

China's Quest to Adopt Electric Vehicles
By Christopher Marquis, Hongyu Zhang, & Lixuan Zhou

Stanford Social Innovation Review
Spring 2013

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C H I N A ' S Q U E S T A D O P T T O E L E C T R I C V E H I C L E S

The Chinese government's effort to create an electric vehicle industry is a bold experiment in local and system-level innovation. It also provides a window into understanding the promise and peril of economic development policies, both for China and for the rest of the world.

BY CHRISTOPHER MARQUIS, HONGYU ZHANG, & LIXUAN ZHOU



The Chinese auto industry reached a major milestone in 2009. After a decade of continuous growth, China became the largest car market in the world. In 2012, it also became the world's largest producer of emissions, in part from the rapid spread of personal cars and gasoline-powered trucks and buses. The Chinese government understood that it had an environmental problem.

China's twelfth Five-Year Plan (2011–2015)—its core economic and social development roadmap—identified seven strategic emerging industries to which the country will devote enhanced policy and financial support. One of these is the alternative fuel vehicle industry, including electric vehicles (EVs). In 2009, the government launched a series of policies and incentives to promote development of the EV sector. By June 2012, critical governmental targets were established: 500,000 EVs (pure electric and hybrid electric vehicles) by 2015 and 5 million by 2020.

China's ambitious goal-setting has happened amid doubts about the EV sector's prospects for scaling up internationally. Toyota, for example, recently delayed the launch of its electric vehicle, eQ, citing misjudgment of demand in the pure EV market coupled with continuing difficulties in improving battery technology. Switching a country or a region to a new generation of environmental technologies like electric vehicles requires the coordination of many actors—car manufacturers, battery developers, charging infrastructure providers, governments, and consumers. Such a challenge is likely too great for any private company—even one as large and path-breaking as Toyota—to accomplish on



A worker at the EV development center of the Beijing Automotive Group, which was created with Beijing government support.

PHOTOGRAPH BY ADRIAN BRADSHAW/EPA/CORBIS



its own. To develop the EV industry, not only must there be a well-designed and properly implemented government policy, coordination and cooperation between public and private sectors is essential.

China's EV experience offers a rare window into understanding the promise and peril of enacting wide-scale, system-level change to deliver EVs to a mass market. Through centralized leadership and prior market-planning success, China has developed a unique strategy of city-based pilot plans. The intent is to develop and refine new business models and markets, in order to introduce new technologies. Other countries have tried city-based experiments, but widespread adoption has been difficult in politically fragmented systems like the United States. China's central government has a distinct advantage: It is able to launch system-level and sector-wide change in multiple cities and regions with no political opposition.

In this article, we investigate China's emerging EV industry, focusing on the continuing challenges to its strategy of using city-based pilots. In 2009, four Chinese governmental ministries overseeing industry and information technology, science and technology, finance, and

national development and reform initiated the "Ten Cities, Thousand Vehicles" program. Initially, the program focused on developing 10 pilot cities, each of which would launch 1,000 EVs into operation within three years.¹ By 2011, the number of pilot cities had climbed to 25.

Yet results have fallen significantly short of the original targets. To understand why, we look at the experience of five representative cities: Beijing, which focused on creating public sector support of EVs; Shanghai, which focused on replicating international models; Shenzhen, the most successful pilot, which focused on creating a leasing model through strategic partnerships; Hangzhou, which has created a rental model; and Chongqing, which has developed fast-charging EV technology. Our aim is to understand system-level change efforts more generally. We ask: How does selection by central planners compare to open competition in fostering system-level innovation? And what do the unmet goals of the Ten Cities, Thousand Vehicles program say about system change in China and more broadly? By contrasting the rollouts in five different pilot cities, we also aim to shed light on how different models of systemic

change fare when it comes to social and environmental innovations and to what degree reforms should be implemented by central planners (top-down) versus generated from local efforts (bottom-up).

SYSTEMATIC CHANGE THROUGH CITY-BASED PILOTS

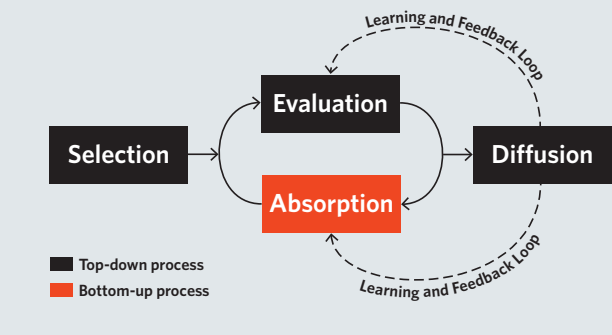
Over the past 30 years, China has established a distinct economic development formula—an experimental strategy based on localized pilots to initiate systemic reforms, such as rural de-collectivization, foreign economic opening, and promotion of private business. Now standard in Chinese development, localized pilots were first conceived by policymakers as macro-laboratories, where new solutions to economic or market problems could be tested, accumulated, and refined at the local level before being fed back into national policy formulation and subsequently rolled out more broadly.

The philosophy for the strategy was vividly expressed by Chinese political leader Deng Xiaoping as “crossing the river by feeling for the stones.” Unlike theory-based planning, this strategy is step-by-step, highly pragmatic, fundamentally empirical, and implemented during its early stages without specific goals or procedures. Pilot areas, established with help from a central government, are designed to respond reflexively to changes during their own development. With the help of many preferential policies, experimental zones have adapted flexibly to a rapidly changing economic environment, developing at amazing speed.

Over several decades of practicing and refining this model, a number of signature elements have emerged to form a generalized process. One element is Beijing’s hands-off approach: The central government sometimes sets general goals for pilot areas, but does not get significantly involved in the implementation process. A second element is the effective way that top-down and bottom-up processes have been blended, leveraging both central sponsorship and local initiative. The success of these pilots has depended on synergy between the two approaches. There are four important stages in the model: selection, evaluation and absorption, diffusion, and the learning feedback loop. (See “China’s Standard Experimental Strategy” above.)

Selection | A crucial stage of the experimental strategy has been the careful top-down selection of experimental sites where the central government can either test policy or try innovative practices. In one of the earliest examples, Shenzhen, a city far from Beijing but close to Hong Kong, was cautiously chosen in 1979 by the central government as the site of the first special economic zone (SEZ). Because great risk is associated with delegating market-based innovation to any area, experimental pilots have typically been focused on areas where there is comparatively little political resistance, areas with economic characteristics conducive to successful reform, and cities that are geographically and economically representative of the country at large, yet far enough away from Beijing that potential

China's Standard Experimental Strategy



political fallout is minimized. Pudong’s New Area in Shanghai, with its solid infrastructure and market-savvy cosmopolitan population, is such an area. It has become an important economic development zone over the past 20 years.

Evaluation and Absorption | The next stage is an evaluation and absorption process that combines bottom-up and top-down approaches. A specially assigned group composed of central government officials and experts evaluates the performance of pilots on behalf of the central government, to modify policies or identify more advanced practices. Recent efforts in national education system reform followed this process. Several pilot areas and schools were established in light of the overall reform goals.² After a year of operation, the pilot areas and schools reported their progress to central authorities, who then documented the most advanced practices for wide diffusion. Policies and practices can be spread to other areas only after they have been approved by the central government.

Diffusion | The final stage of the experimental strategy is gradual top-down diffusion. The central government makes great efforts to popularize the successful practices through media publicity, endorsement by leading politicians, and government guides. The central government does not coerce local governments to implement the new practices, relying instead on publicity to signal its encouragement. For example, starting in 2001, the Ministry of Land and Resources initiated land expropriation to expand cities using an experimental strategy, which led to the Zhengdong New Area system of “harmonious expropriation,”³ whereby the government created incentives for people affected by land expropriation. After an intensive round of publicity promoting the new model, provinces such as Jiangsu, Hebei, Hubei, and Guizhou proposed similar models.

Learning Feedback Loop | A distinctive feature of the experimental strategy is the feedback loop between the evaluation and absorption process and diffusion. During diffusion, the central government pays close attention to how the practices or models are being implemented, repeatedly re-evaluating them, to modify the models or adjust the speed and range of diffusion. Using pilots lowers the costs and risks of reform. It also reduces the severity of consequences in case the reform fails. Later participants in the reform process learn from trial groups and greatly reduce their own risks and costs.

THE TEN CITIES, THOUSAND VEHICLES PROGRAM

The original goal set by the central government in 2009 was to launch

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1,000 EVs in each city. In practice, the pilot cities were subsequently able to set their own vehicle rollout agenda. This approach gave each city significant leeway to choose the model that best played to its strengths. (See “Five Electric Vehicle Pilot Programs” below.)

Beijing: State Leadership Model | In Beijing, the rollout of EVs has been spurred by the power of the government. The Beijing government relies heavily on preferential policies—such as reducing vehicle taxes and granting license plate lottery exemptions—to encourage public and private use of EVs in the capital city. A principal focus of the pilot is building a strong EV industrial base. Three EV industrial campuses have been set up by the Beijing government to promote research and development in EV technologies and attract leading automakers, battery makers, and other industry players. Perhaps most important, the local government has remained active in cooperating with and coordinating important industry players to deploy EVs in the public sector. For example, the Yanqing government (a district in Beijing) has set up a joint venture with BAIC Foton to deploy EV taxis. The Yanqing government provided 50 percent of the capital and the charging facility and personnel, and BAIC Foton provided the other 50 percent capital investment and the taxis. By 2012, 150 electric taxis were operating, and another 50 were scheduled to be deployed by the end of the year.

Shanghai: Platform-Led Business Innovation Model | Shanghai was denoted an international EV pilot city by the central government, and so it has focused more on international cooperation. Shanghai plans to adapt a rental model borrowed from Bremen, Germany. In April 2011, the city set up an international EV demonstration zone, called EVZONE, in the Jiading district. Its goals were to provide a platform for testing and piloting the EV development model; to test innovations in vehicle performance, route design, and charging facility distribution; and to provide a site for auto manufacturer R&D

collaboration to overcome technological roadblocks. The EVZONE is also planning to introduce both a short-term and a long-term EV rental business in Shanghai based on Bremen’s model, under which a shared car can in theory replace four to eight privately owned cars. The EVZONE expects to establish EV leasing stations in busy areas like office buildings, shopping malls, and major subway stations. Consumers can lease an EV with a membership card. Although the Shanghai model is innovative, little progress has been made in actual EV deployment.

Shenzhen: Cooperative Commercialization Model | Capitalizing on its industrial base and the presence of leading electric grid and battery companies, Shenzhen focused on finding a commercial way to spread EVs. The Shenzhen government has fostered a financial leasing model with state-owned enterprises Potevio New Energy and China Southern Power Grid. The Potevio venture has proven quite successful in public transportation, because it reduces the high cost of purchasing an EV. Typically, an EV bus costs \$320,000. Even excluding \$160,000 in subsidies from central and local governments (\$80,000 from each), the remaining \$160,000 is still twice the cost of a conventional-fuel bus. In Potevio’s leasing model, the cost of the battery is separated to reduce capital expenditures; Potevio retains ownership of the battery (around \$56,000) and leases it to the Shenzhen Bus Company. For the remaining \$104,000 capital cost, Potevio offers loan guarantees. Moreover, because of support from the local government and BYD, a local battery manufacturer, Potevio is able to buy the batteries at a subsidized price. With its upfront financial burden alleviated, the bus company expects to roll out 2,050 electrical buses by the end of 2012.

Hangzhou: Flexible Rental Model | Similar to Shanghai, Hangzhou has addressed the high cost of EVs by adopting a rental strategy.

Hangzhou’s model is flexible because people can rent the car or the battery separately, significantly reducing cost. Hangzhou is the first city to adopt a battery rental system, providing free battery rental for three years or up to 60,000 km for people who purchase EV cars. The city is now constructing a battery-charging infrastructure to provide consumers ready access to battery charging or swapping stations.⁴ By June 2012, Hangzhou had constructed five charging stations, 62 battery-swapping and delivery stations, and 620 charging poles; Hangzhou plans to roll out 20,000 rental EVs by the end of 2013.⁵

Chongqing: Fast-Charging Model | Unlike other pilot cities that have adopted

Five Electric Vehicle Pilot Programs

CITY	MODEL	LOCAL STRENGTHS, HISTORY, AND GEOGRAPHIC CONDITIONS
Beijing State Leadership Model	Government relies on preferential policies, and makes a concerted effort to create a strong EV industrial base. Important industry players cooperate actively.	The capital city is good at regulation, and is experienced in cooperating with public and private sectors. Beijing is strongly motivated to cultivate its image as an environmentally friendly city.
Shanghai Platform-Led Business Innovation Model	EV international demonstration zone in Jiading provides a platform to promote EV development. Planners intend to spread EV rental business across city.	With deep roots as an international coastal city, the people are generally more open-minded. Private investment is strong. The ability to develop private business, including infrastructure, human capital, and markets, is comprehensive.
Shenzhen Cooperative Commercialization Model	Multiple industrial players participate actively. Potevio’s financial leasing model reduces cost of purchasing EVs.	Local government has wide experience in policy experiments and innovations. A vibrant private economy with many strong companies, such as BYD, can support the EV industry. Local government is determined to develop an EV industry and has already taken substantive steps.
Hangzhou Flexible Rental Model	People can rent the car or the battery separately. Hangzhou was the first city to adopt battery switching.	Local government gained a great deal of prior experience with the rental model when it developed a public bicycle rental system. Zhejiang Kandi Vehicles Co., a local manufacturer, provides EVs that are powered by Li-ion batteries that have a range of 100 km and a top speed of 70 km/hr.
Chongqing Fast Charging Model	Chongqing is the only pilot city pursuing fast-charging batteries.	The location in a mountainous area with few flat lands made battery switching difficult. Nearby Three Gorges Reservoir Area and Three Gorge Power Grid are sources of a large amount of electrical power and robust electric grid.

battery-swapping (Shenzhen and Hangzhou) or slow-charging stations (Beijing and Shanghai), Chongqing is piloting more grid-intensive fast-charging EV technology. One reason is that Chongqing is near the robust Three Gorge Power Grid. Another is that the city is in the mountains and has few flat areas, which are necessary for battery swapping. Last, Chongqing is home to fast-charging-auto manufacturers that provide industrial support for its strategy.

THE CHALLENGES OF CITY-BASED PILOTS

Although there have been notable successes, the EV rollout in China has met with a variety of challenges. Although standard economic theories would suggest that competition produces useful variations among models, which benefit later rounds of evaluation and absorption, there are also indications that competition has serious drawbacks. First, when many cities are piloting programs, city leaders are more likely to overemphasize their progress so they will appear successful. On October 31, 2011, the four government ministries that initiated the Ten Cities, Thousand Vehicles program held a special meeting and created a supervising team to monitor the progress of the 25 pilot cities. Chen Quanshi, vice director of State Key Laboratory of Automobile Safety and Energy, said that the biggest issue revealed during the evaluation was that local governments were inflating their EV projects' successes, to increase their chances of winning further support.⁶ Many pilot cities put resources into the EV industry because it was a good opportunity to demonstrate an environmentally friendly image and therefore to get financial support. But some selected cities, such as Xiangfan and Nantong, have weak industrial foundations and questionable abilities and resources to produce and promote EVs. Their strategy has been to focus on receiving preferential policies and financial resources, as opposed to developing their EV adoption capability.

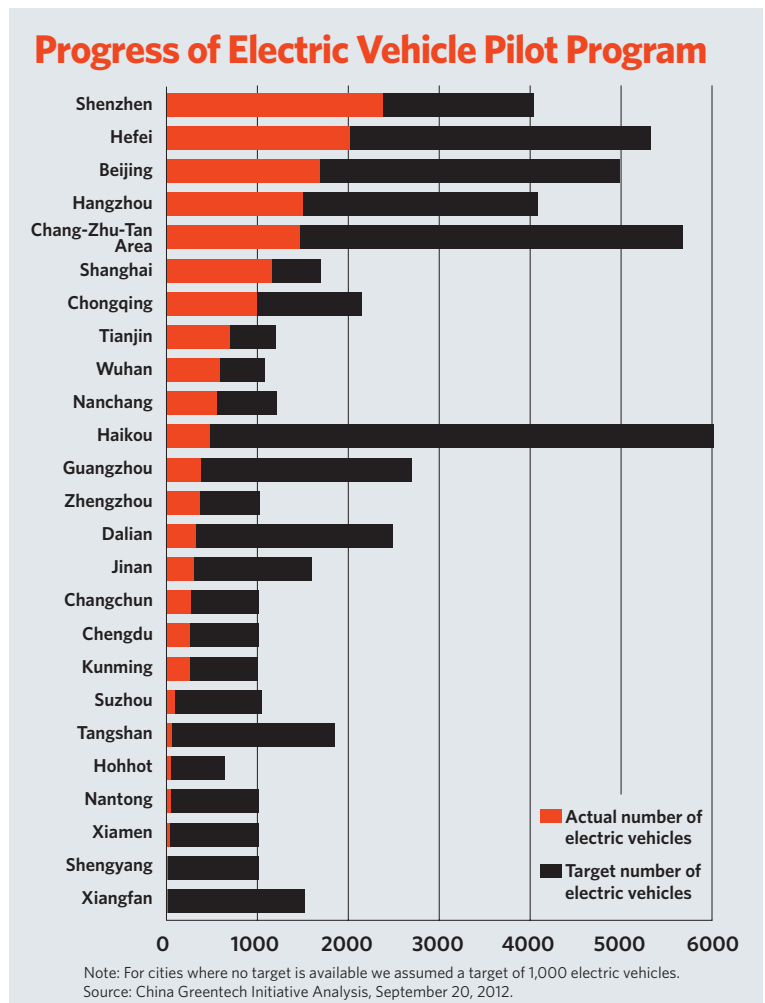
Another problem has been local protectionism. Under China's standard experimental strategy model, the number of pilot sites is usually too small to invite comparisons between cities, and the evaluation process involves improvement and guidance for future rollouts. Because the Ten Cities, Thousand Vehicles program has included as many as 25 cities, however, competition for central government support and resources has forced local governments to become more self-serving. Many local governments have focused on developing standards and technologies that specifically benefit their own location and local companies, rather than working toward national or international standards and goals. In addition, some automakers complain that they are having, as Gaofeng, the vice president of Karry (a brand of the Chery Automobile Co.), put it, "an increasingly tough time selling [their] EVs in other cities, because of huge local financial subsidies for locally produced EVs."⁷ An industry expert who preferred to remain anonymous asserted, "The reason Beijing has not sold a single EV in the private sector is that there is no place to buy one. The Beijing government has made it very difficult for BYD to sell its EVs here." Thus the Ten Cities, Thousand Vehicles program is skewed toward locally focused goals and local firms rather than a long-term national agenda for

developing China's EV industry. As another interviewee said, "The central government and local governments often have misaligned incentives and goals."

Classical and neoclassical economists may find nothing wrong with policy makers adopting comparative advantage as a guiding principle, nor with governments emphasizing their strengths when selecting development strategies in a competitive field. But in a domestic program—one that has the explicit goal of benefitting the population as a whole—too much local competition complicates rather than facilitates the development of a national formula. Without strong guidance from the central government, the city pilots lose sight of overarching goals and produce specialized local standards that are not widely applicable. As a result, opportunities for system-level learning are reduced.

And unlike the standard city-based pilots—such as special economic zones and coastal economic development zones, where the government has been more strategic in selecting appropriate test sites—EV pilot cities are developing idiosyncratic plans specifically suited to their local histories. Shanghai, the only EV international pilot city, has deep roots in internationalization that facilitate its adoption of the Bremen model. Hangzhou has adopted a flexible rental model largely because it had already developed a successful bicycle rental system.

Geographic condition is another crucial factor in determining models. For example, most pilot cities prefer battery-swapping or



slow-charging technology because of safety and management considerations, such as saving energy and making full use of the power grid. Chongqing, however, uses a fast-charging method because of its unique location near the massive Three Gorges hydroelectric dam. These geographic idiosyncrasies present challenges to establishing a national standard, creating consistent evaluation, and replicating the various models across China.

Deep roots in specific local conditions make it difficult to identify a model that can be recommended for national diffusion. To date, Shenzhen is considered the most successful by many observers. Nevertheless, it enjoys several internal strengths that are difficult for other cities to replicate in the short term. First, Shenzhen has an excellent industrial foundation that was already focused on developing EVs with the support of central enterprises, such as Potevio and China Southern Power Grid, as well as of private firms like BYD. One of the interviewees from another city complained, “Shenzhen’s model appears unrealistic to replicate, as Potevio is basically converting some of CNOOC’s gas stations into EV charging stations. For other cities, such construction or conversion would definitely require participation from the grid companies.” Second, battery use is greatly influenced by weather and temperature conditions, making it unfeasible for China’s colder areas to duplicate the Shenzhen model.

Because of these issues, questions have been raised about the future success of the Ten Cities, Thousand Vehicles program. One potential roadblock will be standardization. As one local government official who preferred to remain anonymous lamented, “Standards by the central government on EVs were launched quite late, and before that there were already local standards. So enforcing overall standards is difficult.” A consensus has been reached among various industry players that EV development needs uniform industrial standards for battery types and body materials. They also need a standard design for public EVs (such as buses) to improve trip range, weight, and safety. Yet because of unclear guidance from the central government, local protectionism, and geographic differences, local governments have used many different standards to achieve the 1,000-vehicle goal.

LEARNING FROM THE TEN CITIES, THOUSAND VEHICLES PROGRAM

The Ten Cities, Thousand Vehicles program, a variation of China’s standard experimental strategy, has many advantages, such as generating local government enthusiasm and providing a greater variety of models for subsequent EV evaluation and absorption. But the program has not led to a set of standards or a single model that can be rolled out broadly.

The development of EVs in China demonstrates the limitations of government-driven implementation. The central governing body needs to be clear in its decision-making and communication, particularly during the selection phase. Without initial clarity, both the public and private sectors in the EV pilot cities have relied too much on later signals from the central government, taking a “wait and see” approach. The public sector’s delay in issuing crucial plans has eroded the enthusiasm of some private automakers and battery-makers, which have become reluctant to involve themselves in future planning. In turn, the private sector’s decreasing involvement has tempered government enthusiasm for developing the EV industry.

The models that developed from the pilots have been shaped by the institutional factors at each location; local circumstances need to be taken into account much earlier in the process and steps should be taken to discourage excessive intercity competition. Initial evidence suggests that the various EV models reflect historical differences, conflicting governmental priorities, and existing corporate infrastructure—all of which significantly limit standardization and potential future national rollout. We believe experimental models work best in China, and elsewhere, when there is an active and rigorous site selection process that takes these factors into account.

Although 2012 was officially the concluding year of the Ten Cities, Thousand Vehicles program, the central government still has much to accomplish before arriving at a nationwide model. Much has been written in the West about the importance of centralized policy and implementation for China’s economic successes over the past 30 years, but the execution has frequently been through city-based experiments and decentralized refinement before national rollout. China’s city pilot strategy has not jump-started a national EV industry, which we believe may have to do with how the EV rollout varied from prior city-based pilots.

An additional reason for the lack of progress in developing a national model may be the rise of significant independent power bases in Chinese cities. Over the past two decades, local power bases in China have increasingly focused on local development, making it difficult to execute the types of centrally coordinated strategies that worked for China in the past. Today, city and regional governments are set on meeting their own needs and are prone to protectionist tactics. The expansion of the Ten Cities, Thousand Vehicles program is thus a lesson in how conflicting incentives can lead to local interests taking advantage of central government goals, potentially undermining the implementation of a national-level experimental program. If China is going to maintain its growth trajectory, the central government will have to find a new way to balance or even harness these local interests. ■

We thank Matt Lee, Julian Schwabe, Andras Tilcsik, Zoe Yang, and Yaoqi Zhu for their comments and suggestions, and the China Greentech Initiative team for their considerable insights. Zhang Hongyu thanks the China Scholarship Council for financial support.

Notes

- 1 In 2010, the same four ministries began selecting pilot cities for private sector EV development, including Shenzhen, Hangzhou, and Hefei. Our analysis focuses on EVs in the public sector, as private use of EVs is still in initial stages in China.
- 2 Government document on the national pilot education reform. (http://www.gov.cn/zwqk/2011-01/12/content_1783332.htm)
- 3 Yao Yiran & Zheng Siyuan, “Many Cities Try Land Exploration Reform: Pilot Experiences may be extended nationally,” *Economy & Nation Weekly*, issue 20, 2012. (<http://jingji.cntv.cn/2012/10/08/ARTI1349678672796283.shtml>)
- 4 Hu Zhouying, “Electric Vehicles Can Access Battery Charging or Swapping Stations Within Five Kilometers in Hangzhou.” (http://www.dtkjg.com/news_v.asp?id=93)
- 5 Ray Jing, “Hangzhou to Lease 20,000 EVs in Two Years,” *China Automotive Review*, Aug. 8, 2012. (<http://www.chinaautoreview.com/pub/CARArticle.aspx?ID=7647>)
- 6 Pan Mingjun, “Ten Cities, Thousand Vehicles: Loser-out Tournament? Middle Evaluation Will be Conducted After the Two Sessions,” *Auto Business*, Mar. 2, 2012. (http://www.chinabuses.com/policy/2012/0302/article_2760.html)
- 7 Gao Yiran, “Auto Subsidies, Local Government Should Not Play as a Doting Parent,” *China Business Times*, Sept. 14, 2012. (<http://www.cbt.com.cn/a/chanjingxinwen/qiche/2012/0914/19992.html>)