Brookings–Jinan China Microeconomic Policy Forum 2019

Production and Health Impacts of Environmental Externalities and Policies

Conference Summary

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BROOKINGS-JINAN CHINA MICROECONOMIC POLICY FORUM 2019

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Brookings–Jinan China Microeconomic Policy Forum in 2019 marked the beginning of IESR's cooperation with The Brookings Institution, a Washington DC-based nonprofit public policy organization recognized to be among the most influential think tanks in the United States.

This initiative arose from a shared goal to facilitate closer ties between the institutions' think tanks and to promote research collaboration on a variety of microeconomic topics, including environmental, urban, public, labor, trade, industrial, and transportation economics. The annual event aims to generate important implications for public policy in China by addressing issues concerning the Chinese economy.

Jointly organized by Shuaizhang Feng from IESR and Clifford Winston from The Brookings Institution, the 2019 conference centered on the production and health impacts of environmental externalities and policies, and involved the presentation of seven scholarly papers by Hui Zhou (Cornell), V. Brian Viard (CKGSB), Yao Pan (ZUEL), Caixia Shen (ZUFE), Peng Zhang (HK PolyU), Wangyang Lai (SUFE) and Qu Tang (Jinan IESR). Paper discussants included Richard Morgenstern (RFF), David Brownstone (UC Irvine) and Ashley Langer (U Arizona).

The Brookings Institution is a nonprofit public policy organization based in Washington, DC. It was founded by the American businessman, civic leader and philanthropist Robert S. Brookings in 1927, although the institution traces its beginnings to 1916, when a group of leading reformers founded the Institute for Government Research (IGR), the first private organization devoted to analyzing public policy issues at the national level. Brookings' mission is to conduct in-depth research that leads to new ideas for solving problems facing society at the local, national and global level. It brings together more than 300 leading experts in government and academia from all over the world who provide the highest quality research, policy recommendations, and analysis on a full range of public policy issues. Research topics cover foreign policy, economics, development, governance and metropolitan policy.

Today, The Brookings Institution is one of the most influential thinks tanks in the United States.

The Institute for Economic and Social Research (IESR) was founded at Jinan University in December 2015. Since then, IESR has played a leading role in economics education, research, public service, and international cooperation. Operating under the leadership of internationally renowned scholars, including Professor Shuaizhang Feng as Dean and Professor James Heckman as Chair of the Advisory Board, IESR currently has 42 full-time faculty members, many of whom are graduates of renowned institutions such as Yale University, University of Chicago, LSE, UC Berkeley, and UCLA. Research at IESR covers all major economic fields, and undergraduate and graduate students receive rigorous training in economics. The Institute runs a Survey Data Center for data collection and management, as well as a Center for Policy Research that adopts the motto *Think globally, Act locally* for policy analysis and evaluation.

The mission of the Institute is to advance policy-oriented economic and social research by addressing pressing social and economic issues in China. Our work is driven by the following objectives:

- Developing China-based research programs in applied economics and other fields
- Collecting original survey data related to China's economic and social development
- Building a leading Chinese think tank to inform and influence national policymaking
- Guiding IESR students to become future leaders in economic and social research
- Facilitating academic exchanges between scholars in China and abroad.

Environmental Protection or Local Protectionism? Evidence from Tailpipe Emission Standards in China

Presented by Hui Zhou, Cornell University

(Co-authors: Shanjun Li, Danxia Xie)

China implemented its first national vehicle emission standards in 2001, and has been tightening the standards every several years, from level one to level six. Starting from 2008, some cities started to use the emission standard as a barrier on used vehicle trade under the stated goal of improving local air quality. This city-level policy restricted the import of used vehicles from other cities that do not meet the local emission standard.

By leveraging the staggered roll-out of the policy across cities and the universe of new and used vehicles registration, this paper examines the impacts of the policy on intercity trade of used vehicles, local air pollution, and new vehicle market to shed light on the policy choices by local governments.

We first estimate a gravity equation with the triple difference design to examine the policy impact on intercity trade flows of used vehicles (intercity sales). The regressions control for a rich set of fixed effects including city-pair fixed effects, origin by time (i.e., quarter of sample) fixed effect, and destination by time fixed. The results suggest that the restriction policy based on tailpipe emissions standard dramatically reduced the intercity trade flow of dirty vehicles (i.e., used vehicles that do not meet the emissions standard adopted by the destination city) relative to the local sales of used vehicles.

Next, we examine whether the impact on the trade flow of used vehicles translate to an improvement on local air quality. We aggregate the hourly ambient air pollution data (PM2.5, PM10, CO, and NO2) from more than 1000 monitoring stations into the city-day level. We control for local weather condition by matching each city with its closest weather station. The regressions show no significant changes in any of the pollutants after the policy, suggesting that the policy has not achieved its stated objective of improving local air quality.

Our last set of analyses focuses on the policy impact on the new vehicle market. We divide the vehicle brands into two categories: locally brands (if the brand has a plant in the city), and non-local brands. Using the universe of new vehicle sales data by city by model by quarter during 2013-2015, we find that the restriction policy has led to a

significant increase in the sales of local brands by 36.6%, but no significant effect on non-local brands.

Our study documents a concrete example where local governments engage in practices of local protectionism under the disguise of environmental protection. These type of policies not only hinder the development of the used vehicle market and limit the gain from trade but also distract attention from effective environmental regulations that are much needed to combat pressing environmental challenges. The recent mandate by the central government to remove trade restrictions on used vehicles should help the used vehicle market to grow and enhance social welfare.

Comments by Ashley Langer (University of Arizona)

Governments worldwide have enacted a wide range of environmental policies in order to address both local environmental damages that affect health, the natural environment, and quality of life, and global environmental damages that contribute to climate change. However, governments at the national and sub-national level also use environmental policies to protect local industries and workers from competition. This use of potentially welfare-improving policies to instead capture local rents and decrease overall efficiency has been a subject of extensive debate in international trade negotiations and has led some to distrust the intentions of environmental policy advocates.

This paper investigates whether cities in China use emissions standards to protect local vehicle manufacturers from competition rather than to reduce emissions. I agree with the authors that city-level emissions standards seem ripe for misuse. One of the primary goals of emissions standards globally is to encourage the development of more efficient vehicles by manufacturers, but individual cities (even large ones in China) will generally not have enough purchasing power to encourage this type of investment unilaterally. This paper takes important first steps of showing that these emissions standards were likely more important for protecting local industry than for reducing air pollution, at least in the short run.

I think that this paper could make a larger impact by expanding its current analysis in two directions. First, the authors plan to work more on the anticipated theoretical impact of these city-level emissions standards, and I agree that this is a fruitful direction for continued work. Understanding how we expect these policies to affect trade between

markets and the sale of different products is critical for understanding whether these policies have a hope of improving environmental outcomes moving forward. Further, I would encourage the authors to expand their analysis to investigate the distributional impacts of these policies. If the largest, most polluted cities impose these policies, and that leads to increased pollution in smaller cities, does this redistribution improve or decrease overall welfare? Relatedly, are these policies regressive in that they reallocate pollution to low-income areas or are the progressive by decreasing vehicle costs in low-income areas relative to higher income areas? Understanding the broader welfare and distributional impacts of these policies is important for understanding whether central government intervention is required to curb local rent-seeking via environmental policy.

How Extensive are Air Pollution Spillovers? An Application to China's Manufacturing Productivity

Presented by V. Brian Viard, Cheung Kong Graduate School of Business

(Co-authors: Shihe Fu, Peng Zhang)

Air pollution levels far exceed the social optimum because spillovers, including trans-boundary, are not internalized. These can be corrected through either centralized environmental policies or decentralized Coasian bargaining. Regardless of the method, a necessary input is the magnitude and geographic extent of the spillovers involved. Centralized decision-making to internalize spillovers requires knowledge of how far they extend at significant levels. Alternatively, assigning property rights and allowing for decentralized Coasian bargaining requires a method for the parties to estimate the origin of spillovers and their damage.

Estimation of air pollution spillovers requires quantifying the amount of pollution that drifts as a function of distance and also the harm that it causes upon arrival. Air pollution spillovers have been documented, but their size relative to local effects and as a function of distance has not. We estimate spillovers of particulate matter smaller than 10 micrograms (PM10) on manufacturing labor productivity in China for a large firm-level panel data set from 2001 to 2007. We find that pollution exerts a substantial negative effect on productivity even at relatively far distances. A one μg/m3 annual increase in PM10 in a city within 50 kilometers decreases the average firm's annual labor

productivity by CNY 535 (0.035%). This effect declines to CNY 83 (0.005%) for nearby cities at 600 kilometers after which it declines slowly to zero at about 1,000 kilometers. This compares to a local effect of CNY 4,613 (0.302%). Such long-range effects suggest that alleviating trans-boundary air pollution requires coordination at the supra-provincial level.

There are two main determinants of the trans-boundary effect of pollution on productivity: how much air pollution is physically transported across cities (which we call the spillover decay function) and the causal effect of this pollution on productivity upon its arrival in the destination city. Ideally, the pollution spillover can be estimated flexibly to allow for a highly nonlinear gradient. However, the causal effect requires instruments for pollution and is therefore constrained to linear estimating equations.

To accomplish this, we proceed in two steps. In the first step, we estimate the spillover decay function of nearby- on focal-city pollution flexibly as a function of distance using daily data conditional on wind blowing toward the focal city. In the second step, we estimate the causal effect of focal-city air pollution on labor productivity of the focal-city's firms. Multiplying the spillover decay effects from the first step by the causal effect from the second step is equivalent to a reduced-form approach and allows us to estimate air pollution spillovers on labor productivity flexibly over a range of distances and compare it to the local effect.

In the second step we instrument for the endogeneity of pollution using air pollution imported from the nearest nearby city. This requires daily data to identify days in which pollution is imported rather than exported. We employ a mixed two-stage least squares method to accommodate annual labor productivity in the second stage but daily data in the first-stage. This approach can be applied in other settings where high-frequency pollution but only low-frequency outcome data are available such as GDP, morbidity, and mortality.

Comments by Richard Morgenstern (Resources for the Future)

One reason air pollution levels exceed the social optimum is because spillovers, including trans-boundary flows, are not internalized in decisionmaking. Fu, Viard and Zhang (2019) develop a method for estimating the magnitude and geographic extent of the pollution spillovers in China. Focusing on fine particles (PM_{10}) as a pollution metric,

they go beyond other studies which have demonstrated the existence of spillovers but not the magnitudes, and find that 'pollution spillovers are large and extend far.' Importantly, they directly link the spillovers to economic measures (productivity) and do not rely on the indirect exposure-response method to estimate health costs. As they note, their results support the case for supra-provincial policies to improve air pollution controls.

To estimate causal effects between pollution and labor productivity, Fu et. al. demonstrate that ordinary least squares (OLS) is inadequate because of the limited variation in annual pollution data and the vulnerability of annual data to common inter-regional economic or other shocks. Instead, the authors instrument for the endogeneity of pollution via a two-stage technique. In a first stage they estimate a pollution decay function using *daily* pollution and wind data. In a second stage they estimate the causal effects of air pollution on productivity with a mixed two stage least squares (M2SLS) approach that allows daily wind data to instrument for pollution, which they then link to *annual* productivity data. This is a novel applications of high frequency wind data and the M2SLS technique.

The paper adds to the growing literature examining the direct effects of air pollution on labor productivity. As the authors note, labor productivity serves as metric for multiple health effects such as decreased stamina and increased worker/family loss days in the short run, and premature mortality and cognitive damage over the long run.

A number of issues arise in trying to use this paper to support supra-provincial policies to reduce air pollution.

- Existing (US) literature identifies spillovers via a source-receptor approach, e.g., linking SO2 *emissions* to PM *concentrations*. Linking pollutant *concentrations* in nearby cities to productivity impacts in focal cities is valuable contribution but it is unclear how the results can readily support policy reforms. At least in the US, policy reforms regarding transboundary pollution are typically defined in terms of specific pollution sources rather than concentration levels in nearby cities. Perhaps the policy process is sufficiently different in China to make their approach viable, but the authors should address this issue.

- A large fraction of PM is created via secondary transformation of SO2 and NOx emissions. The authors do not address this issue in their analysis.

- Reported simulations focus on reductions in concentrations in *all* nearby cities fail to identify/prioritize those nearby cities which have the greatest spillovers. The authors should explore alternative model simulations which prioritize the large spillover cities. Also, it is unclear if the authors' calculations of Coasian prices are based on individual city pairs or average effects.

- Beyond prioritizing nearby cities, the most relevant policy applications would, as noted, provide linkage to specific sources in the large spillover cities.

- In terms of model estimation, a number of data issues should be clarified.

    - Wind measurement can be tricky. More information on how these data are defined and used would be helpful, e.g., what is the vertical measurement of the wind data?
    - Local topography can confound results. More explanation on how topography is considered in the models would be helpful.
    - Treatment of missing data is unclear. More explanation needed.

The US experience suggests that it can be challenging to deal with trans boundary pollution. Section 126 of the Clean Air Act (CAA), adopted in 1977, allows states to ask EPA to set emissions limits for specific air pollution sources in other states that *significantly* contribute to nonattainment or interfere with maintenance of one or more National Ambient Air Quality Standards in the petitioning state. However, there has been very limited use of this provision.

A more successful policy approach to transboundary spillovers can be found in Title IV of CAA (1990) wherein Congress itself imposed the requirements for reductions of SO_2/NOx in the eastern U.S. It is significant that the Congress and not regulatory agency (EPA) established the specific requirements to limit the transboundary spillovers. In subsequent years, the EPA did successfully address transboundary spillovers, e.g., in the NOx Budget Program (2003), the Clean Air Interstate Rule for SO_2/NOx (2007), the Clean Air Mercury Rule for Hg emissions (2007), and the Cross State Air Pollution Rule (2011). However, there was much controversy about these rules and progress was interrupted by multiple lawsuits.

Overall, this is a highly innovative paper which uses existing data to examine an important policy issue. At the same time, the US experience reveals challenges for politicians and regulators to address transboundary spillovers. The paper is important

step in building the case for reforms, but further analyses are needed to identify/prioritize key pollution sources, and design optimal reduction strategies within the context of China's air pollution management system.

Late-life Cognition: Do Childhood Conditions Play Any Role?

Presented by Yao Pan, Zhongnan University of Economics and Law

Individual's cognitive ability tends to reduce with ageing. Recently, whether and how to buffer this age-related decline has been one of the greatest concerns to the society. One well-established hypothesis argues that early life conditions will not only increase the total stocks of cognitive skills but will also affect the efficiency of producing subsequent cognitive skills and rate of deterioration rate. In other words, people who grew up in good conditions are more likely to obtain a higher level of cognitive stocks and are more efficient producers of cognitive skills. In this paper, we analyze the impact of childhood conditions on the individuals' late life cognitive functioning by addressing the question whether the same change in age will have different consequences on the late life cognition given different levels of childhood conditions based on the China Health and Retirement Longitudinal Study (CHARLS) data. Cognition is measured by word recall and mental intactness while we constructed a so-called childhood conditions index to measure childhood conditions. This study applies both OLS and FE analysis to examine the research question. Our findings show that childhood conditions play a strong role in shaping the age decline = late in life. Everything else constant, the same variation in age is found to have a stronger adverse effect on the word recall outcomes of individuals experiencing poorer childhood conditions. This gap increases with age, suggesting that the gains from better early life conditions remains substantial even at older ages. However, childhood conditions are not found to affect the marginal effect of age on mental intactness much. Results inform policy makers about the intergenerational consequences of public policies designed to improve the social and economic inclusion of individuals. Monitoring and helping those children under worse childhood environment at current generation could help improve old-age cognition and slow down their cognitive decline for the future generation.

Comments by David Brownstone (University of California, Irvine)

Late life cognition is impacted by many factors, but this paper concentrates on childhood conditions. The key new contribution is to look at the impact of childhood conditions on the decline of cognition using data from the China Health and Retirement Longitudinal Study (CHARLS). While there are some papers relating the level of cognition to childhood conditions (including birth weight), this is one of the few papers to look at the rate of decline of cognition using longitudinal data.

This paper shows important impact of childhood status, but without better data it is not possible to identify key mechanisms. One possible mechanism not discussed is through birth weight. Low birth rate is correlated with many bad child and adult outcomes, and may be caused by poor household conditions during pregnancy (and/or poor health care provision). More research is warranted given the high costs of caring for people with declining cognitive abilities.

The paper begins with a static model:

$$Y_{it} = \alpha + AGE_{it}' \beta_1 + AGE_{it}^2 '\beta_2 + CHILD_i '\beta_3 + z_{it}' \gamma_1 + w_i '\gamma_2 + c_i + \varepsilon_{it}$$

Where c_i and ε_{it} are unobserved error terms. The paper estimates this model under random effects (assuming that c_i are uncorrelated with any right hand side variables) and under fixed effects. Of course, under fixed effects the only impacts that can be identified are those corresponding to time-varying variables. The author should use the classic Hausman test to check the strong assumptions of the random effects model. Alternatively (or in addition) the author could try an alternative dynamic specification:

$$Y_{i2} - Y_{i1} = \alpha + AGE_{i2} '\delta_1 + AGE_{i2}^2 '\delta_2 + CHILD_i '\delta_3 + z_{i2}' \eta_1 + w_i '\eta_2 + \mu_{it}$$

This specification allows identification of effects from both time-varying and time-fixed variables.

The author collapses the data on childhood status into a single index, but the paper shows that the four components of this index are not highly correlated and may have different policy implications. It would therefore be interesting to include all four components in the model. Also, the paper excludes those older than 80, but this group is important since it experiences the most cognitive decline.

Pollution Mitigation and Productivity: Evidence from Chinese Manufacturing Firms

Presented by Caixia Shen, Shanghai University of Finance and Economics

(Co-authors: Gautam Gowrisankaran, Michael Greenstone, Ali Hortaçsu, Mengdi Liu, Bing Zhang)

The economy of China, and other countries such as India, have experienced a huge transformation over the past 20 years, but a major cost of development has been air and water pollution. As China has become wealthier, pollution reduction has become a priority of the Chinese government. Even though pollution reduction has become a priority, pollution remains a huge problem in China. Air and water contamination in China remain at very high levels. Moreover, this pollution is affecting the health and longevity of its residents and the productivity of its workers, and there is substantial willingness to pay to avoid pollution.

The fact that pollution remains a central problem for China suggests that it may be very costly to mitigate pollution, in terms of lost productivity and revenues. This view is supported by studies that find a substantial productivity cost of pollution mitigation in the U.S. context, but is refuted by the Porter hypothesis that postulates that environmental policies lead to greater productivity. The current empirical evidence on these tradeoffs in China is both limited and ambiguous, with some studies finding a substantial productivity cost of pollution mitigation and others finding evidence in favor of the Porter hypothesis.

This paper has two goals. First, we seek to evaluate whether Chinese policies to lower pollution have been successful. Second, we seek to quantify the productivity and distributional costs of these policies.[1]

Comments by Richard Morgenstern (Resources for the Future)

Gowrisankaran, Greenstone, Hortaçsu, Liu, Shen, and Zhang (2019) seek to evaluate the effects of policies to reduce emissions/discharges in China's manufacturing sector,

[1] No study results were available as of February 2020.

focusing on the effectiveness of recent changes in tax/fee policies and their impacts on firms' productivity. The authors combine firm/year level data on environmental discharges; information from the Chinese Annual Survey of Industrial Production (which includes firms with annual sales above 5 million RMB, equivalent to U.S. Census of Manufactures); and provincial discharge fees. Four different air and water pollution discharges are considered (air pollutants: SO2 and NOx; water pollutants: COD and NH3-N), covering an estimated 85 percent of China's total industrial discharges. Identification relies on the arguably exogenous temporal and spatial variation of environmental discharge fees implemented by different Chinese provinces, following a 2003 state order allowing for differential fee increases, and on pollution reduction mandates from various Chinese Five-Year Plans.

Although China's pollution discharge fees began in 1979 as uniform charges across all provinces, they were widely considered ineffective until a 2003 state order allowed substantial increases in the fees, to be decided by individual provinces. Examples of the uniform 2003 fees were: 0.63 CNY / KG of SO2 and 0.74 CNY / KG of COD.

The greatest number of fee changes were observed in 2010. By 2017, the fees varied across provinces between 1.3 and 11 CNY / KG for SO2 and between 1.5 and 10.5 CNY / KG for COD.

At various points in time, some provinces raised the fees while neighboring provinces did not. The authors refer to the former as the "treatment provinces" and estimate a variety of difference-in-difference (DID) specifications to exploit the differences between firms in the two types of provinces. Year and province or firm fixed effects are included in all specifications. Most specifications also allow for region and year interactions. As a robustness check, the authors develop a so-called border analysis, using only firms within 20km of the border between treatment provinces and comparison provinces. To address the possibility that the provinces which raised their fees had relatively low pollution mitigation costs, Gowrisankaran et. al. instrument for fee changes with the provincial pollution reduction levels mandated by the 11th and 12th Five-Year Plans.

Both structural and reduced form models are used in the estimation of the impacts of the fees on pollution discharges and on productivity. Key conclusions are:

- Fees appear to have lowered emitted pollution substantially Water fees also appear to have lowered productivity.
- No direct effect of air fees on lowering pollution, although firms are switching fuels away from coal that may contribute to reduced pollution.
- Heterogeneous impacts based on capital and labor.
    - Fees appear to have increased the productivity of capital and lowered productivity of labor.
    - Results robust to relative usages of capital and labor.

At this early stage of the research I would pose a number of questions for the authors:

- As is well known, China's relatively small and uniform pollution fees in place prior to 2003 were rebated (in part) to firms to subsidize equipment purchases or other mitigation activities. It is not clear to this reviewer whether similar subsidies also allowed in the post 2003 fee programs. If so, could that information be incorporated in the modeling?
- How important is the fact that 100 percent of the revenue is now designated for local governments vs the previous situation where the central government took a portion of it? Does that alter the incentives for enforcement?
- How important is the fact that the old system made no distinction between small vs large polluters whereas under the new system large polluters pay higher rates than small ones? Could that be incorporated into the modeling?
- How to explain the apparent effectiveness of the new fees vs the old ones? Is it simply the larger size of the new fees or are other factors also at play, e.g., strengthened enforcement, different fee design?
- Does the modeling consider fee exemptions for firms that discharge directly to centralized sewage and waste treatment facilities?
- How to explain that water fees have larger impacts than air pollution charges?

The Effect of Air Pollution on Body Weight and Obesity: Evidence from China

Presented by Peng Zhang, The Hong Kong Polytechnic University

(Co-authors: Olivier Deschenes, Huixia Wang, Si Wang)

Overweight and obesity are important risk factors for a variety of chronic diseases, including diabetes, cardiovascular and kidney diseases, and some cancers (WHO, 2018a). The last decades have seen an unprecedented increase in the fraction of population with body weight issues worldwide. In response to this epidemic, numerous economics studies have sought to understand the complex and varied causes of obesity. Most studies focused on economic factors, including proximity to fast food outlets (Currie et al., 2010), income (Akee et al., 2013), education (Brunello et al., 2013), and peer and neighborhood effects (Carrell et al., 2011). This paper focuses on an environmental factor, namely, air pollution.

Identifying the causal effect of air pollution on body weight is challenging primarily because air pollution is correlated with economic confounders. In this study, we apply an instrumental variables approach and use thermal inversion as an instrumental variable for air pollution. Thermal inversions occur when the temperature in the upper atmospheric layer is higher than that of the lower layer, thereby trapping air pollution near the surface. The formation of thermal inversions is a complex meteorological phenomenon and is typically independent of economic activities. In addition, we utilize the longitudinal structure of the data, and compare the same individual over different years.

Using a two-stage least squares (2SLS) estimator, we find a positive and statistically significantly effect of PM2.5 on body weight. Specifically, a 1 μg/m3 (1.54%) increase in average PM2.5 concentrations in the past 12 months increases BMI by 0.27%, and increases the overweight and obesity rates by 0.82 and 0.27 percentage points, respectively. The dynamics of exposure to air pollution matter: we do not detect significant short-run effects coming from exposure to air pollution in the past one to three months.

We then study the effect of pollution on behavioral responses including physical and sedentary activities, sleeping, transportation mode, and calorie intake. We find that air

pollution reduces physical activity, the probability of walking to work/school, and sleeping time. On the other hand, air pollution increases fat intake. This suggests that the behavioral channels play an important role in the pollution-obesity relationship.

Comments by David Brownstone (University of California, Irvine)

This is a very good study estimating the causal effect of air pollution on obesity. It is particularly notable that the Body Mass Index (BMI) is measured independently (instead of the usual self-reports), and that air pollution is consistently estimated with good satellite data. The data covers 1989-2015 from 9 Chinese provinces. It would be interesting to include measures of individual avoidance (masks, air conditioning, air purifiers) if these are available.

The paper recognizes the potential endogeneity of air pollution since both air pollution and obesity are affected by economic activity. The paper uses a binary indicator of thermal inversions as the key instrumental variable for air pollution (as measured by small particulate concentrations, PM2.5). It would likely be better to use the strength of inversions (temperature difference between upper and lower atmosphere) as the instrument since the stronger the inversion the more pollutants are trapped.

The paper uses a 12-month exposure window which seems appropriate given time lags for behavioral mechanisms to impact body weight. However, the panel is long so it should be possible to investigate the impact of early childhood exposure on adult BMI for those captured in panel as children. This would be particularly interesting if the data include the birthweight of these children since there is a substantial literature showing the negative long-run impacts of low birthrate.

There may be threshold effects of air pollution beyond the linear effects considered in this paper. It is possible that there is a minimum level or air pollution before any negative effects are apparent, and it is also possible that the effects may be nonlinear so the marginal effects are larger (or smaller) above a certain level. This could be investigated by including indicators for very low pollution levels and/or higher order terms.

Section 5.6 and table 6 imply that there are not enough instruments to estimate models with interaction effects, but interactions between exogenous variables and inversions are valid instruments for interactions between exogenous variables and air pollution.

Indoor Air Pollution and Mortality Rates: Evidence from Natural Gas Pipelines Expansion in China

Presented by Wangyang Lai, Shanghai University of Finance and Economics

(Co-authors: Wei Huang, Liguo Lin)

Air pollution is considered as a major issue for the global community. While previous research documents a number of detrimental impacts of ambient air pollution on health and economic outcomes (Arceo, Hanna and Oliva 2016; Chay and Greenstone 2005; Chen et al. 2013; Greenstone and Hanna, 2014, Ebenstein et al. 2017), the causal health impacts due to indoor air pollution remain understudied. According to World Health Organization (2018), more than three billion people or 43% of the global population, largely in developing countries, still rely on biomass fuels for their domestic energy needs, constituting a major source of household air pollution. Establishing the true public health cost of air pollution has been a challenge. Without further estimation of the impact of indoor air pollution on health outcomes, the literature fails to provide the information required to fully conduct the benefit-cost analysis surrounding the environmental health issue in this context.

The purpose of this paper is to estimate the mortality impact of indoor air pollution caused by household use of dirty fuels in China. China represents an excellent context to investigate this issue for its large share of population replying on dirty fuels as primary sources of energy (Duan et al. 2014). The data link administrative death records from China Disease Surveillance Point (DSP) with indoor energy usages in multiple large-scale national household datasets from 2004 to 2015, representing the best data available for our research purpose. The identification exploits the precise timing when different segments of the West-to-East Natural Gas Pipeline start functioning as well as the distances between pipelines with DSP locations. The key identifying assumption is that counties with different distances to pipelines have This assumption is validated under an event study framework. As further support for causal evidence, we explore the impact on death rates due to diseases unlikely to be caused by air pollution.

Consistent with the expectation, we first document a sharp increase of 32.4 percent in gas usage among households that are close to gas pipelines. We then find that the expansion of gas pipelines reduces 42 death per 100,000 population caused by cardiovascular diseases and lung cancer (-14.37%). A 10 kilometer further away from

the natural gas pipeline increases 4 death per 100,000 population (1.4%). The heterogeneous analysis reveal that the rural female is the worst affected for the reason that the female members in rural areas are often in charge of cooking. By contrast, we find little and insignificant impacts on mortality due to diseases unlikely to be caused by air pollution. Finally, nonfarm labor supply among female population increases in rural China, suggesting economically independence of women.

Comments by Ashley Langer (University of Arizona)

While there is extensive evidence of the health impacts of air pollution, the overwhelming majority of this research has focused on outdoor air quality. Yet most people spend much of their day indoors, and indoor air quality has been relatively under-studied. This paper expands on this important literature by looking at how cleaner cooking stoves, made possible by the arrival of natural gas transmission lines, affect health.

While this is an interesting an important question, the paper goes further than just looking at the effect of natural gas availability on overall health. The authors recognize that if there is a substantial decrease in the pollution generated by cooking, then women are likely to be more directly affected than men are. This takes the analysis in an important and interesting direction: can reductions in pollution have positive effects on seemingly unrelated outcomes such as women's labor force participation and earnings? The paper finds that, in fact, women *do* have larger mortality benefits than men from the arrival of the natural gas pipeline and that they *do* appear to work more and earn more money when natural gas is available for cooking.

Once the authors fully confirm their results, I believe that this paper could have a substantial impact on not only how we think about the benefits of pollution reductions but also how policymakers think about improving outcomes for disadvantaged populations. The authors should push their results further to ask whether health improvements are concentrated among working-aged women who are healthier and therefore able to work more and earn more money, or whether they are concentrated among older women, who may then be available to provide childcare for their grandchildren. These two different stories have very different implications for public policy: one suggests that worker health is somehow hindering women from fully contributing to the workforce while the other suggests that policies to improve childcare

and household help may reap substantial benefits. These are first-order questions far beyond energy provision, and I am excited to learn from the authors' continued research.

The Unintended Impacts of Agricultural Fires: Human Capital in China[2][3]

Presented by Qu Tang, Jinan University[4]

(Co-authors: Joshua Graff Zivin[5], Tong Liu[6], Yingquan Song[7], Peng Zhang[8])

The deliberate setting of fires as a tool for agricultural management has a long history that remains ubiquitous around the world today (Andreae and Merlet, 2001). Thes fires generate considerable smoke comprised of a number of pollutants that are known to be harmful to human health (e.g., Chay and Greenstone, 2003; Currie and Neidell, 2005; Schlenker and Walker, 2015). Yet, the direct study of the causal relationship between agricultural fires on human health has been greatly hampered by concerns of endogeneity and the competing benefits and costs from local fires. The goal of this paper is to examine the impacts of agricultural fires on one important component of human capital – cognitive performance.

More specifically, we exploit high-resolution satellite data on agricultural fires in the granary regions of China and a unique geocoded dataset on test performance on the

[2] We thank Tom Chang, Andrew Foster, Guojun He, Alberto Salvo, Klaus Zimmermann, and other seminar participants at Xiamen University, Hong Kong Baptist University, Peking University, Jinan University, Shanghai Jiaotong University, EAERE, and the National University of Singapore for helpful comments. All errors are our own.

[3] Originally titled as "Behind the Flames: Unintended Impacts of Straw Burning on Human Capital" in the conference program.

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Chinese National College Entrance Examination (NCEE) to investigate the impacts of fires on cognitive performance. This setting is attractive for a number of reasons. First, the majority of agricultural fires take place in the developing world where environmental controls are less stringent and the returns to human capital are generally substantial. China, in particular, is the largest grain producer in the world, with approximately one-third of all grain cropland managed through burning practices.[9]

Second, the NCEE is one of the most important institutions in China. It is taken by all seniors in high school (around 9 million students each year) and the exam score is almost the sole determinant of admission to institutions of higher learning in China. As such, the NCEE serves as a critical channel for social mobility with important implications for earnings over the lifecycle (Jia and Li, 2017). Test takers face high-powered incentives to do as well as possible on the test and thus any impact from agricultural fires is likely to represent an impact on cognitive performance rather than effort.

Finally, several features of the NCEE make it particularly well suited to causal inference. The exam date is fixed, and thus self-selection on test dates are impossible. Fortuitously for our research design, the exam takes place during the height of the agricultural burning season. Moreover, students must take the exam in the county of their household registration (hukou), rendering self-selection on exam locations virtually impossible. Our NCEE data includes test scores for the universe of students who were admitted into colleges and universities between 2005–2011 from the granary regions which form the basis of our study.

Despite the many virtues of our empirical setting, identifying the causal effect of agricultural fires on cognitive performance is challenging for reasons alluded to earlier. Agricultural fires are designed to reduce labor demands and improve farm profitability, both of which could also impact test performance. To address concerns of this type, we follow the approach recently pioneered by Rangel and Vogl (2018), and leverage exogenous variation in local wind direction during the exam period. Specifically, we compare the effect of upwind and downwind fires on students' test scores, and interpret that difference as the causal effect of pollution exposure on students' cognitive

[9] China Ministry of Agriculture: http://www.moa.gov.cn/zwllm/zwdt/201605/t20160526_5151375.htm.

performance net of economic impacts.

Our results suggest that a one-standard-deviation increase in the difference between upwind and downwind fires during the NCEE decreases the total exam score by 1.42 percent of a standard deviation (or 0.6 point), and further decreases the probability of getting into first-tier universities by 0.51 percent of a standard deviation. These impacts are entirely contemporaneous. Fires one to four weeks before the exam have no impact on performance. Reassuringly, neither do fires one to four weeks after the exam. The results are robust to alternative approaches for assigning pollution to test takers as well as a number of other specification checks. While a lack of pollution data from our study period does not allow us to utilize fires as an instrumental variable, data from a more recent period suggests that, consistent with evidence from Israel (Ebenstein et al., 2016) these cognitive impairments are likely the result of exposure to fine particulate matter.

Together, these results suggest that agricultural fires impose non-trivial external costs on the citizens living near them. They also contribute to ongoing debates about the appropriate role of standardized testing in determining access to higher education and employment opportunities (Ceci, 2000). While our analysis is based on NCEE test performance, the impacts are likely much broader, touching all aspects of life that rely on sharp thinking and careful calculations. Indeed, the impacts in lower-stakes environs may well be larger as the incentives to succumb to the fatigue and lack of focus that also typically accompanies exposure to pollution are greater, and thus more likely to exacerbate any impacts on cognitive decision making. Given the importance of human capital for economic growth (Romer, 1986), these impacts should play an important role in the calculus of developing country policy makers when designing rules to manage the use of agricultural fires.

Comments by David Brownstone (University of California, Irvine)

This is a very nice paper that finds significant negative short-term impacts of agricultural fires on Chinese National College Entrance Examination (NCEE) performance. This test is a very high-stakes test that solely determines admission to Chinese universities. The key idea is the use of wind direction (upwind versus downwind) to isolate the causal effects of agricultural fires.

The policy implications of this paper's results are not totally clear. The agricultural fires

(although illegal) are likely the most efficient way to remove harvest debris from fields. These results could be used to justify equipping testing centers with air conditioning and/or filters. Ideally there could be a randomized trial where some centers are equipped with filters and AC to mitigate impacts from fires. This would also validate the identification strategy used in this paper. The results from this paper could also be used to justify stronger efforts to reduce air pollution, or to reduce reliance on high stakes single tests, or at least to restrict fires around the testing dates.

Section 5.5 shows that fires are primarily linked to higher PM10 and PM2.5 concentrations. The authors could try to measure PM10 and PM2.5 directly using MERRA-2 Satellite data. This would allow looking at impacts of very high PM levels not caused by agricultural fires. In previous work the authors have used similar data to examine the impact of extreme heat on NCEE test performance. They should therefore consider the joint effects of heat and pollution caused by fires. Are these effects additive?

The largest impacts are found among high-achieving students. It is possible that they are under the most pressure (from parents and peers) and therefore more susceptible to distraction. Finally, if it is possible to follow students through college (and possibly beyond), then the results of this paper suggests that students who took NCEE under fire (and/or high heat) conditions should perform better than their peers (if the effects of fires that caused lower test scores are temporary).

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