Dec 17, 2021

Zhenxuan Wang
9 Circuit Drive
Durham, NC 27708
zhenxuan.wang@duke.edu

Innovation Research Boot Camp
National Bureau of Economic Research
1050 Massachusetts Ave
Cambridge, MA 02138

Dear Professors,

I am writing to apply for the NBER Innovation Research Boot Camp. My research interests lie at the intersection of environmental and energy economics, climate policy, and economics of innovation. Specifically, I study the driving force of innovations and the impact of information technologies on consumer and firm welfare. This boot camp can greatly benefit my research agenda by extending my knowledge in the economics of innovation, inspiring me to create new research ideas, and introducing me to people working on similar topics.

I have requested my advisor, Dr. Robyn Meeks (robyn.meeks@duke.edu), to write a letter of recommendation. My application packet includes my cv, academic transcript, and a two-page essay describing my research work.

Thank you for your time and consideration! Look forward to hearing from you.

Sincerely,

Zhenxuan Wang
PhD Candidate in Environmental Policy
Duke University

ZHENXUAN WANG

zhenxuan.wang@duke.edu • www.zhenxuanwang.org
9 Circuit Drive, Duke University, Durham, NC 27708, U.S.

INTERESTS

Environmental and Energy Economics
Empirical Industrial Organization
Public Economics
Applied Econometrics

EDUCATION

Duke University, Durham, NC, U.S.

Ph.D. in Environmental Policy — 2018 – Present
Concentration: Economics
Advisors: William Pizer, Robyn Meeks

Certificate in College Teaching — 2019 – Present

Preparing Future Faculty Program — 2021 – Present
Mentor: Roger von Haefen

Wuhan University, Wuhan, Hubei, China

B.A. in Economics — 2013 – 2017

B.S. in Mathematics — 2013 – 2017

JOURNAL PUBLICATIONS

Sexton, S., Z. Wang, and J. T. Mullins (2022). "Heat Adaptation and Human Performance in a Warming Climate". *Journal of the Association of Environmental and Resource Economists*, 9(1), 141-163.

Cui, J., J. Dai, Z. Wang, and X. Zhao (2022). "Does Environmental Regulation Induce Green Innovation? A Panel Study of Chinese Listed Firms." *Technological Forecasting and Social Change*, Accepted.

Zhang, J., Z. Wang, and X. Du (2017). "Lessons Learned from China's Regional Carbon Market Pilots". *Economics of Energy & Environmental Policy*, 6(2), 19-38.

WORKING PAPERS

Ahmad, H., A. Ali, R. Meeks, Z. Wang, J. Younas (2021). "Electricity Services and COVID-19: Understanding the Role of Infrastructure Improvements and Institutional Innovations". *Working Paper*.

Meeks, R., H. Thompson, Z. Wang (2021). "Electrification to Grow Manufacturing? Evidence from Nepal". *Under Review*.

Ahmad H. F., A. Ali, R. Meeks, V. Plutshack, Z. Wang, J. Younas (2021). " Breaking the Culture of Non-Payment: A Qualitative Analysis of Utility Intervention Project Sarbulandi in Karachi Electric, Pakistan". *R&R*.

Wang, Z. and J. Zhang (2021). "The Value of Information Disclosure: Evidence from Mask Consumption in China". *Under Review*.

Meeks, R., R. Isaev, A. Omuraliev, and Z. Wang (2021). "Impacts of Electricity Quality Improvements: Experimental Evidence on Infrastructure Investments". *Under Review*.

Cui, J., Z. Wang, and H. Yu (2021). "Can International Climate Cooperation Induce Knowledge Spillover to Developing Countries? Evidence from CDM". *R&R*.

Cui, J., T. Li, and Z. Wang (2020). "Research Collaboration beyond the Boundary: Evidence from University Patents in China". *Under Review*.

WORKS IN PROGRESS

"Distributional Effect of the Clean Air Act". with Steven Sexton

"Competitiveness Effects of Global Climate Change Policy". with Joseph Aldy and Billy Pizer

"Smart Meters, Infrastructure Improvements, and Institutional Innovations: Evidence from Pakistan and Kyrgyzstan on COVID and Power System Resilience". with Robyn Meeks, Husnain Ahmad, Ayesha Ali, Victoria Plutshack, Javed Younas, Ruslan Isaev, Arstan Omuraliev

"Smart Meter Technology and Quality of Service". with Robyn Meeks and Jacquelyn Pless

REFEREE SERVICES

China Economic Review, Journal of Environmental Economics and Management, Journal of Health Economics, Nature Climate Change, PLOS ONE

RESEARCH EXPERIENCE

Duke University, Sanford School of Public Policy
Research Assistant, Billy Pizer — 2020 – Present
Research Assistant, Steven Sexton — 2019 – Present
Research Assistant, Robyn Meeks — 2019 – Present

Duke Kunshan University, Environmental Research Center
Research Assistant, Junjie Zhang — 2017 – 2018

University of Montana, The Maureen and Mike Mansfield Center
Visiting Scholar, Global Environmental Issues — Summer 2017

Wuhan University, School of Economics and Management
Research Assistant, Jingbo Cui — 2016 – 2017

Research Assistant, Wei Zou 2016 – 2017

Teaching Experience

Duke University
Teaching Assistant

Microeconomics and Public Policy Making	Fall 2021
Quantitative Evaluation Method	Spring 2021
Economics of Sustainable Development	Fall 2020
Economics of the Public Sector	Fall 2019

North Carolina State University
Guest Lecture

Climate Econometrics	Fall 2021

Duke Kunshan University
Teaching Assistant

Environmental Economics	Fall 2017
China Environmental Issues	Fall 2017

Wuhan University
Teaching Assistant

Data Analysis: Theory and Practice	Spring 2017
Advanced Topics in Environmental Economics	Spring 2017
Production and Consumption Theory	Fall 2016
Real Analysis	Fall 2016
Financial and Monetary Economics	Spring 2016

Honors & Awards

Duke University

Preparing Future Faculty Fellow	2021
Anne T. and Robert M. Bass Fellowship	2021
Energy Data Analytics Fellowship	2021
Energy Doctoral Student Fellowship	2020 – 2023
James B. Duke Fellowship	2018 – 2023
Summer Research Fellowship	2019, 2020, 2022

Conference

EAERE Participation Grants, EAERE	2021
Best Student Paper, The Chinese Economist Society	2021

U.S. Department of State

Scholarship on Studying Global Environmental Issues	2017

Wuhan University

Outstanding Bachelor Thesis (Top 3%)	2017
Outstanding Graduates (Top 1%)	2017
First-Class Scholarship (Top 5%)	2015, 2016
Outstanding Student (Top 5%)	2015, 2016
Honorable Mention, Mathematical Contest in Modeling	2016

University Freshmen Scholarship (Top 10%) 2013

GRANTS

Energy for Economic Growth (EEG) 2020 – 2021
"Power Systems and COVID 19 in the Developing World: Understanding the Role of Metering and Infrastructure Improvements in Power System Resilience" (Co-PIs: Ayesha Ali, Javed Younas, Husnain Ahmad, Ruslan Isaev, Arstan Omuraliev, Zhenxuan Wang)

National Natural Science Foundation of China 2018 – 2022
"An Empirical Study of Air Pollution Cost through the Defensive Expenditure Approach" (PI: Junjie Zhang)

The Energy Foundation 2017 – 2019
"An Economic Analysis of the Top-Level Design of Chinas Carbon Market" (PI: Junjie Zhang)

National Natural Science Foundation of China 2017 – 2018
"Analysis of the Potential Risks and Policy Responses of the United States' Withdrawal from the Paris Agreement" (PI: Junjie Zhang)

Chinese Academy for Environmental Planning 2016 – 2017
"Index System of Regional Environmental Credit in China" (PI: Junjie Zhang)

SEMINARS & CONFERENCES

2021
Colorado Technology Primer, Golden
Camp Resources XXVII, Asheville
AERE Annual Summer Conference, Online
EAERE 26th Annual Conference, Online
CES Annual Conference, Online
Economics of Innovation in the Energy Sector, NBER
UPEP Seminar, Duke

2020
UC Berkeley Summer School in EEE, UC Berkeley
AERE @ SEA Annual Conference, New Orleans
UPEP Seminar, Duke
CES NA Annual Conference, Boston
AERE @ EEA Annual Conference, Boston

2019
Workshop on Environmental and Energy Economics, Shanghai
UPEP Seminar, Duke University
AERE Annual Summer Conference, Lake Tahoe
Duke-Northwestern Causal Inference Workshop, Duke

UNIVERSITY SERVICE

Duke Graduate & Professional Student Council — 2019 – 2020
General Assembly Representative

Duke University UPEP Seminar — 2019 – Present
Organizer

MEMBERSHIP

American Economic Association
Association for Public Policy Analysis & Management
Association of Environmental and Resource Economists
European Association of Environmental and Resource Economists
Society of Duke Fellows
The Chinese Economist Society

PATENTS

An Approach to Analyze Enterprise Weather Risk (CN201610447237.3)

A Time Series Method for Forecasting Future Weather Variable Probability Distribution (CN201610454703.0)

LANGUAGES

Chinese (native), English (fluent), Russian (Basic)

COMPUTER SKILLS

Expert in Stata, LaTeX, Asymptote
Proficient in R, MATLAB, Python, echart.js
Basic in C/C++, SAS, ArcGIS, Geoda, SQL, Javascript, HTML/CSS, Github

Last Updated: January 14, 2022

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Duke University

Official Transcript

Name: Zhenxuan Wang
Student ID: 2455372
Print Date: 10/31/2021

THE NAME OF THE UNIVERSITY APPEARS IN WHITE ACROSS THE FACE OF THIS 8 1/2 X 11 DOCUMENT

A BLACK AND WHITE DOCUMENT IS NOT OFFICIAL

Academic Program

Program: Grad - PhD Interdis — Status: Active in Program
Plan: Environmental Policy - PhD

Program: Grad - Certificate Programs — Status: Active in Program
Plan: Certificate in College Teaching

Beginning of Graduate Record

2018 Fall Term

Course		Description	Earned	Grade
CTN	1	CONTINUATION	0.000	
ECON	701D	MICROECONOMIC ANALYSIS I	3.000	A
ECON	703D	ECONOMETRICS I	3.000	A
GS	710	RESPON CONDUCT RSRCH-CAMPUS	0.000	-
GS	712	CONDUCT IN RSRCH: DEPT FORUM	0.000	-
PUBPOL	901	POL. ECON. OF PUBPOL	3.000	A-
Term GPA	3.900	Term Earned	9.000	

James B. Duke Fellowship

2019 Spring Term

Course		Description	Earned	Grade
CTN	1	CONTINUATION	0.000	
ECON	705D	MICROECONOMIC ANALYSIS II	3.000	A+
ECON	707D	ECONOMETRICS II	3.000	A
GS	712	CONDUCT IN RSRCH: DEPT FORUM	0.000	-
GS	730	EIS ACADEMIC WRITING II	3.000	CR
PUBPOL	902	ETHICS OF PUBPOL	3.000	A
Term GPA	4.000	Term Earned	12.000	

2019 Summer Term 1

Course		Description	Earned	Grade
CTN	1	CONTINUATION	0.000	
Term GPA	0.000	Term Earned	0.000	

2019 Fall Term

Course		Description	Earned	Grade
CTN	1	CONTINUATION	0.000	
ECON	821	NON-MARKET VALUATION	3.000	A+
ECON	881	TOPICS IN APPLIED MICROECON	1.500	A
Topic:		DYNAMIC DESCRETE CHOICE		
ECON	890	SPECIAL TOPICS IN ECONOMICS	3.000	A
Topic:		INDUSTRIAL ORGANIZATION		
INCS_ECG	715	ENVIRONMNTL & RESRCE ECONMCS	3.000	A+
Term GPA	4.000	Term Earned	10.500	

2020 Spring Term

Course		Description	Earned	Grade
CTN	1	CONTINUATION	0.000	
ECON	883	TOPICS IN ECONOMETRICS	1.500	A
Topic:		CAUSAL INFER/TREATMENT EFFECTS		
ECON	885	TOPICS IN ECONOMIC THEORY	1.500	S
Topic:		PSYCHOLOGY AND ECONOMICS		
STA	561D	PROBABILISTIC MACHINE LEARNING	3.000	S
Term GPA	4.000	Term Earned	6.000	

2020 Summer Term 1

Course		Description	Earned	Grade
CTN	1	CONTINUATION	0.000	
Term GPA	0.000	Term Earned	0.000	

2020 Summer Term 2

Course		Description	Earned	Grade
ECON	890	SPECIAL TOPICS IN ECONOMICS	3.000	A
Topic:		PYTHON		
Term GPA	4.000	Term Earned	3.000	

2020 Fall Term

Course		Description	Earned	Grade
CTN	1	CONTINUATION	0.000	
ENVIRON	829D	NATURAL RESOURCE ECONOMICS	3.000	A+
GS	711	RESPON CONDUCT RSRCH-GRADUATE	0.000	-
GS	714	RESPON CONDUCT RSRCH-ACAD INT	0.000	-
PUBPOL	908S	DISSERTATION PROPOSAL SEM I	3.000	A
Term GPA	4.000	Term Earned	6.000	

2021 Spring Term

Course		Description	Earned	Grade
CTN	1	CONTINUATION	0.000	
GS	750	FUNDAMENTALS COLLEGE TEACHING	1.000	CR
GS	990	DUKE GRADUATE ACADEMY	0.000	CR
Topic:		ONLINE TEACHING		
PUBPOL	909	DISSERTATION PROPOSAL SEM II	3.000	A
Term GPA	4.000	Term Earned	4.000	

2021 Summer Term 1

Course		Description	Earned	Grade
CTN	1	CONTINUATION	0.000	
Term GPA	0.000	Term Earned	0.000	

2021 Fall Term

Course		Description	Earned	Grade
CTN	1	CONTINUATION	0.000	
GS	760	COLLEGE TEACHING & VISUAL COMM	0.000	
Term GPA	0.000	Term Earned	0.000	

Bass Teaching Assistantship

Graduate Career Earned
Cum GPA: 3.978 **Cum Earned 50.500**

Non-Course Milestones

Program: Grad - PhD Interdis
Preliminary Exam
Status: Completed
Date Completed: 04/28/2021

Exam Attempt: 04/28/2021 Completed
Exam Taken:

End of Official Transcript

THE OFFICIAL SIGNATURE IS WHITE AND IS IMPOSED UPON THE INSTITUTIONAL SEAL

Zhenxuan Wang

Frank Blalark, University Registrar

DUKE UNIVERSITY TRANSCRIPT GUIDE

CREDIT, ALL SCHOOLS: The Graduate and Professional Schools, except for the Divinity School, list credit in semester hours. Prior to 1969, credit for Trinity College of Arts & Sciences, the Pratt School of Engineering, and the Divinity School was recorded in semester hours. A semester-hour unit represents one lecture or recitation period of 50 minutes per week for a fifteen-week semester or its equivalent. Beginning Fall 1969, credit for Trinity, Pratt, and the Divinity School has been listed in semester-courses.

NOTE: One semester-course credit unit is equivalent to four semester hours.

UNDERGRADUATE LOAD AND COURSE NUMBERING SYSTEM: Since 1969, the normal undergraduate load has been four semester-course credits per semester. Full-time status requires three or more semester-course credits. For undergraduate matriculants from Fall 1969-Summer 1988, the graduation requirement was 32 semester-course credits; for matriculants in Fall 1988 and after, it is 34. From 1930-2012, introductory-level courses are numbered below 100; advanced-level courses are numbered 100 and above. Courses numbered 1-49 were primarily for first-year students; courses numbered 200-299 were primarily for seniors and graduate students. Effective Fall 2012, undergraduate (Trinity and Pratt), Graduate School, Nicholas School of the Environment, Sanford School of Public Policy, Divinity School and Fuqua School of Business courses were renumbered. In the new numbering scheme, courses numbered at the 100 level and below are introductory courses; 200- and 300-level courses are above introductory; 400-level courses are advanced undergraduate, capstone-type courses typically taken by seniors; 500- and 600-level courses are graduate courses open to advanced undergraduates; courses numbered 700 and above are for graduate students only. A more detailed description of the course numbering scheme and process can be found at the following website: http://admin.trinity.duke.edu/course-renumbering.

DUKE KUNSHAN UNIVERSITY: Beginning Summer 2014 Duke University began offering graduate and professional degree programs and undergraduate semester programs at Duke Kunshan University, in Kunshan, China. Credits and degrees are awarded through Duke University and are displayed as such on Duke University transcripts, with a notation indicating the coursework was taken through Duke Kunshan University.

GRADING SYSTEMS

Spring 2020: COVID-19 required changes to enrollment patterns and grading.

UNDERGRADUATE

Trinity College of Arts & Sciences, Pratt School of Engineering, the School of Nursing, and the Woman's College:

1967-present				1930-1955		Quality Points per semester hour
A+	4.0	C+	2.3	A	Exceptional	3
A	4.0	C	2.0	B	Superior	2
A-	3.7	C-	1.7	C	Satisfactory	1
B+	3.3	D+	1.3	D	Low Pass	0
B	3.0	D	1.0	F	Failure	
B-	2.7	D-	1.0	(1955-1967, quality points per semester hour carried one more point per semester hour.)		
		F	0.0			

In 1972, Trinity College and the Woman's College merged into the coeducational Trinity College of Arts & Sciences.

GRADUATE AND PROFESSIONAL

The Graduate School, Pratt School of Engineering, Nicholas School of the Environment, and Sanford School of Public Policy:

Summer 2004-present				Through Spring 2004	
A+	4.0	B-	2.7	E	Excellent
A	4.0	C+	2.3	G	Good
A-	3.7	C	2.0	S	Satisfactory
B+	3.3	C-	1.7	F	Failure
B	3.0	F	0.0	P	Passing (Pass/Fail Course)

From Fall 1967, plus and minus signs have been possible. Through Spring 2004, the undergraduate grading system applies when a graduate student takes a course at the 100 level. All students admitted to The Graduate School, the Engineering Management program, and Sanford School of Public Policy in Summer 2004 and later will have a grade point average calculated, based on the scale noted above. No GPA is calculated for students admitted to those schools prior to Summer 2004. The Nicholas School of the Environment does not calculate a GPA.

The Fuqua School of Business:

Sept. 1980-present			Sept. 1977-Sept. 1980	
SP	4.0	Superior	A	Excellent
HP	3.5	High Pass	B	Superior
P	3.0	Pass	C	Average
LP	2.5	Low Pass	D	Low Pass
F	0.0	Failure	F	Failure

Prior to September 1977, the School of Business Administration used the same grading system as the Graduate School.

The Divinity School:

Fall 1971-present: the Divinity School has employed the same grading scale as the undergraduate schools.

1951-Fall 1971		Before 1951	
A	Excellent	E	95-100
B	Superior	G	85-94
C	Average	S	70-84
D	Inferior	F	69 & below
F	Failure		

The School of Nursing:

Spring 1993-present			
A	4.0	C+	2.3
A-	3.7	C	2.0
B+	3.3	C-	1.7
B	3.0	F	0.0
B-	2.7		

From 1974-1992, plus and minus signs were not used.

The Law School:

Fall 2013-present

4.1-4.3	Exceptional (<= 5% of any course with 40 or more students)
2.0-4.0	Passing in ascending order of proficiency
1.5	Failing

Fall 2004-2013	Fall 1989-2004	
4.1-4.3	4.1-4.5	Exceptional (<= 5% of any course with 40 or more students)
1.6-4.0	1.6-4.0	Passing in ascending order of proficiency
1.1-1.5	1.1-1.5	Failing

Fall 1971-Fall 1989

3.5-4.0	H	Honors
2.7-3.4	HP	High Pass
1.8-2.6	P	Pass
1.3-1.7	LP	Low Pass
1.0-1.2	F	Failure

OTHER SYMBOLS (all schools):

—	Completed
*	No Credit
AD	Audited
AP	Advanced Placement Program Credit
CR	Credit Only
I	Incomplete
IPC	International Placement Credit
N	No grade reported at this time from instructor
NC	No Credit
P	Pass - in Pass/Fail course (after 1966)
S	Satisfactory - in Satisfactory/Unsatisfactory course (for undergraduates beginning Fall 2010)
TR	Transfer Credit
U	Failure - in Pass/Fail course (after 1966); Unsatisfactory - in Satisfactory/Unsatisfactory course (for undergraduates beginning Fall 2010)
W	Withdrew from course
WA	Withdrew from an Audited course
WE	Withdrew, Student Registration Error
WF	Withdrew, Failing (after 1974)
WI	Withdrew, Illness
WP	Withdrew, Passing (after 1974)
X	Absent from Examination (with excuse)
Z	Year-long course, grade given next semester

ACCREDITATION: Duke University is accredited by the Southern Association of Colleges and Schools, Atlanta, GA 30365.

Office of the University Registrar
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Durham, NC 27701
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Revised March 2020

Statement of Purpose

My research interests lie at the intersection of environmental and energy economics, climate policy, and economics of innovation. Specifically, I study the driving force of innovations, the impact of information technologies on consumer and firm welfare, and how infrastructure innovation in the electricity sector affects service quality and grid resilience.

My early work explores the impact of environmental and energy policies on low-carbon innovation or pollution-mitigate technologies using patent data. In Cui et al. (2022), we revisit the "weak" version of the Porter Hypothesis to study the impact of a clean production audit program in China on firms' environmental innovations measured by patents related to pollution mitigation. We classify environmental innovation into two types, incremental and radical environmental innovation, which is similar to the distinction made by innovation management scholars. Our results show that the environmental regulation effect is more pronounced in encouraging radical innovations relative to incremental ones.

In a related paper, Cui et al. (2021), we explore whether the Clean Development Mechanism (CDM), by far the most notable voluntary international climate cooperation, can induce knowledge spillover from developed countries to developing countries. We find that CDM projects contribute to firms' innovation quantity, quality, and direction in renewable energy and energy-efficient technologies. These results can be explained by a rich set of project heterogeneity, capturing the learning-by-doing effect and the economics of scale.

In addition to the impacts of policy incentives or environmental regulations, my research also explores how improvements in transportation infrastructure can facilitate collaborations among innovators. In the paper, Cui et al. (2020), we use a quasi-natural experiment featured by High-Speed Railway (HSR) lines in China to identify the causal impact of this substantial improvement in the intercity transportation infrastructure on collaborative innovation across cities. We find that HSR induces a substantial increase in the innovation quantity and quality of collaborative patenting innovation between universities and corporates. We also build up the mapping from academic disciplines to technological fields. This mapping helps reveal the mechanism of how universities collaborate with corporate partners.

Another strand of my research studies the role of information technologies in addressing market failures. Pollution is a leading contributor to disease burden in developing countries, but their households appear to be less responsive to pollution risks due to a lack of adequate and high-quality pollution information. In a paper, Wang and Zhang (2021), we quantify the effect of real-time air

pollution information provision, enabled by automatic pollution monitoring technologies, on $PM_{2.5}$ respirator purchases in China. Our results show unambiguous evidence that information disclosure significantly induces effective and $PM_{2.5}$ targeted avoidance behavior, greatly reducing household pollution exposures.

The information technology not only benefits consumers but also provides support for public service providers. In Meeks et al. (2022), we conducted a randomized experiment in Kyrgyzstan, and find that high-frequency data provided by the smart meters directed the utility to the most problematic locations within the electricity distribution system, leading to improved electricity service quality and substantial consumer benefits.

Currently, I am working with Dr. Robyn Meeks and Dr. Jacquelyn Pless on a research project that studies how electric utilities' deployment of advanced metering infrastructure (AMI) impacts electricity reliability as measured by power outage frequency and duration. Our preliminary findings indicate that AMI indeed improves reliability, and the effects are economically meaningful. On average, AMI rollouts reduce the duration of power outages by 6 percent. Our mechanism analyses suggest that reliability improvements are mainly driven by action taken on the utility side through load control.

I would be excited to attend this boot camp. First, the lectures, offered by an impressive lineup of leading experts, greatly overlap with my interests and can inspire me to create new research ideas. Second, I have benefited a lot from these instructors' scholarships and hope to discuss my research ideas with them. For example, I want to talk with Professor John Van Reenen about my research on the economics of innovation in the energy sector. I am confident that their expertise will offer me valuable suggestions, refine my ideas, and improve my research project. Lastly, this program offers me an excellent opportunity to meet future colleagues, talk to other students, and identify potential collaborators. Networking with people from different fields enables enlightening discussions and will benefit my research and career development in the long run.

Cui, J., J. Dai, Z. Wang, and X. Zhao (2022). Does Environmental Regulation Induce Green Innovation? A Panel Study of Chinese Listed Firms. Technological Forecasting and Social Change, Accepted.

Meeks, R., R. Isaev, A. Omuraliev, and Z. Wang (2021). Impacts of Electricity Quality Improvements: Experimental Evidence on Infrastructure Investments. Under Review.

Cui, J., Z. Wang, and H. Yu (2021). Can International Climate Cooperation Induce Knowledge Spillover to Developing Countries? Evidence from CDM. R&R.

Cui, J., T. Li, and Z. Wang (2020). Research Collaboration beyond the Boundary: Evidence from University Patents in China. Under Review.

Wang, Z. and J. Zhang (2021). The Value of Information Disclosure: Evidence from Mask Consumption in China. Under Review.

Duke SANFORD SCHOOL OF PUBLIC POLICY

Robyn C. Meeks
Assistant Professor
Sanford School of Public Policy
Duke University

January 20, 2022

Brett Maranjian
NBER

Dear Brett,

I am writing this letter with my strongest support of Zhenxuan Wang's application for the Innovation Research Boot Camp. I am the co-chair of Zhenxuan's dissertation committee – co-advising with Billy Pizer -- and have been working with Zhenxuan for several years.

Mr. Wang is halfway through his fourth year in Duke's University Program in Environmental Policy (UPEP), which is a joint program between the Nicholas School of the Environment and Sanford School of Public Policy. Zhenxuan's research portfolio to date is rooted in environmental economics, with much of the work focused on developing countries, including China, Nepal, and Pakistan. With that orientation towards environmental economics, Zhenxuan is implementing research addressing the impacts of various energy policies and technologies, climate policy, and infrastructure – much of which touches on innovation. I think introducing Zhenxuan to advancements in the innovation literature would benefit his own research; however, bringing his knowledge of the climate and energy policy to the innovation group could also benefit the work of other researchers as well.

Perhaps it is most useful for me to describe one relevant project that Zhenxuan is currently working on with Jacquelyn Pless (Assistant Professor at MIT) and myself. This project is a strong example of Zhenxuan's push to understand the impacts of technological innovations and the firm and consumer response to the introduction of these technologies.

In this research (Meeks, Pless, and Wang), we explore smart metering systems employed in the electricity sector, technologies that have experienced great gains via recent technological innovations in the last 10 to 15 years. Smart meters are already pervasive in the United States, with approximately 102.9 million installed as of 2020 (U.S. Energy Information Administration 2021), many of which were publicly funded by the $4.5 billion allocated to the Department of Energy through the 2009 American Recovery and Reinvestment Act. President Biden also recently signed a $1 trillion infrastructure bill into law with $108 billion allocated towards upgrading the electricity grid, including smart grid technology. However, relatively little is known about whether smart technology actually enhances electricity reliability – one of the stated goals of the technology -- and if so, whether such improvements are driven by changes in customer or utility behavior. In our paper, we examine how electric utilities' deployment of smart meters impacts electricity reliability as measured by power outage frequency and duration. We study this by exploiting a regulatory change in Texas that authorized utilities to apply a surcharge on customers' bills. This change removed a key barrier to smart meter

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technology expansion, as it allowed utilities to recover the costs of smart meters, and it induced utilities to invest in the technology in the years that followed.

While these findings provide new evidence that smart meters can improve infrastructure service quality, which is important in its own right, disentangling whether this is driven by changes in consumer or utility behavior can provide more nuanced insight for informing policy. We explore this by examining how the effects vary based on specific technology features.We observe whether customers can access energy use data through a web portal or other electronic means (which we refer to as "data access") and whether utilities can execute load control such that they shut down or cycle a customer's equipment on short notice. If improvements are achieved through customer response, the effects should be largest when the data access feature is available. If they are driven by utilities, the effects should be largest in the presence of load control. We also observe whether there is a home area network (HAN) that allows meters to communicate with specific devices within the premises, which can enhance the potential of both data access and load control.

Although he is a Phd student working with two faculty members on the project, Zhenxuan contributes equally to the intellectual development and progress of the research project. Overall, Zhenxuan is a productive scholar. He has two published papers, seven working papers, and has four other projects underway. Two of these papers/projects derive from his time as a research assistant prior to coming to Duke, but the remainder were since coming to Duke. This is an outstanding portfolio for a student at this stage in the PhD. I feel very comfortable in saying that Mr. Wang is an extremely strong student and I am confident he would bring the tools that he learns at IRBC to energy and climate research topics.

I would end by noting that in addition to having a pipeline of projects and laudable teaching experience as well, Zhenxuan is also a conscientious community member and a pleasure to interact with. At Duke, he is always looking and asking for ways to help his classmates and the school, organizing our weekly PhD student seminar. When he travels to conferences, he regularly finds new people to collaborate with. I suspect having Zhenxuan in the bootcamp would not only help his productivity, but would manifest itself in new research and collaborations with other bootcamp participants.

In summary, Zhenxuan's academic performance is impressive. He is making great progress and his trajectory would only be enhanced by participating in this bootcamp. If there are any questions, please do not hesitate to contact me.

Sincerely,



Robyn Meeks