-fine-speeding-Finland-hes-rich.html

National Bureau of Statistics of China, National Data, undated. As of December 20, 2013, in Chinese: http://data.stats.gov.cn/workspace/index?m=hgnd

——, *China Statistical Yearbook*, 1996.

——, *China Statistical Yearbook*, 1997.

——, *China Statistical Yearbook*, 1998.

——, *China Statistical Yearbook*, 1999.

——, *China Statistical Yearbook*, 2000.

——, *China Statistical Yearbook*, 2001.

——, *China Statistical Yearbook*, 2002.

——, *China Statistical Yearbook*, 2003.

——, *China Statistical Yearbook*, 2004.

——, *China Statistical Yearbook*, 2005.

——, *China Statistical Yearbook*, 2006.

——, *China Statistical Yearbook*, 2007.

——, *China Statistical Yearbook*, 2008.

——, *China Statistical Yearbook*, 2009.

——, *China Statistical Yearbook*, 2010.

——, *China Statistical Yearbook*, 2011.

——, *China Statistical Yearbook*, 2012.

National Development and Reform Commission, "国家发展改革委办公厅关于开展碳排放权交易试点工作的通知 [Notice from General Office of National Development and Reform Commission on the development of pilot carbon emission-trading markets]," October 29, 2011.

——, "国家发展改革委办公厅关于印发首批10个行业企业温室气体排放核算方法与报告指南(试行)的通知 [National Development and Reform Commission on the issuance of the greenhouse-gas emissions accounting methods and reporting guidelines (trial) for the first batch of ten industries and enterprises]," October 15, 2013.

NDRC—*See* National Development and Reform Commission.

Organisation for Economic Cooperation and Development, *OECD Territorial Reviews: Guangdong, China 2010*, Geneva, November 15, 2010. As of April 5, 2015: http://www.oecd-ilibrary.org/urban-rural-and-regional-development/oecd-territorial-reviews-guangdong-china-2010_9789264090088-en

Osnos, Evan, "Boss Rail: The Disaster That Exposed the Underside of the Boom," *New Yorker*, October 22, 2012. As of April 20, 2015: http://www.newyorker.com/magazine/2012/10/22/boss-rail

Pillkahn, Ulf, *Trends und Szenarien als Werkzeuge zur Strategieentwicklung* [Trends and scenarios as instruments for strategy development], Erlangen: Publicis Publishing, 2007.

Ping An Insurance (Group) Company of China, "车险种类 [Types of auto insurance]," undated.

Popper, Steven W., Nidhi Kalra, Richard Silberglitt, Edmundo Molina-Perez, Youngbok Ryu, and Mike Scarpati, *Strategic Issues Facing Transportation, Vol. 3: Expediting Future Technologies for Enhancing Transportation System Performance*, Washington, D.C.: Transportation Research Board, National Cooperative Highway Research Program Report 750, 2013. As of April 20, 2015: http://www.trb.org/Main/Blurbs/170083.aspx

Prabu, Karthick, "Chinese Online Car Rental Market Shifts to Top Gear as Yongche Raises $60 Million," *tnooz*, December 19, 2013. As of November 11, 2014: http://www.tnooz.com/article/chinese-online-car-rental-market-shifts-top-gear-yongche-raises-60-million

Purdy, Mark, Gong Li, and David Light, "The View from China's Productivity Frontier," Accenture, February 2014. As of April 5, 2015: http://www.accenture.com/us-en/outlook/Pages/outlook-journal-2014-beyond-capital-and-labor-china-productivity-frontier.aspx

Qi, Liyan, "China Won't Bail Out Debt-Laden Local Governments: Beijing Will Impose Ceilings on Localities' Borrowing," *Wall Street Journal*, October 3, 2014.

Qiu Quanlin, "Guangzhou to Keep Even-Odd License Plate Rule," *China Daily*, December 29, 2010. As of November 11, 2014: http://www.chinadaily.com.cn/china/2010-12/29/content_11768648.htm

Randall, Tom, "Pain at the Pump: Gasoline Prices by Country," Bloomberg Visual Data, September 3, 2013. As of November 11, 2014: http://www.bloomberg.com/visual-data/gas-prices/20133:China:USD:g

Reja, Binyam, Paul Amos, and Fan Hongye, "China Road Tolls Policy: Past Achievements and Future Directions," World Bank, June 14, 2013. As of November 11, 2014: http://www.worldbank.org/en/news/opinion/2013/06/14/china-road-tolls-policy-past-achievements-and-future-directions

Rogowsky, Mark, "Kandi Crush: An Electric-Car Vending Machine from China Could Upend the Auto Industry," *Forbes*, December 28, 2013. As of November 11, 2014: http://www.forbes.com/sites/markrogowsky/2013/12/28/kandi-crush-an-electric-car-vending-machine-from-china-could-upend-the-auto-industry/

Rozenberg, Julie, Céline Guivarch, Robert Lempert, and Stéphane Hallegatte, *Building SSPs for Climate Policy Analysis: A Scenario Elicitation Methodology to Map the Space of Possible Future Challenges to Mitigation and Adaptation*, Fondazione Eni Enrico Mattei Working Paper 52.2012, 2012. As of April 20, 2015: http://www.feem.it/getpage.aspx?id=4951&sez=Publications&padre=73

Ruan, Y., C. C. Hang, Y. M. Wang, and R. F. Ma, "The Role of Government in an Emerging Disruptive Innovation: The Case of E-Bike in China," paper presented at the 2012 Institute of Electrical and Electronics Engineers International Conference on Management of Innovation and Technology, 2012.

Russell, Clyde, "China Crude Oil Impact Strength Masks Full Story," Reuters, October 22, 2013. As of April 20, 2015: http://www.reuters.com/article/2013/10/22/column-russell-china-oil-idUSL3N0IC0B120131022

Schweizer, Vanessa Jine, and Elmar Kriegler, "Improving Environmental Change Research with Systematic Techniques for Qualitative Scenarios," *Environmental Research Letters*, Vol. 7, No. 4, 2012.

Sen, Sandip, "Exporting China's E-Bike Marvel," *China Dialogue*, April 5, 2012. As of April 20, 2015: https://www.chinadialogue.net/article/show/single/en/4855-Exporting-China-s-e-bike-marvel

"Shanghai Car Plate Auction Hits New High," Xinhua News, May 19, 2012.

"Shanghai Puts Cap on License Plates," Xinhua News, October 21, 2013.

"Shanghai Studies Traffic Congestion Charge to Control Pollution," *Bloomberg Business*, October 18, 2013. As of November 11, 2014: http://www.bloomberg.com/news/2013-10-18/shanghai-studies-traffic-congestion-charge-to-control-pollution.html

Shao, Xiaoyi, and Kevin Yao, "China Home Price Fall Deepens Despite Policy Support, FDI Slips," Reuters, November 18, 2014. As of April 5, 2015: http://www.reuters.com/article/2014/11/18/us-china-property-prices-idUSKCN0J204U20141118

Sicular, Terry, "The Challenge of High Inequality in China," *Inequality in Focus*, Vol. 2, No. 2, August 2013. As of April 20, 2015: http://www.worldbank.org/content/dam/Worldbank/document/Poverty%20documents/Inequality-In-Focus-0813.pdf

Song, Sophie, "Prices of Beijing's Black Market License Plates Now Double the Cost of Most Popular New Car," *International Business Times*, February 4, 2014. As of December 12, 2014: http://www.ibtimes.com/prices-beijings-black-market-license-plates-now-double-cost-most-popular-new-car-1553158

Sorensen, Paul, Thomas Light, Constantine Samaras, Liisa Ecola, Endy M. Daehner, David S. Ortiz, Martin Wachs, Evan Enarson-Hering, and Steven Pickrell, S*trategic Issues Facing Transportation,* Vol. 5: *Preparing State Transportation Agencies for an Uncertain Energy Future*, Washington, D.C.: Transportation Research Board, National Cooperative Highway Research Program Report 750, 2014. As of April 20, 2015: http://www.trb.org/Main/Blurbs/170763.aspx

Southern Daily, "深圳市碳交易市场碳交易量超13万吨领跑全国 [The amount of carbon trading in Shenzhen carbon trading market has exceeded 130,000 tons, taking the lead nationwide]," November 28, 2013. As of November 19, 2014, in Chinese: http://www.gmw.cn/ny/2013-11/28/content_9635915.htm

Szamosszegi, Andrew, and Cole Kyle, *An Analysis of State-Owned Enterprises and State Capitalism in China*, Washington, D.C.: U.S.–China Economic and Security Review Commission, October 26, 2011. As of April 5, 2015: http://www.uscc.gov/sites/default/files/Research/10_26_11_CapitalTradeSOEStudy.pdf

Taiyuan Daily, "停车难车位贵 太原新建住宅小区停车问题严重 [Parking is difficult and expensive: Taiyuan's new residential districts have a serious parking problem]," January 21, 2014. As of November 14, 2014, in Chinese: http://news.taiyuan.soufun.com/2014-01-21/11952604.htm

Taiyuan News, "树成线花成片 20条'绿道'编织美丽龙城 [Tree-lined and filled with flowers: 20 greenways form a beautiful dragon city]," August 2, 2013. As of November 11, 2014, in Chinese: http://www.tynews.com.cn/jrjj/content/2013-08/02/content_7569.htm

Tsuruoka, Doug, "Is China's Shadow Loan Problem Not That Dark?" *Investor's Business Daily*, August 4, 2014.

United Nations, Department of Economic and Social Affairs, Population Division, *World Urbanization Prospects: The 2014 Revision, Highlights*, ST/ESA/SER.A/352, 2014. As of April 20, 2015: http://esa.un.org/unpd/wup/Highlights/WUP2014-Highlights.pdf

U.S. Department of State, "Report of the U.S.–China Climate Change Working Group to the 6th Round of the Strategic and Economic Dialogue," Washington, D.C., July 14, 2014. As of April 20, 2015: http://www.state.gov/r/pa/prs/ps/2014/07/229308.htm

U.S. Energy Information Administration, "Barrels of Crude Oil per Metric Ton," *International Energy Statistics*, undated. As of April 20, 2015: http://www.eia.gov/cfapps/ipdbproject/IEDIndex3.cfm?tid=94&pid=57&aid=32

Wang Jiamei, "Averted Bond Default Sets Worrying Precedent," *Global Times*, July 28, 2014. As of April 5, 2015: http://www.globaltimes.cn/content/872975.shtml

Wang Tingting, "新能源汽车拥有量排名 北京第三 [Ranking of new energy vehicle ownership: Beijing ranks third]," *Legal Evening News*, September 6, 2013. As of November 19, 2014, in Chinese: http://www.fawan.com/Item/210481.aspx

Wang, Yichuan, "High-Speed Rail Is at the Foundation of China's Growth Strategy," *Quartz*, August 22, 2013. As of April 5, 2015: http://qz.com/116190/high-speed-rail-is-at-the-foundation-of-chinas-growth-strategy/

"Why China Is Creating a New 'World Bank' for Asia," *Economist*, November 11, 2014. As of April 20, 2015: http://www.economist.com/blogs/economist-explains/2014/11/economist-explains-6

Wong, Edward, "One-Fifth of China's Farmland Is Polluted, State Study Finds," *New York Times*, April 17, 2014. As of April 5, 2015: http://www.nytimes.com/2014/04/18/world/asia/one-fifth-of-chinas-farmland-is-polluted-state-report-finds.html

World Bank, "World Development Indicators," December 2011. As of April 5, 2015: http://data.worldbank.org/data-catalog/world-development-indicators/wdi-2011

——, "World Development Indicators," updated July 2, 2013. As of April 5, 2015: http://data.worldbank.org/data-catalog/world-development-indicators/wdi-2013

Xie, Yu, and Xiang Zhou, "Income Inequality in Today's China," *Proceedings of the National Academy of Sciences*, Vol. 111, No. 19, May 13, 2014, pp. 6928–6933.

Xinhua News, "黑车司机眼中的黑车管理 [How illegal taxi drivers look at illegal taxi management]," September 2, 2014.

Xue Chaohua and Xu Wei, "Lanzhou Firstly Takes Odd-Even License Plate Restriction to Curb Car Use," *People's Daily Online*, November 18, 2013. As of November 11, 2014: http://english.peopledaily.com.cn/90882/8458633.html

Yardley, Jim, "Beneath Booming Cities, China's Future Is Drying Up," *New York Times*, September 28, 2007. As of April 5, 2015: http://www.nytimes.com/2007/09/28/world/asia/28water.html

Yi Zhang, and Tan Jun, "An Empirical Study of the Housing-Price-to-Income Ratio of Some Typical Cities: On the Basis of Purchase Installment Payment Model," paper presented at International Conference on the Modern Development of Humanities and Social Science, Hong Kong, December 1–2, 2013.

Yu, Rose, "Battling Pollution, Beijing to Cut New Car Quota by 90,000," *Wall Street Journal*, November 5, 2013. As of November 11, 2014: http://blogs.wsj.com/chinarealtime/2013/11/05/battling-pollution-beijing-to-cut-new-car-quota-by-90000/

Zeng, Heshuang, "China Transportation Briefing: Bus Rapid Transit in China—On the Way," *City Fix*, May 9, 2013. As of November 11, 2014: http://thecityfix.com/blog/bus-rapid-transit-brt-china-transportation-briefing-series-guangzhou-beijing-heshuang-zeng/

Zhao, Kiki, "Water from China's South-North Transfer Project Flows to Beijing," *Sinosphere*, December 25, 2014.

Zhu Hong, "上海市第三次综合交通调查成果简介 [Summary of outcomes of the third comprehensive transport survey in Shanghai]," Shanghai Institute of Traffic Engineering, October 23, 2012. As of November 24, 2013, in Chinese: http://www.tranbbs.com/Advisory/TPlan/Advisory_63801.shtml

Zmud, Johanna P., Vincent P. Barabba, Mark Bradley, J. Richard Kuzmyak, Mia Zmud, and David Orrell, *Strategic Issues Facing Transportation,* Vol. 6: *The Effects of Socio-Demographics on Future Travel Demand*, Washington, D.C.: Transportation Research Board, National Cooperative Highway Research Program Report 750, 2014. As of April 20, 2015: http://www.trb.org/Main/Blurbs/171200.aspx

Zmud, Johanna, Liisa Ecola, Peter Phleps, and Irene Feige, *The Future of Mobility: Scenarios for the United States in 2030*, Santa Monica, Calif.: RAND Corporation, RR-246, 2013. As of April 5, 2015: http://www.rand.org/pubs/research_reports/RR246.html

Figures and Tables

Abbreviations

BEV	battery electric vehicle
BJTRC	Beijing Transportation Research Center
BRT	bus rapid transit
CNY	Chinese yuan
E-2W	electric two-wheeled vehicle
EIA	U.S. Energy Information Administration
EU	European Union
EV	electric vehicle
GDP	gross domestic product
GHG	greenhouse gas
HSC	Horizon Scanning Centre
HSR	high-speed rail
ifmo	Institute for Mobility Research
IMF	International Monetary Fund
JRC	Joint Research Centre
NDRC	National Development and Reform Commission
NEV	new-energy vehicle
PHEV	plug-in hybrid electric vehicle
RAHS	Risk Assessment and Horizon Scanning

ISBN-10 0-8330-9035-6
ISBN-13 978-0-8330-9035-5

$60.00

www.rand.org
RR-991-ifmo