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on Energy, Economy and Environment

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NEWSLETTER

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Cover Image: Harvard-China Project photo contest winner, "Namtso - A Lake, The Paradise" by Jialin Liu, HCP Alumnus

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RESEARCH HIGHLIGHT

New Series: Harvard-China Project Research Briefs

This spring semester, the Harvard-China Project initiated a new series of research briefs summarizing new Project publications for non-specialists.

The first explored the publication, "China's Emission Control Strategies Have Suppressed Unfavorable Influences of Climate on Wintertime PM$_{2.5}$ Concentrations in Beijing Since 2002" from *Atmospheric Chemistry and Physics*. The study by lead author Meng Gao (former China Project postdoc and Assistant Professor in the Department of Geography of Hong Kong Baptist University) and Project co-authors Peter Sherman, Shaojie Song, and Prof. Michael B. McElroy analyzed haze days – those with high levels of very small particles less than 2.5 micrometers in diameter (PM$_{2.5}$), which often happen in China's capital city of Beijing – and the effects of pollution control measures on such days. The haze problem is particularly severe in winter, when the atmosphere is more stable than other seasons due to weaker sunlight. The researchers found that meteorological conditions over the study period would have led to an increase in haze in Beijing, but the strict emission control measures more than compensated for the unfavorable influences of the recent climate. Read the full brief under "News" on our homepage.

The second brief summarized the publication "Energy Consumption of Urban Households in China," from *China Economic Review*. The research began while Wenhao Hu (now Assistant Professor at Ma Yinchu School of Economics, Tianjin University) was a visiting Ph.D. fellow at the China Project, advised by Project economists Mun S. Ho and Jing Cao. The smart design of energy and environmental policies requires a knowledge of how various energy consumers are likely to respond to them. In the particular case of market-based policies, the researchers wanted to explore how firms and households respond to energy prices. Do they cut their use of fossil fuels or electricity by a lot when a 10% tax is added to energy prices? Or are they mostly unable to change? And are they better able to adapt over time? Analyzing a large household survey dataset from 1992-2009 for China, the research team estimated income and price elasticities of demands for different energy forms. They first concluded that much higher gasoline and travel demands, decelerating growth in use of electricity, and a slowing of coal demand should be expected in the future. They then concluded that urban consumers show some modest ability to substitute for energy in response to prices, which means that market-based policies, such as tax-based ones, may be effective. Read the full brief under "News" on the homepage.

Fall Events Recap

Prior to the abrupt March closure of the Harvard University campus because of COVID-19, the Harvard-China Project hosted a talk with **Xi Yang**, Visiting Scholar, Harvard-China Project; Associate Professor, China University of Petroleum Beijing. Her talk on "China's Coal-to-Gas Policy for Residential Heating: Between the Shadow and the Light" explored modeling analyses of China's policies to substitute gas for coal in residential heating in the northern region.

Following the campus closure, the Project shifted its seminar series into a series of weekly group meetings conducted online, to maintain the Project's internal engagement and community. Faculty, postdoctoral researchers and visiting researchers took turns presenting, gaining interdisciplinary feedback from their colleagues in the Project. Stay tuned to our website for information on the fall semester, including public lectures.

RESEARCH HIGHLIGHT

Opportunity Blows for Offshore Wind in China

Under the Paris Climate Agreement, China committed to rely on renewable resources for 20 percent of its energy needs by 2030. Currently, the country is on track to double that commitment, aiming to hit 40 percent by the next decade. Wind power is critical to achieving that goal. Over the past 20 years, China's wind power capacity has exploded from 0.3 gigawatts to 161 gigawatts.

But, in recent years, that growth has slowed and the hopes for China's wind-powered future have dampened.

Why? Location, location, location.

Populous coastal provinces, including Guangdong and Jiangsu, consume about 80 percent of the nation's total electricity but the vast majority of China's wind capacity comes from land-based wind farms in places like Inner Mongolia, more than a thousand miles away from most major cities.

To make matters worse, recent climate studies have suggested that the weakening land-sea temperature gradient due to global climate change is making historically windy regions, like Inner Mongolia, less windy.

In addition, much of the wind power from those regions isn't being used because of when it's produced. Research has suggested that some 16 percent of total potential wind generation was wasted between 2010 and 2016, costing more $1.2 billion.

If China is to meet and exceed its Paris goal by 2030, it's going to need to find a way to increase its wind capacity.

In a recent study, researchers from the Harvard John A. Paulson School of Engineering and Applied Sciences (SEAS) and Huazhong University of Science and Technology in China, found that offshore wind could be a big part of the solution.

The research is published in *Science Advances*.

"This is an important new contribution, recognition that China has abundant off-shore wind potential that can be developed and brought on shore to the power hungry coastal provinces at costs competitive with existing coal-fired polluting power plants," said Michael McElroy, the Gilbert Butler Professor of Environmental Studies at SEAS and senior author of the paper.

To calculate the capacity and cost of offshore wind in China, the researchers first identified the regions where offshore wind farms could be built, excluding shipping zones, environmentally protected areas and water depths higher than 60 meters. They calculated the wind speeds in those areas and estimated the hourly capacity for each of the turbines.

They found that the total potential wind power from wind farms built along the Chinese coast is 5.4 times larger than the current coastal demand for power.

"We estimate offshore wind costs according to a range of values derived from recent offshore wind farm developments," said Peter Sherman, a graduate student at the department of Earth and Planetary Science and first author of the paper. "Offshore wind turbines have historically been prohibitively expensive, but it is clear now that, because of significant technological advances, the economics have changed such that offshore wind could be cost-competitive now with coal and nuclear power in China."

The researchers estimated that if electricity prices are high, offshore wind could provide more than 1,000 terawatt-hours, or about 36 percent of all coastal energy demand. If electricity prices are low, it could provide more than 6,000 terawatt-hours, or 200 percent of total energy demand.

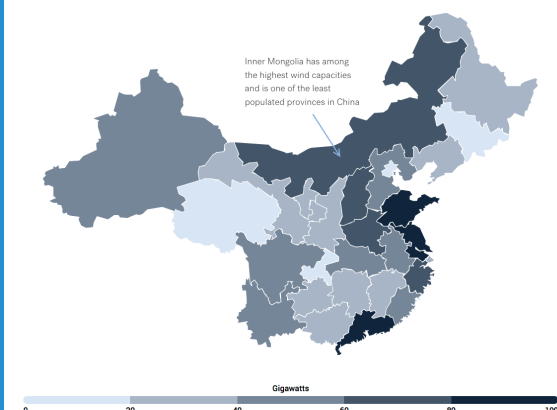"Our research demonstrates the potential for cost-effective, offshore wind to power coastal regions, reduce greenhouse gas emissions and improve air quality in China," said McElroy.

This research was supported by the Harvard Global Institute, National Science Foundation China, and the State Key Laboratory on Smart Grid Protection and Operation Control.
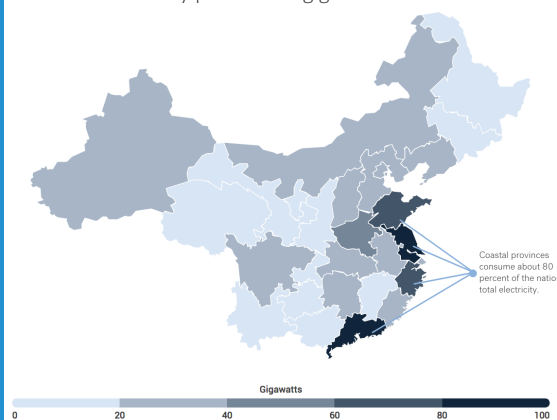
By Leah Burrows, Harvard Paulson School of Engineering & Applied Sciences

This map shows the available wind capacity by province in gigawatts.

Inner Mongolia has among the highest wind capacities and is one of the least populated provinces in China

Gigawatts
0   20   40   60   80   100

This map shows electricity demand by province in gigawatts.

Coastal provinces consume about 80 percent of the nation's total electricity.

Gigawatts
0   20   40   60   80   100

Dr. Faan Chen, Harvard-China Project

RESEARCHER Q&A

"Driving and the Built Environment: Is Transit-Oriented Development (TOD) Effective in Shanghai?" Dr. Faan Chen, Postdoctoral Fellow

This is the first in a new Q&A series with our research contributors.

The rapid growth of Chinese cities, including Shanghai, has presented many challenges for local government officials, planning and transit practitioners, and property developers. These challenges include traffic congestion, energy consumption, and emissions of both air pollutants and carbon dioxide (CO_2), the leading greenhouse gas contributing to climate change. As one of the more visible urban forms of smart growth, Transit-Oriented Development (TOD) has been actively promoted as a model for urban development to respond to these challenges. The Harvard-China Project caught up with **Faan Chen**, one of its postdoctoral fellows, to learn more about a recent study he has led on the subject that is currently being peer-reviewed by a journal.

Previous empirical studies of TOD have provided insights into the associations between travel behavior and built environment designed to encourage transit use. However, the vast majority of studies have been conducted in North American and European cities. Such research is still in its infancy in most developing countries, including China, where residential and transport choices are likely to be more constrained, and travel-related attitudes quite different from those in the developed world. Using data collected from more than 8,000 Shanghai residents

living in both TOD and non-TOD neighborhoods, the study by Chen and colleagues aims to help fill the gaps by investigating the causal relationship between the built environment of TOD and travel behavior. By exploring these issues for residents of different housing types in China, the team is able to control for residential self-selection, i.e., the fact that some are drawn to TOD areas because they already favor transit, with travel behavior that reflects this preexisting attitude more than the effect of TOD built environment itself. Specifically, the

"At some point it becomes wiser for society to shift limited public resources into other policies that offer comparable health or other benefits at lower costs."

research team examines whether – and to what extent – altering the built environment can actually lead to meaningful changes in travel behavior, e.g., less Vehicle Kilometers Traveled (VKT) and less associated CO2 and air pollution emissions.

Harvard-China Project: We understand that TOD exists in 48 places in the U.S. on

state, regional and local scales. Has TOD become a priority in many of China's major cities, or are you seeing it only in Shanghai? Are officials at a national level pushing TOD, or is it spearheaded by local entities?

Faan Chen: Since Peter Calthorpe introduced TOD in his book, The Next American Metropolis in 1993, it has been actively promoted as a model for urban development. It has also been increasingly advocated as an effective response to urban growth challenges, including traffic congestion, energy consumption and greenhouse gas and pollution emissions. This is especially true in developing countries like China, where rapid urbanization is occurring. China's urban growth rate is 2-4% per year, and the urban share of the population has grown rapidly in just 20 years, from less than 30% in 1997 to more than 60% in 2019. TOD has become a priority in many of China's major cities as urban rail transit systems are constructed. This is the case in Shanghai, which has the world's largest rail transit system by total route length (420 miles).

In recent years, governments and planning organizations have vigorously developed and promoted national-level legal standards and policies supportive of TOD. These include the "National New-type Urbanization Plan (2014-2020)," published by the State Council; "Planning Guidance for TOD," developed by the Ministry of Housing and Urban-Rural Development in 2015; and more.

In addition, TOD policies and guidelines have been developed by local governments and entities in cities besides Shanghai, such as Shenzhen, Guangzhou, and Chengdu.

HCP: To collect data, you and colleagues completed two years of interviews with more than 8,000 residents of TOD and non-TOD neighborhoods. What was the biggest take-away from this survey, in terms of their motivation to either reside or not reside near transit-oriented development?

FC: For me, it was quite interesting to talk with residents face-to-face. I, of course, could not speak directly with all respondents, but tried to communicate with as many as possible and quite enjoyed that experience. You can learn about their thinking, their relocation history, their life events, and even their future life plans. Our questionnaire explores a variety of topics, including individual and household socio-demographics, travel behavior records, residential preferences, travel-related attitudes, and so forth. This data can support research on many related topics, including travel behavior, housing mobility, social inequality, and others.

In terms of motivation for residential relocation, we find there are three important factors that draw people to TODs: 1) easy access to the public transport system; 2) easy access to highways; and 3) easy access to facilities, shops and services for daily life. On the other hand, there are three key criteria that people consider when looking for housing in non-TODs: 1) cost of housing; 2) quality of neighborhood; and 3) easy access to highways. Based on these results, we anticipate a possible future publication entitled "Where people want to be: An empirical analysis from Shanghai."

HCP: Likewise, what were some individual characteristics that you saw in those who choose to live in a TOD area? For example, did education, income, or commuting distance have a significant effect?

FC: It's interesting to find that at the individual level, residents in TOD areas tend to be younger, with higher educational levels, and more often working in government positions than those in non-TOD areas. At the household level, people living in TOD areas tend to have smaller households, fewer minors, less ownership of cars, and higher

RESEARCHER SPOTLIGHT

Yingying Lu
Postdoctoral Fellow

When Yingying Lu was in elementary school, she was fascinated with fantasy. "Just with a pencil," says Lu, an associate at the Harvard-China Project and postdoctoral fellow at the Harvard Graduate School of Design (GSD), "I was so focused in a dream world." What turned out to be an early ambition to be a designer stuck with her. And so did her zany creativity: she was drawn to reasoning, logic, and science, too.

Such interests finally brought her to Harvard Graduate School of Design, where she fused her passions of design and science into an interdisciplinary master's degree that later transformed into doctoral work. She asks, "how [can we] design a more sustainable built environment in both architecture and on the urban scale?" Her doctoral study focused on walking as an environmentally-friendly transport and healthy activity and how the built environment, social environment, and culture influence it.

Now, from a base at the Harvard-China Project, she collaborates with Prof. Ann Forsyth, her post-doctoral advisor at the GSD, to examine active transportation, aging in place, and healthy places.

With other Harvard-China Project researchers, she contributes to analysis of environmental health and urban transportation issues. Lu enjoys the interdisciplinary comradery at the Harvard-China Project, where she contributes her people-centered research and is grateful to her colleagues at the Project and her dissertation advisors who have been "beacons" of sorts, she says, "lead[ing] the way to go further in my research path."

To this day, Lu is reminded of the world-building daydreams she had as a young girl: she wants to make her vision of healthful, equitable, and eco-friendly cities a reality. Her prior work on walking may serve as a springboard to this broader goal. "For a city to be efficient, it needs a really effective transportation system to support all mobilities and it should be human-oriented," she says.

Looking to the future, sustainable transportation is one such area she intends to pursue while here. "I wish to contribute to a more pedestrian-oriented, multi-modal transportation system," she says, focusing on health and aging, and diverting car usage to lower pollutant emissions. "So it's a better environment for all populations."

Written by Liza Tarbell

incomes. It is evident that in terms of choosing where we live, our socio-demographics and travel attitudes do have great impacts on residential relocation choices.

HCP: What is one behavior or circumstance in China that allows TOD to flourish, as opposed to the United States?
FC: Conceptually, rail transit is of course the main physical attribute that makes TOD work. The Ministry of Transport of China initiated the Transit Metropolis Programme in 2011, through which 37 cities were selected to serve as pilots for TOD initiatives with rail transit expansions. To date, there are 45 cities with urban rail transit systems (operational or under construction) in mainland China. This creates a strong environment for TOD to flourish. When comparing this to the US, you find a different picture because development is still so auto-dependent. But to be honest, a considerable number of the so-called TODs in both China and the US should also more appropriately be considered TAD (Transit-Adjacent Development) or TRD (Transit-Related Development), underdeveloped versions that may feature TOD physical forms and project configurations but without the full functional outcomes. From this point of view, I think one of the challenges that China and the US should address will be moving TOD more fully from rhetoric to reality.

HCP: TOD can have an impact on emissions. Can you speak about this, and other likely positive impacts of residing in a TOD neighborhood?
FC: Well, as you know, the transportation sector is one of the largest contributors to CO_2 emissions. Globally, according to the International Energy Agency, transport accounts for 24% of energy-related CO_2 emissions; the share is much lower, but growing, in China. Previous empirical studies have shown that residents living in TOD neighborhoods tend to have less VKT than their counterparts in non-TOD neighborhoods, and therefore lower energy consumption and emissions. More specifically, from the results of our research, a randomly selected resident's personal daily VKT will decrease by an average of 38% when he/she moves from a non-TOD neighborhood to a TOD one, chiefly due to the impact of the built environment of TOD. At an aggregate level, this means huge energy-saving and emission reductions. I emphasize the greenhouse gas CO_2 here, but TOD of course has a similar effect on air pollution emissions.

Other benefits for new and existing residents living in TODs are increased transit ridership, increased walking and healthier lifestyles, reduction in dependency on cars, and increased efficiency in land use.

Reference: Faan Chen, Jiaorong Wu, Xiaohong Chen, Chris P. Nielsen. Submitted (2020). "Disentangling the impacts of the built environment and self-selection on travel behavior: An empirical study in the context of different housing types."

Signals of the Pandemic Seen in GHG Levels at the Harvard-Tsinghua Observatory?

The below figures show cumulative probability distributions of carbon dioxide (CO_2) and methane (CH_4), the two leading greenhouse gases, as measured in March of 2019 (red) and 2020 (green) at the Harvard-China Project's joint observatory with Tsinghua University at Miyun, north of Beijing. Depending on prevailing winds, the site sometimes measures clean background air from the northwest and sometimes polluted air from Beijing and surrounding areas. The lowest parts of the distributions represent background air, which have higher values in 2020 compared to 2019 due to annual increases in global CO_2 and CH_4 levels. The upper ends of the distributions represent polluted urban plumes from Beijing. Despite the increase in the global background, the latter levels are not as high in 2020 as they were in 2019, very likely due to reduced emissions from pandemic restrictions of economic activities and transportation. The comparisons of 2019 and 2020 are not yet controlled for meteorological differences in March of the two years, but the results are indicative. *Units: ppm = parts per million; ppb = parts per billion.*
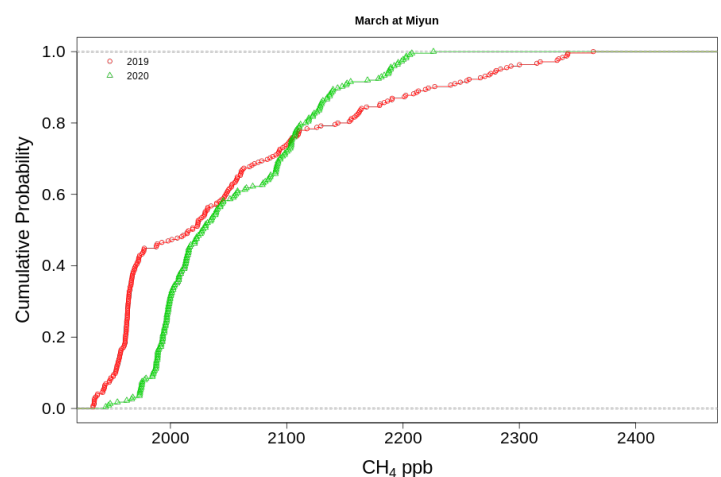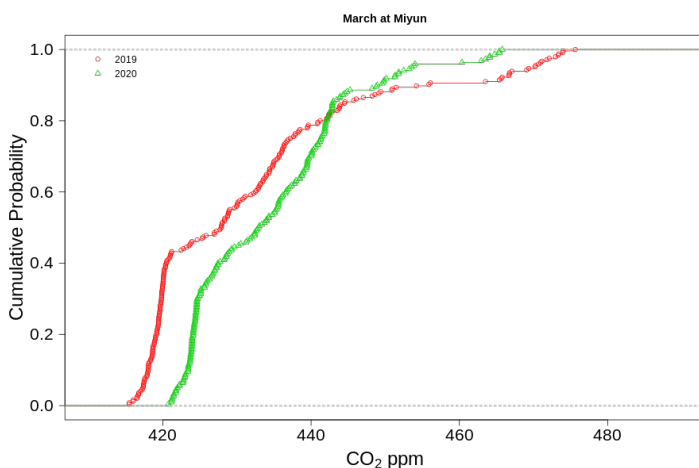
RECENT PUBLICATIONS

Archana Dayalu, J. William Munger, Yuxuan Wang, Steven C. Wofsy, Yu Zhao, Thomas Nehrkorn, Chris P. Nielsen, Michael B. McElroy, and Rachel Chang. 2020. **"Evaluating China's anthropogenic CO_2 emissions inventories: a northern China case study using continuous surface observations from 2005 to 2009."** *Atmospheric Chemistry and Physics*.

Peter Sherman, Xinyu Chen, and Michael B. McElroy. 2020. **"Offshore wind: an opportunity for cost-competitive decarbonization of China's energy economy."** *Science Advances*, 6, 8.

Jing Cao, Mun S. Ho, Wenhao Hu, and Dale W. Jorgensen. 2020. **"Estimating flexible consumption functions for urban and rural households in China."** *China Economic Review*, 61, pp. 101453.

Meng Gao, Zirui Liu, Bo Zheng, Dongsheng Ji, Peter Sherman, Shaojie Song, Jinyuan Xin, Cheng Liu, Yuesi Wang, Qiang Zhang, Jia Xing, Jingkun Jiang, Zifa Wang, Gregory R. Carmichael, and Michael B. McElroy. 2020. **"China's emission control strategies have suppressed unfavorable influences of climate on wintertime $PM_{2.5}$ concentrations in Beijing since 2002."** *Atmospheric Chemistry and Physics*, 20, 3.

Meng Gao, Jinhui Gao, Bin Zhu, Rajesh Kumar, Xiao Lu, Shaojie Song, Yuzhong Zhang, Beixi Jia, Peng Wang, Gufran Beig, Jianlin Hu, Qi Ying, Hongliang Zhang, Peter Sherman, and Michael B. McElroy. 2020. **"Ozone pollution over China and India: seasonality and sources."** *Atmospheric Chemistry and Physics*, 20, 7.

Jing Cao, Mun S. Ho, and Wenhao Hu. 2020. **"Analyzing carbon price policies using a general equilibrium model with household energy demand functions."** In *Measuring Economic Growth and Productivity: Foundations, KLEMS Production Models, and Extensions*, edited by Barbara Fraumeni. Cambridge, MA: Academic Press.

Richard Goettle, Mun S. Ho, and Peter Wilcoxen. 2020. **"Emissions accounting and carbon tax incidence in CGE models: bottom-up versus top-down."** In *Measuring Economic Growth and Productivity: Foundations, KLEMS Production Models, and Extensions*, edited by Barbara Fraumeni. Cambridge, MA: Academic Press.

Chenghe Guan, Sumeeta Srinivasan, Bo Zhang, Liangjun Da, Chris P. Nielsen, and Jialin Liu. 2020. **"The influence of neighborhood types on active transport in China's growing cities."** *Transportation Research Part D: Transport and Environment*, 80, 102273.

Xueli Zhao, Xiaofang Wu, Chenghe Guan, Rong Ma, Chris P. Nielsen, and Bo Zhang. 2020. **"Linking agricultural GHG emissions to the global trade network."** *Earth's Future*, 3, 3.

Jialin Liu, Fangyan Cheng, J. William Munger, Timothy G. Whitby, Peng Jiang, Siyue Chen, Weiwen Ji, and Xiuling Man. 2020. **"Precipitation extremes influence patterns and partitioning of evapotranspiration and transpiration in a deciduous boreal larch forest."** *Agricultural and Forest Meteorology*, 287, 107936.

Jianxiong Sheng, Shaojie Song, Yuzhong Zhang, Ronald G. Prinn, and Greet Janssens-Maenhout. 2019. **"Bottom-up estimates of coal mine methane emissions in China: A gridded inventory, emission factors, and trends."** *Environmental Science and Technology Letters*, 6, 8, pp. 473-478.

Ying Wang, Bin Chen, Chenghe Guan, and Bo Zhang. 2019. **"Evolution of methane emissions in global supply chains during 2000-2012."** *Resources, Conservation and Recycling*, 150, 104414.

Wenjie Tian, Xudong Wu, Rong Ma, and Bo Zhang. 2019. **"Quantifying global CH_4 and N_2O footprints."** *Journal of Environmental Management*, 251, 109566.

Ran Hao, Tianguang Lu, Qiuwei Wu, Xinyu Chen, and Qian Ai. 2019. **"Distributed piecewise approximation economic dispatch for regional power systems under non-ideal communication."** *IEEE Access*, 7.

Shaojie Song, Athanasios Nenes, Meng Gao, Yuzhong Zhang, Pengfei Liu, Jingyuan Shao, Dechao Ye, Weiqi Xu, Lu Lei, Yele Sun, Baoxian Liu, Shuxiao Wang, and Michael B. McElroy. 2019. **"Thermodynamic modeling suggests declines in water uptake and acidity of inorganic aerosols in Beijing winter haze events during 2014/2015–2018/2019."** *Environmental Science & Technology Letters*, 6, pp. 752-760.

Yingying Lu. 2019. **"Walking culture in China."** DDes dissertation, Harvard Graduate School of Design. This dissertation uses data from the Project's household survey in Chengdu, Sichuan.