# Abstracts for IPWSD 2025
*List is ordered alphabetically by last name.*
*Where available, we provide the author's extended abstract via the supplied link instead.*

## Jeanne Astier (Institut Polytechnique de Paris – ENSAE)

**Title: Climate Change Effects on Ports in the Shipping Network**

**Abstract:** *link here*

## Sushant Banjara (University of Chicago)

**Title: Environmental Degradation in One's Own Backyard: Who Gains and Who Loses from Sand Mining in India** *(joint with Claire Fan and Varun K)*

**Abstract:** Sand, the backbone of modern construction, makes up 85% of global mineral extraction. Its large-scale removal—especially from fragile river ecosystems—has raised serious environmental concerns, particularly in developing countries experiencing construction booms and lacking strong environmental regulation. Yet, the full extent of these effects, their social and economic consequences, and how they are distributed across communities remain poorly understood. This project combines novel administrative data with satellite imagery in a difference-in-differences framework to estimate the causal impacts of sand mining in Bihar, India. We find that sand mining increases flood inundation rates and flood frequency by 1.5 and 2 percentage points, respectively, from a baseline of 10%. Agricultural output, measured by vegetation index, declines by 5%. Despite these environmental costs, sand mining raises local income—proxied by nightlight intensity—by 10–20% in nearby villages. Income gains are broadly distributed within villages, reaching both ex-ante wealthier and poorer households, but are concentrated among socially dominant groups, particularly upper castes and OBCs. These findings help explain why sand mining continues with local support despite environmental harm and regulatory efforts. The unequal balance of economic benefits on social groups highlights the need for targeted policies—those that mitigate flooding, ensure sustainable mining, and compensate marginalized communities bearing the brunt of net harm.

## Clara Berestycki (Columbia University)

**Title: Impact of Wildfire-Induced Air Pollution on Time Allocation: Evidence from Smartphone Data** *(joint with Keith Chen)*

**Abstract:** Wildfire-induced air pollution is contributing to a rollback in years of air quality gains in the United States. In this paper, we use novel mobility data with high spatial and temporal resolution to explore behavioral responses to air pollution shocks

caused by wildfires in California. Using geo-localized smartphone pings, we construct individual, daily measures of time allocation. We estimate dose-response functions to wildfire-induced PM2.5 air pollution for different time allocation metrics. Time spent at work, outside, and distance travelled decrease with pollution, while time at home and time spent inside increase. We observe some non-linearity in responses to extreme levels of pollution for time spent at home and inside. We explore heterogeneity in these responses across demographic groups and find suggestive evidence that Black and Hispanic residents adapt less than White and Asian residents to extreme levels of pollution. Estimating time allocation dose-response functions for precipitation, we find that the increase in time spent at home during an extreme pollution event is equivalent to approximately four times that of a rainy day.

We also explore the salience of air pollution alerts by leveraging a discontinuity in the minimum AQI level at which air alerts are issued, in a design inspired by the work of Neidell (2009). Sometimes air quality alerts are issued, but the realized air quality is moderate and not dangerous for health. We find that individuals adapt their behavior to spend more time at home and inside and less time outside when an alert is called, even when the realized air quality is moderate.

## Nabin Bhandari (Auburn University)

**Title: Impact of Bird Diversity on Corn and Soybean Yields: A National Scale Analysis**
*(joint with Ruiqing Miao)*

**Abstract:** The relationship between humans and birds is significantly influenced by people's evaluation of birds' ecosystem services, particularly agro-ecosystem services. However, an objective and comprehensive evaluation of birds' agro-ecosystem services can be challenging. Current evaluations are mainly based on field experiments whereby scientists compare crop yields between plots with and without bird exposure. This is an important gap because inferences from experiments conducted in a few small-sized fields may not reflect birds' true agro-ecosystem services at the national-scale. This article intends to fill this gap by investigating the impact of birds on crop yields, with a focus on U.S. corn and soybeans. Furthermore, none of the previous studies have examined how pesticide use moderates the birds ecological service in determining crop yields. Ignoring the moderating effect of pesticides on bird ecological services while determining the crop yields leads to an incomplete and inaccurate assessment of bird's true value in agricultural systems. Thus, the present study also explores the interaction relationship between different bird groups—grassland birds, insectivorous birds, and endangered species—and pesticide use, specifically focusing on neonicotinoids. Our contributions to existing literature are fourfold. First, to the best of our knowledge, we are the first to investigate the impact of birds on crop yields at national level. Second, we investigate the relationship between birds and pesticide use in determining crop yields. Third, we add to the literature of IPM suggesting that grassland birds are valuable factors

to incorporate in pest management strategies in corn and soybean crops. Finally, we estimate the annual economic cost associated with grassland birds' extinction and neonicotinoids ban, which assist in assessing the value of ecological service of birds on corn and soybean yields. We estimate two different models for each crop (i.e., corn and soybean): the fixed effect (FE) model and the fixed effect model with instrumental variables (FE-IV). Our preliminary results show that grassland birds' abundance and richness have a statistically positive impact on corn and soybean yields, respectively. In addition, we find statistically negative impact of insectivorous bird richness and evenness on corn yield. However, we find no statistically significant impact of endangered birds' diversity on corn and soybean yields. From the counterfactual analysis, we estimate that if grassland birds were to become extinct, then the corn yield would decrease by 11.52% (annual economic cost equivalent to $9.3 billion), a higher percentage as compared to the counterfactual of no use of neonicotinoids in corn fields (3.82%). To maintain corn yield in the case of grassland bird extinction, our counterfactual analysis shows that the neonicotinoid use should be increased by 219.43%. Furthermore, when there is a ban on the use of neonicotinoids, increasing the grassland bird population by 32.93% would maintain the current level of corn yield, holding other factors constant.

## Cheng Bi (University of Illinois at Urbana-Champaign)

**Title: Can Biopesticides and Natural Enemies Reduce Pesticide Use Without Harming Farmers' Welfare?: A Bioeconomic Analysis of Integrated Pest Management** (*joint with Shady S. Atallah and Samantha Willden)*

**Abstract**: Modern agriculture faces the challenge of maximizing crop yields while minimizing environmental impact, particularly through the reduction of chemical pesticide use. While policymakers, such as the European Commission's Farm to Fork Strategy, have set ambitious pesticide reduction targets, achieving these goals requires economically viable alternatives that farmers are willing to adopt. Integrated Pest Management (IPM) offers a promising framework by incorporating biological, cultural, and chemical control methods, yet farmer adoption remains limited due to concerns over cost-effectiveness and pest control efficacy. This study addresses the key question: Under what ecological and economic conditions will farmers reduce chemical pesticide use when given access to commercial natural enemies and biopesticides?

To explore these questions, we develop a bioeconomic model that integrates ecological pest dynamics with farmer decision-making regarding chemical and biological pest control. The model explicitly incorporates the augmentation of commercial natural enemies alongside naturally occurring predators and evaluates the impact of non-linear predation dynamics using a Michaelis-Menten-Holling functional response. A key innovation of this model is the incorporation of the Natural Enemy-Adjusted Economic

Threshold (NEET), which accounts for the opportunity cost of pesticide application by considering its adverse effects on beneficial predators.

Preliminary findings suggest that a 70% subsidy on commercial natural enemies is required to make them as cost-effective as conventional pesticides. Furthermore, transitioning from conventional pesticides to biopesticides necessitates an 80% subsidy to maintain farm profitability. The analysis also reveals that assuming linear predation, as in traditional models, may lead to overuse of pesticide when actual predator–prey interactions follow a non-linear pattern. By integrating these ecological and economic factors, the model offers a more comprehensive framework for evaluating trade-offs between chemical pesticides, biopesticides, and biological control.

This research advances the literature on sustainable pest management by providing a dynamic optimization framework that accounts for both ecological interactions and economic incentives. The findings have important policy implications, suggesting that targeted subsidies for biological control agents and biopesticides could facilitate the transition to more sustainable agricultural practices without compromising farmers' welfare.

## Marisa Camargo (University of Helsinki)

**Title: Exploring Private Sector Engagement Strategies in Climate Action: Tackling Externalities**

**Abstract:** Over the past decade, my research has evolved to address the complexities of private sector involvement in climate action, grounded in systematic empirical methods. It began with an analysis of a dataset comprising 115 REDD+ (Reducing Emissions from Deforestation and Forest Degradation) projects, revealing that private sector engagement often prioritized reputational gains over the internalization of environmental externalities. The focus then shifted to a key commodity driving climate change, cocoa and chocolate supply chains, through in-person, on-the-ground interviews with stakeholders in producing and consuming countries, including Brazil, Ghana, the Netherlands, Belgium, and the United States. This study highlighted the need to address environmental, social, and economic externalities across entire value chains—not just at the farm level—but by improving sectors such as transport, packaging, and retail, which ultimately capture a larger share of the value. Finally, the research explored the critical role of private sector philanthropy through a case study. This case examined how private philanthropic efforts have supported the development of global sustainability standards, such as those established by the International Sustainability Standards Board (ISSB), contributing to systemic global progress. Together, these studies demonstrate an evolving research agenda that draws on empirical insights to identify diverse strategies for engaging the private sector in meaningful climate action and sustainable development.

<u>Francesco Cenerini</u> (University of Illinois at Urbana–Champaign)

**Title: Long-Term Environmental Effects of the Indonesian Transmigration Program**

**Abstract:** Deforestation in Indonesia has been a major environmental issue for decades, driven by multiple factors, including migration and agricultural expansion. This paper investigates the long-term environmental externalities of Indonesia's Transmigration Program, a state-sponsored policy that relocated over two million individuals from Java and Bali to the country's sparsely populated Outer Islands.

While previous studies have explored the role of palm oil and migratory patterns in Indonesia's deforestation crisis, especially their recent drivers, this research uniquely identifies the long-term causal effects of transmigration on ecosystem integrity. Establishing these effects is crucial as migrant relocations are increasingly occurring worldwide due to conflicts and climate-related disasters. Moreover, the environmental consequences of large-scale resettlement policies inform future migration and land-use planning, especially considering Indonesia's relocation of its capital to one of these areas.

The study utilizes data from the 1998 Transmigration Census, the 2000 Population Census, and a novel environmental outcome variable, the Forest Landscape Integrity Index (FLII), which captures the degree of anthropogenic disturbance in forested areas. A Propensity Score Matching approach is employed to address potential endogeneity in village locations, ensuring comparability between transmigrant and indigenous villages. Moreover, in order to provide nuanced results, the empirical strategy relies on OLS regression models with extensive sensitivity analyses, controlling for geographic, climatic, and socioeconomic factors. Furthermore, the analysis explores the role of ethnic diversity in mitigating environmental degradation, utilizing measures of ethnic fractionalization and transmigrant ethnic share within villages.

Findings reveal that transmigrant villages exhibit significantly lower levels of ecosystem integrity compared to indigenous villages. On average, the FLII score in transmigrant villages is 2.7–3% lower, with this effect increasing to 6–7.5% when considering the share of transmigrants in a village. These results suggest that the relocation of economically vulnerable communities into unfamiliar environments contributed to higher deforestation rates. Notably, palm oil production emerges as a key driver of environmental degradation in these villages, with its adoption strongly correlated with low rice suitability rather than high palm oil suitability. This finding supports the hypothesis that transmigrant communities turned to palm oil cultivation as a coping mechanism after encountering difficulties with rice farming on randomly assigned land, rather than a competitive advantage for its production.

Additionally, the study finds that higher ethnic fractionalization within villages is consistently associated with better environmental outcomes, a surprising result given previous literature linking diversity to weaker public goods provision. This suggests that

greater integration between indigenous and transmigrant populations may have fostered knowledge-sharing and more sustainable land-use practices.

These findings have significant policy implications for resettlement programs, land-use planning, and the sustainability of export crops in developing countries. Policies that promote integration between migrant and indigenous communities and diversify economic opportunities beyond monoculture plantations could mitigate the environmental costs of resettlement, while incentives for forest-friendly export crops could provide a better balance between rural economic growth and environmental conservation.

## Moumita Das (University of California, Santa Cruz)

### Title: Temperature and Temporary Migration in India

**Abstract:** By 2050, there could be 50 million internal climate migrants in South Asia, an area in which temporary or short-term migration is very common.In light of the increasing certainty and scale of climate change, this project studies the impact of rising temperatures on temporary migration patterns using a novel household survey in India. Specifically, our research questions are:what are the patterns of temporary migration in India and how do they interact with temperature? How might these patterns change over time in response to rising average temperatures? We find evidence for higher out-migration due to temperature shocks and motivated by this, construct a spatial equilibrium model to predict how migration responds to the IPCC climate scenarios.

## Merve Demirel (Stockholm University)

### Title: Encouraging Educational Migration: Evidence from a Mentoring Program in India

**Abstract:** This research examines how distance shapes higher education choices in India and tests whether mentoring programs can reduce barriers to educational migration, particularly for women. While migrating for education offers significant economic returns through both human capital accumulation and access to higher-income locations, we lack evidence on how students make these high-stakes decisions and whether there are effective policy tools to support beneficial educational migration.

Using administrative data from elite engineering universities in India, I first document that students systematically trade off educational quality for geographic proximity. The median student is willing to accept a significantly lower-ranked program to stay closer to home - a striking finding given these students' substantial investment in preparing for India's most competitive examination. These preferences vary markedly by gender: women demonstrate both stronger aversion to distance and weaker preferences for

program quality, resulting in them attending lower-ranked programs despite similar academic preparation. Preliminary survey evidence suggests these patterns are driven by non-pecuniary costs of migration, such as safety concerns and family disapproval, which are particularly salient for female students.

Building on these findings, I will implement a randomized controlled trial to test whether low-cost mentoring interventions can effectively reduce migration barriers. The intervention will match prospective university students with current students who have successfully navigated educational migration. Through structured mentoring sessions, mentors will share practical knowledge about relocating for education and provide social-emotional support. The study will survey 1000+ prospective students and their parents across multiple states in India, allowing me to examine how mentoring affects both students' and parents' perceptions of educational migration opportunities.

This research contributes to our understanding of spatial inequality in education access and provides evidence on scalable interventions to support beneficial educational migration. The findings have important implications for both educational equity and economic mobility, particularly for women's representation in STEM fields.

## Konrad Dierks (TSE and University of Toulouse Capitole)

**Title: Optimal storage capacity with (only) intermittent wind energy**

**Abstract:** Current economics literature on optimal investment in electricity storage uses either deterministic models or stochastic models with few periods or states for intermittent renewable electricity sources. This could result in sub-optimal storage policies that lead to an over- or underestimation of the value of electricity storage. I provide a dynamic, stochastic central planner model of the optimal management of electricity storage at the grid level where wind electricity supply follows a realistic stochastic process in continuous time and is the main (or only) source of electricity. The model can be solved using efficient numerical methods. The setting without any fossil backup sources is reminiscent of consumption-saving models with a borrowing constraint, with an additional upper bound on savings, and highlights the importance of demand elasticity for optimal storage capacity. By including settings with a fossil fuel backup, I show that whenever the latter is not fully flexible, a higher storage capacity may be optimal. The results also shed light on the necessity of very large storage capacities in the absence of a fossil fuel backup.

## Benji Edelstein (University of Pennsylvania, Loyola University of Chicago)

**Title: Water Scarcity Management and Housing Markets: Evidence from Water Impact Fees in Colorado**

**Abstract:** This paper examines the effects of local water scarcity management on housing markets, water use, and welfare in Colorado. Rising costs of securing water for new developments have led water utilities to raise the water impact fees (WIFs) that home builders pay to connect new units to the water system, and to adopt variable WIFs based on expected water use. Using a novel dataset on water utility policies, housing outcomes, and aerial imagery with a staggered difference–in–differences approach, I find that variable WIFs reduce new single-family lot sizes by 15% and irrigated areas by 30%, decreasing household water use by 15%. I also find that WIFs are fully capitalized into house prices. To estimate the effect on total water use, housing supply, and welfare, I develop and estimate an equilibrium model of new single-family housing where landowners endogenously choose the lot size and irrigated area of new housing. I estimate that variable pricing policies have increased welfare by $120 million and consumer surplus by $3,500 per household. However, even though metropolitan-area level water use declines, changes to housing supply cause a local rebound effect that increases utility-level water use among adopting providers by 3%. In contrast, counterfactual policies that cap irrigated areas lower utility-level water use among adopters by 8%, but have limited welfare effects.

## Claire Fan (University of Chicago)

**Title: Dam Thy Neighbor: Private and International Consequences of Impounding Rivers**

**Abstract:** Globally, tens of thousands of dams generate spatially uneven distributions of costs and benefits. Despite controversies, they continue to be built at ever-larger scales. Especially controversial are dams on rivers traversing multiple countries, which make up 60% of Earth's freshwater. These dams spark diplomatic tensions, as they allow their governments to impose externalities on foreign downstream countries. Yet, we have little causal evidence on the economic impacts of dams across international borders. And, what role do international relations between neighboring riparians play?

This paper studies the effects of dams, through their hydrological consequences, on downstream economic growth in both the upstream dam country and foreign downstream countries. I leverage the spatial tributary structure of rivers to construct an intuitive continuous measure of exposure to an upstream dam, and identify the causal effects of dams under two assumptions. First, local economies near rivers are adapted to their local pre-dam river discharge. Downstream of a dam, as the river converges with the undammed flow of numerous tributaries, the share of the discharge originating from the dammed location decreases, diluting the potential impact of the dam. Thus, the share of baseline local river flow that is now dammed provides a continuous measure of dam "exposure" among cells along the same river. Second, within any county-equivalent region ("county"), cells would see parallel trends in outcomes if all were subject to the same dammed flow share. Using staggered difference–in–differences with the flow share

measure as treatment, and cell and county-year fixed effects, I estimate the effects of dams by comparing cells within the same county that are more vs less exposed to the dam.

I present three sets of findings. First, overall, dams negatively impact economic growth in downstream river-adjacent areas, as measured by nightlights. The effects are especially pronounced from hydroelectric dams, and on irrigated cropland. Second, although the hydrological changes induced by some dams have significant negative domestic effects, in downstream foreign countries, the externalities are insignificant on average. However, third, that result masks heterogeneity based on power relations between the upstream dam-building country and the downstream country. Areas in downstream countries that are more trade-dependent on the dam-building country at baseline, face negative externalities from the dams, while the externalities are insignificant when there is a high level of trade dependence in the other direction.

This paper is the first to generate plausibly causal evidence on the transboundary externalities of dams, as well as on the role played by international relations in mitigating transboundary environmental externalities. Beyond dams, this paper contributes to the nascent literature on the consequences of and adaptation to changes in surface water availability. Surface water changes are increasingly important with climate change, glacial melt, and human consumption, differing from groundwater in ecological value, access, and management institutions. Secondly, this paper contributes to the literature on the economic consequences of geopolitics. A small body of recent papers shows the linkages between trade dependence and geopolitics. This paper advances the literature by measuring the welfare-adjacent economic implications of those geopolitics.

## Beatrice Fontenelle-Weber (Insper)

**Title: Market-Based Environmental Conservation Policies and Their Effects on Deforestation**

**Abstract:** This study evaluates the impact of Brazil's 2012 Forest Code on deforestation, focusing on the introduction of the Legal Reserves compensation mechanism. Legal Reserves are a cornerstone of Brazil's forest legislation, requiring private landowners to maintain a percentage of their property as native vegetation. The reform created a market for native forests, enabling farmers to trade their preservation obligations. Under the new policy, landowners who exceed their legal deforestation limits can fulfil their preservation requirements by protecting equivalent areas offsite, while those with "extra" unused land can supply it to the market.

Using a microeconomic model, we demonstrate that this compensation mechanism inadvertently increases deforestation. Unlike carbon markets, it lacks a binding overall deforestation limit. More productive farmers maximize land use by dedicating their

entire property to agricultural production and purchasing offsite, less productive land for Legal Reserves—land that would likely have remained untouched otherwise. This effect is more pronounced in biomes with greater heterogeneity in land productivity.

To test these theoretical predictions, we employ a difference-in-differences (DiD) approach, using access to markets as a treatment variable. We further refine the analysis with a triple difference (DDD) strategy, isolating the relative deforestation effects in municipalities spanning multiple biomes. Empirical results corroborate the model's predictions, highlighting the unintended consequences of the Legal Reserves market in regions with significant productivity disparities.

Our findings emphasize the need for ecological compensation mechanisms with robust safeguards to prevent perverse incentives, particularly in complex and diverse ecological systems like those in Brazil.

## Prashikdivya Gajbhiye (University of Massachusetts, Amherst)

**Title**: Weather Shocks, Workfare, and the Farmer Suicide Crisis in India

**Abstract:** One farmer commits suicide every hour in India, totaling over 8,000 deaths annually. These are not just numbers but lives lost, shattered families, and livelihoods destroyed. Weather shocks threaten food security and the agricultural economy (Aragon et al., 2021; Carleton, 2017), impacting billions reliant on agriculture. In India, over 50% of 1.4 billion people depend on small farms, mostly under 3 acres.

Research Questions: I examine how weather shocks affect farmer suicide rates, and whether government assistance programs can mitigate these effects, among 120+ million people in the Indian state of Maharashtra.

Significance: First, it evaluates the effectiveness of the National Rural Employment Guarantee Act (NREGA), the world's largest workfare program, which guarantees 100 days of paid manual unskilled work to rural residents. I show how this social safety net mitigates temperature-related farmer suicides through income diversification, demonstrating its crucial role in protecting agricultural households during weather-induced income shocks. Second, it utilizes a unique dataset combining high-resolution village-level weather measurements with daily farmer suicide records, enabling a novel analysis of farmer suicides using within-district variations (Hoang et al., 2024).

Methodology: I construct a village-level panel (2000–2023) of farmer suicides (confidential) and weather shocks (ERA5) across 40,000 villages, totaling 355 million daily observations, reflecting actual weather conditions on farmers' lands.

I estimate the causal relationship between farmer suicides and weather shocks using a temperature response model from agronomic climate econometrics literature (Carleton,

2017; Schlenker and Roberts, 2009). The village-level suicide rate (per 100,000) is modeled as a function of growing degree days and precipitation, with a linear spline of growing degree days (knots at 5°C intervals from 15°C to 35°C) to capture cold and heat stress effects.

To isolate causality, I control for confounders: cubic precipitation, village-year trends, and year fixed effects, ensuring that the estimated impact reflects temperature-induced agricultural stress rather than broader influences (Rothler et al., 2024; Carleton, 2017).

I evaluate NREGA's impact using its staggered rollout and a difference-in-differences approach, integrating climate econometric regressions (Garg et al., 2020; Taraz, 2023). This allows for assessing how NREGA mitigates weather shock effects on farmer suicides by comparing changes over time between villages with and without the program.

Results: I find that on high-temperature days (over 30°C) during the growing season, each 1°C rise in the mean temperature increases farmer suicides by 0.104 per 100,000, about 12 extra deaths statewide. This study is the first to show a stronger sensitivity to temperatures above 30°C, with trends flat between 20°C–30°C and minimal negative effects below 20°C, suggesting a potential protective influence, contrasting (Carleton, 2017). The findings highlight the significant impact of extreme heat on farmer suicides and the need for government support.

I find that NREGA as one such support program, significantly weakens the temperature-suicide relationship, reducing hot-day suicides from 0.38 to 0.08 per 100,000 under the program. This suggests NREGA's financial support helps mitigate the farmer suicide crisis.

I further explore heterogeneity, finding the effect strongest in cotton-growing villages and varying with socioeconomic and infrastructure factors.

## Yuqing Han (University of Illinois at Urbana-Champaign)

**Title: Long-run Effect of Radiation Exposure on Mortality: Evidence from the Nuclear Weapon Tests in the U.S.**

**Abstract:** This study examines the long-term mortality effects of radiation exposure from atmospheric nuclear weapons testing conducted at the Nevada Test Site between 1951 and 1962. While previous research has documented the short-term and medium-term health impacts of radiation exposure, little is known about its long-run effects on longevity, particularly regarding low-dose exposure. This research leverages quasi-random geographic and temporal variation in radiation fallout exposure across the continental United States to provide causal evidence of these effects.

The analysis employs a generalized difference-in-differences approach, utilizing county-level variation in cumulative fallout deposition and age differences at exposure.

Using the Longitudinal Intergenerational Family Electronic Micro-Database (LIFE-M), which combines administrative vital records from Ohio and North Carolina with the 1940 Census data, this study tracks individuals' mortality outcomes over several decades. This unique dataset offers comprehensive mortality coverage and enables effective tracking of both male and female subjects throughout their lives, addressing a significant limitation in historical data analysis.

The findings reveal substantial age-specific and gender-specific impacts of radiation exposure. Children exposed before age 15 experienced approximately 16 months reduction in lifespan, while individuals exposed after age 61 showed a more severe 28-month decrease. Notably, cohorts exposed during their teenage years demonstrated delayed effects, with significant decreases in survival probability emerging only after age 50. The analysis also uncovers important gender disparities, with elderly females showing greater vulnerability to radiation exposure compared to their male counterparts, consistent with medical literature on radiation sensitivity of reproductive tissue.

Investigation of prenatal exposure effects yields particularly striking results. A one percent increase in fallout deposition during the 10-12 months before birth is associated with a 0.3% reduction in survival probability to age 1, a 0.4% reduction to age 3, and a 0.5% reduction to age 50. These findings extend beyond traditional research focusing on in-utero effects by demonstrating that pre-conception exposure can significantly impact future mortality outcomes.

The economic implications of these mortality effects are substantial, with estimated social costs of $812 billion for cohorts exposed during their teenage years and $1,324.79 billion for those exposed between ages 61 and 70. These findings have significant policy implications for current radiation exposure standards, nuclear energy development, and historical nuclear waste cleanup efforts. The research suggests that existing radiation monitoring standards, primarily based on adult male conditions, may inadequately protect more vulnerable populations such as women, teenagers, and the elderly. As nations increasingly turn to nuclear power to address climate change concerns, these findings underscore the critical importance of maintaining stringent safety standards and careful waste management in nuclear energy development.

This research makes several important contributions to existing literature. It provides the first direct evidence linking early-life radiation exposure to long-term mortality outcomes, reveals delayed health effects of low-dose radiation exposure, advances understanding of prenatal pollution exposure by demonstrating pre-conception effects, and contributes to economic history literature through comprehensive analysis of both male and female outcomes. The findings inform current policy debates surrounding nuclear energy development, radiation safety standards, and the long-term public health implications of nuclear technology.

## Siyuan Hu (University of Wisconsin–Madison)

**Title: Lead in the Water, a Risk in the Pipes: The Value of Information on Lead Service Lines** *(joint with Fanyu Wang)*

**Abstract:** Lead contamination in drinking water remains a critical public health concern, with millions of households in the United States still relying on lead service lines (LSLs) for their water supply. Public awareness of the risks associated with lead exposure and the prevalence of lead service lines remains misaligned with reality, often leading to inaccurate perceptions of both personal risk and the broader scope of the issue. Many households lack precise information about the composition of their water service lines, which may influence both their perceived risk of contamination and their willingness to invest in mitigation measures. This study examines how targeted information about LSLs affects individuals' beliefs regarding water safety, their confidence in these beliefs, and their willingness to pay (WTP) for lead concentration testing. Using a randomized controlled survey experiment with a representative sample of New York City residents, we analyze how personalized versus general information on LSLs influences risk perception and financial commitment to water safety.

Participants were randomly assigned to a treatment group, which received specific information about the material of their water service lines, or a control group, which received only general information about lead regulations. Before and after the intervention, respondents reported their perceived likelihood of having lead pipes, their confidence in this belief, and their WTP for lead concentration testing. The analysis measures shifts in these responses, providing insights into how individuals update their beliefs in response to new information. The experimental design allows us to isolate the effect of personalized risk information on decision-making and assess whether exposure to such information leads to more rational investment in water safety.

Preliminary findings suggest that households systematically overestimate the likelihood of having lead service lines. Among those in the treatment group, receiving precise information about their service line composition leads to a downward revision of this belief, while the control group's perception remains elevated. Additionally, households who receive targeted information exhibit higher confidence in their revised beliefs, indicating a reduction in uncertainty regarding their water supply. WTP for lead concentration testing increases across both groups, suggesting that information—regardless of its specificity—heightens concern about water quality. However, the increase is most pronounced among households that learn they have lead service lines, implying that personal risk assessment plays a key role in shaping demand for mitigation efforts. Further analysis reveals significant heterogeneity in the effects of information provision across household characteristics. Households with children, higher levels of education, and higher incomes exhibit stronger responses to the information shock, suggesting that pre-existing awareness, risk aversion, and financial capacity may shape how individuals process and act upon new information about lead exposure.

These results underscore the importance of targeted information in shaping public perceptions of environmental health risks. While correcting misperceptions about lead exposure, information provision also strengthens engagement with preventive measures, encouraging households to take proactive steps to ensure water safety. This study contributes to the literature on risk perception and public health communication by demonstrating how personalized information affects belief updating and economic decision-making. The findings have direct implications for policymakers and water utility providers, emphasizing the need for strategic communication strategies that not only inform residents about lead risks but also motivate action. By improving the design of public information campaigns, these insights can help enhance participation in lead remediation programs and promote safer drinking water for urban populations.

## Léo Jean (Paris School of Economics)

**Title: The long-term costs of delaying carbon taxation in the oil sector**

**Abstract:** Transitioning to a low carbon economy requires ambitious climate action to reduce fossil fuel consumption as well as production. However, delayed policy implementation undermines governments' credibility, leading oil producers to continue investing heavily in new facilities and overproducing in existing ones. This paper examines the implications of a delayed implementation of a carbon tax on emissions reductions in the oil producing sector, with a specific focus on the concept of carbon lock-in. Two scenarios are compared: a baseline scenario where a carbon tax aligned with the 2°C objective is implemented in 2016, and an alternative scenario with a delayed implementation of the tax until 2030. Results suggest that the delay induces an overshooting of the corresponding oil carbon budget by 36.5% (131GtCO2eq), of which 59% occurs at the intensive margin and 41% at the extensive margin. The robustness of these findings is confirmed through testing various investor anticipations. To estimate the cost of carbon lock-in, I identify committed emissions from investments that would not be made in the presence of the tax but become locked-in once producing facilities are built. I find that these overcommitted emissions represent half (47GtCO2eq) of total committed emissions during the 2016-2029 period. The distribution of these overcommitted emissions exhibits large heterogeneity, with a significant concentration in certain offshore projects, particularly deepwater ones. I derive from these results policy recommendations arguing that locally-routed policies can achieve large carbon abatement and favour the progressive ramp up of supply-side policies to larger scales.

## Rafał Jednoróg (Kozminski University)

**Title: Electric Shadows: Understanding the Nexus of Coal Power Plant Failures and Air Quality Dynamics** *(joint with Kinga B. Tchórzewska and Yuvraj Pathak)*

**Abstract:** In 2022, coal accounted for approximately 69.2% of Poland's energy mix, reflecting the country's historical and ongoing dependence on this fossil fuel. As Poland continues to struggle to comply with the EU's National Emission Reduction Commitments directive, coal-based power plants still constitute a major pollution source and contribute to almost half of the country's greenhouse gas emissions. This paper expounds on the need for Poland to reduce the air pollution related to coal-based power plants and investigates the energy and air pollution interlinkage, at the same time answering the following research questions: 1) Do outages affect air pollution levels 2) Is the effect on air pollution long-lasting? 3) What is the mechanism behind the effect?

High-frequency data is utilized to investigate the environmental consequences of unplanned outages at coal power plants, focusing on their effects on air quality. Specifically, we analyze how outages influence the concentration of key pollutants - carbon monoxide (CO), nitrogen dioxide ($NO_2$), nitrogen oxides ($NO_x$), particulate matter (PM10 and PM2.5), and sulfur dioxide ($SO_2$). To this end, we construct a novel, hourly-level dataset of 5 million observations spanning the years 2015-2022 (at unit level) in Poland. This dataset combines information on outages from the European Network of Transmission System Operators for Electricity (ENTSO-E) with detailed air pollution data from the Chief Inspectorate of Environmental Protection, as well as meteorological variables such as wind speed and temperature from Poland's State Institute of Meteorology and Water Management. The empirical approach employs a fixed effects model to isolate the causal impact of unplanned outages on pollution concentrations. By controlling for unit-specific characteristics such as unit age and capacity, meteorological factors (wind speed, minimum and maximum temperatures), and incorporating unit and month*year fixed effects, the analysis accounts for temporal and spatial heterogeneity while clustering standard errors at the plant level. We carry out the analyses both at the aggregated and dynamic level (lags, leads).

The results reveal statistically significant increases in all six pollutants during unplanned outages, however substantial heterogeneity is present across pollutants. Specifically, concentrations of CO increase by 0.019 $mg/m^3$, $NO_2$ by 0.77 $\mu g/m^3$, $NO_x$ by 2.08 $\mu g/m^3$, PM10 by 2.67 $\mu g/m^3$, PM2.5 by 1.17 $\mu g/m^3$, and $SO_2$ by 0.91 $\mu g/m^3$. These findings demonstrate that outages have immediate and substantial effects on air quality and that they persist for hours after the events have finished. We show that the positive effects result from employing less efficient units. The study underscores the role of unplanned coal power plant outages in intensifying air pollution, with profound implications for public health and economic costs. While prior research focused on pollution outcomes in developing contexts, e.g. Kassem & Lin (2025) shows an increase in pollution following an outage due to self-generation in New Delhi, this study sheds light on the environmental vulnerabilities of coal-dependent developed countries by providing novel, high-frequency empirical evidence (Zhang et al. 2024). Finally, following Deryugina et al. (2019), we argue that pollution reduction should be prioritized in heavily populated regions, where coal power plants are typically located.

## Hayeon Jeong (Columbia University)

**Title: Cell phones and SUVs kill: The Impact of Vehicle Weight, Size, and Smartphone Use on Pedestrian Safety**

**Abstract:** Pedestrian deaths in the U.S. decreased until 2010, after which they began to rise. Our research aims to investigate the causes behind this recent increase in pedestrian fatalities, which is unique to the U.S., and to interpret this trend in terms of pedestrian-driver inequality. Our hypothesis is that the rising popularity of smartphones and heavy vehicles, such as SUVs, since 2010 has contributed to more frequent traffic accidents and more severe crashes, leading to an increase in pedestrian deaths. We found that smartphone penetration increases the crash frequency while vehicle size increases the pedestrian fatality conditional on a traffic accident. However, heavy and large vehicles provide greater safety for drivers, as they act as a shield in the event of a collision. We emphasize the necessity of laws and regulations to protect pedestrians marginalized by U.S. transportation and automobile policies. We propose modifying the Corporate Average Fuel Economy (CAFE) standard, and we advocate for regulations that incentivize the production of lighter electric vehicles (EVs) and stricter regulations on cell phone use while driving in the U.S.

## Saumya Joshi (University of British Columbia)

**Title: Welfare implications of Mining under Communal Property Rights: Evidence from India's Scheduled Areas**

**Abstract:** In 1950, the Indian Constitution designated administrative units (blocks, subdistricts, districts) with a tribal-majority population as "Scheduled Areas" (SA). This classification provided legal protections against the dispossession of tribal land. Consequently, SAs have a special process for the sale of land by a tribal owner to non-tribal entities—a village-level referendum is required for the sale to be legal. In non-SA districts, the sale of land occurs directly between the individual owner and the entity. As of 2015, 65% of India's mineral production is concentrated in SAs.

My research questions are: Do mining firms choose to enter SA districts more than non-SA districts, given an equal distribution of deposits? How does mining activity affect the distribution of income, as well as health and education outcomes, in SA versus non-SA areas?

I'm applying a fuzzy regression discontinuity design for the main analysis. The classification of SAs—based on whether administrative units had greater than 50% Scheduled Tribe population—will serve as the cutoff variable. For secondary analysis, I plan to conduct a spatial RDD.

## Seung Min Kim (Columbia University)

**Title: Political bias in U.S. federal disaster assistance** *(joint with Hannah Farkas)*

**Abstract:** Federal disaster aid in the U.S. plays an important role in helping households and municipalities recover from natural disasters. The political impartiality of such federal assistance has been under recent scrutiny, with some studies finding correlation between disaster assistance and political variables (e.g., president and governor co-partisanship) after controlling for disaster intensity. However, such studies neglect the role of FEMA field offices' preliminary damage assessments (PDAs), which provide initial information from the local level up to the executive branch for formal assessment and aid dispersion. Here, we combine novel administrative data on PDAs and satellite-based estimates of flood damage to identify the extent and the origins of political biases in the disaster declaration and the aid process. We find strong evidence suggesting political bias at the stage between field-level PDAs and the federal-level disaster declaration. In contrast, we fail to find evidence of systematic political bias in field-level PDAs. The results suggest that future efforts to address political biases in federal disaster assistance must be focused on the federal level rather than on the field damage assessment stage.

## Rafael Lembi (Michigan State University)

**Title: Exploring Energy Commons as an Anti-Colonial Praxis: Perspectives from Indigenous and Traditional Communities in the Brazilian Amazon**

**Abstract:** Access to electricity is foundational for quality of life, yet nearly one million people in the Brazilian Amazon, particularly Indigenous and traditional communities, have limited or no access. These off-grid communities often rely on diesel generators for just 2–4 hours of electricity per day when fuel is available. The national "Light for All Program" has expanded electricity access through decentralized solar systems but faces criticism for its top-down approach, which often excludes community engagement.

In contrast, some NGOs, universities, and communities have experimented with community-engaged approaches, where communities govern and own their energy systems. This alternative model, conceptualized as "energy commons," builds social relations and governance structures in participatory ways. Literature suggests energy commons can support an anti-colonial praxis, yet there remains a lack of empirical research centering communities' lived experiences and examining how energy commons actively resist colonial structures. Therefore, this paper asks:

(1)     What are the impacts and outcomes of gaining access to electricity via decentralized energy systems, as experienced by traditional and Indigenous communities in the region of Santarém, Pará, Brazil?

(2)  What is the role of community engagement and participation in influencing the impacts of implementing decentralized energy systems?

(3)  To what extent can an energy commons approach advance an anti-colonial praxis towards energy systems?

The first author co-developed the research design with Projeto Saúde e Alegria and the Federal University of Western Pará. Data was collected from three communities (two Indigenous, one traditional riverine) benefiting from distinct off-grid electrification projects: one government-led (top-down) and two using an energy commons approach (led by a university and an NGO). Over the course of three months of fieldwork, the first author utilized participant observation and semi-structured interviews (n = 40) as key methods.

Qualitative analysis indicates that both approaches improve quality of life, particularly by enabling food preservation via freezers. Government-led projects, with greater funding, provide more electricity, allowing for additional appliances. However, they establish a "customer-provider" model with monthly bills, which can conflict with local values of sovereignty and self-governance.

Energy commons projects, in contrast, cover only maintenance costs and exclude profit motives. They also offer flexible fundraising options for maintenance and repair, such as community labor, and prioritize training to ensure communities can autonomously maintain and expand their systems. Furthermore, these projects create deliberative arenas where communities establish and negotiate rules for self-governance.

This paper argues that energy commons approaches to off-grid electrification, which integrate community participation in planning, training, and implementation, advance an anti-colonial praxis by centering energy sovereignty. By rejecting tutelage-based relationships, energy commons foster alternative governance models that strengthen community autonomy in emancipatory ways.


## Yifan Liu (Georgia Institute of Technology)

**Title: Why is EV Charging So Unreliable? The Role of Competition in Supplementary Services** (*joint with Omar I. Asensio and Michael W. Toffel*)

**Abstract:** Many companies are providing sustainability-oriented supplementary services such as carbon credits to offset airline emissions and electric vehicle (EV) recharging at hotels. Despite their being a growing source of revenue and differentiation, little is known about what drives the wide variation in the quality of supplementary services. Although competition is widely studied as a driver of improvement in core service quality in literature, its effect on supplementary services is less understood.

This study examines how competition influences the reliability of U.S. public EV charging stations, a rapidly expanding supplementary service hosted by hotels, retailers, parking facilities, and other businesses. Using data from 27,192 U.S. charging stations from 2011 to 2024, we apply machine learning techniques to assess reliability based on consumer reviews. Despite a dramatic increase in the number of public EV charging stations over the past decade, much of the current infrastructure suffers from poor maintenance, with consumer reviews indicating negative user experiences nearly half of the time. Using the panel data, we regress the station reliability on the number of nearby providers by business type using OLS and fractional outcome regression models and also address potential concerns about reverse causality. We also adopt staggered DID to analyze the effects of new entry of nearby stations on focal charging quality.

We find that increased competition among establishments providing the same core business improves charging reliability, but charging station reliability declines as more competition arises from establishments offering different core businesses. The latter is especially important given that most EV charging stations in the U.S. compete against establishments operating different core businesses, which provides an explanation for the declining trend in charging reliability. We project that an average annual increase in competition is associated with a decrease in service reliability scores ranging from 11% to 23% across the most common establishment types over a 5-year period, suggesting a potential further erosion in EV charging service quality. Moreover, the positive effects of competition are geographically constrained, attenuating within 10 miles and showing not statistically different from zero in rural or disadvantaged areas. These findings highlight the importance of targeted investments to stimulate the benefits of competition to promote equitable and reliable EV charging infrastructure nationwide.

To our knowledge, this study is the first to empirically test how competition affects the quality of supplementary services. We empirically confirm our hypotheses that the effects of competition on supplementary service quality vary depending on the nature of competitors. On one hand, when increased competition in the charging market comes from the same core industry, charging reliability improves through mechanisms like reputation-building, peer effects, and visibility. On the other hand, when increased competition in the charging market comes from different core industries, charging reliability declines. This occurs because managers can still benefit from nearby providers' charging services without making investments themselves or losing customers to direct competitors, which aligns with free-riding behaviors. We argue that implementing more effective public monitoring and real-time quality updates could be a potential information-based solution to this service quality puzzle.

**Yanxu Long** (University of Minnesota)

**Title: Rural Poverty Alleviation and Forest Conservation**

**Abstract:** Forest conservation is increasingly recognized as vital in combating climate change, given forests' crucial role in regulating the Earth's climate and mitigating global warming. However, poverty often drives deforestation and forest degradation, as economically disadvantaged populations frequently lack the resources, knowledge, or incentives to adopt sustainable forest management practices (Leichenko and Silva, 2014; World Bank, 2020). In this context, poverty alleviation presents a significant opportunity to promote forest conservation by reducing reliance on forest exploitation and encouraging sustainable practices. This dynamic raises a key question: can poverty alleviation and forest conservation be pursued simultaneously? Specifically, can efforts to lift millions out of poverty also contribute to forest conservation? Despite the importance of this relationship, it remains under-explored in the literature (Hubacek et al., 2017; Malerba, 2020).

To address this gap, this study examines the impact of rural poverty alleviation on forest conservation. As part of efforts to lift rural residents above the extreme poverty threshold of USD 1.90 per day (World Bank, 2022), China identified 11 poverty-stricken regions as priority areas for targeted interventions in 2011. These regions were selected based on indicators such as county-level GDP and farmers' income. The rollout of poverty alleviation programs within these regions provided a quasi-experimental framework to evaluate the effects of poverty reduction initiatives on forest cover.

This analysis relies on two primary datasets. The first classifies counties into two groups: poor counties that initiated poverty alleviation efforts within the national poverty-stricken regions from 2011 onward and wealthier counties that had not previously engaged in poverty alleviation programs. This classification facilitates a precise evaluation of the impact of rural poverty alleviation initiatives. The second dataset consists of 30-m Land Use and Land Cover (LULC) data, providing high-resolution insights into the distribution of land use categories and their temporal dynamics.

The study employs a generalized difference-in-differences (DiD) research framework, using the implementation of poverty alleviation initiatives as the treatment under the parallel trends assumption. This empirical strategy addresses potential confounding factors by accounting for county-specific characteristics that remain constant over time (e.g., historical land use patterns and socio-economic conditions), controlling for temporal shocks affecting all counties uniformly (e.g., national policy changes or economic trends), and accommodating differential but smooth trends in land use change between designated poverty-stricken counties and those not designated.

The analysis reveals that rural poverty alleviation positively impacts forest conservation, contributing to an approximate 0.5% annual increase in forest cover during the post-implementation period from 2011 to 2020. Although results vary spatially across regions, they consistently confirm the positive effects of rural poverty alleviation on forest conservation. To assess the broader implications, the study evaluates the ecosystem service benefits of increased forest cover. Whether estimating the carbon

storage gains directly from the marginal effect of forest area or accounting for the land-use changes underlying this increase, the value of marginal carbon storage—calculated using the social cost of carbon—is approximately five times the cost of implementing poverty alleviation efforts. These findings underscore rural poverty alleviation as a cost-effective strategy for achieving both poverty reduction and environmental sustainability.

The primary mechanism underlying the positive effect on forest conservation is the conversion of cropland to forest, rather than other types of land use changes. This highlights the direct link between rural poverty alleviation and forest gains, as rural poverty is often tied to farming activities on croplands. Additional evidence points to the significant role of relocation initiatives associated with poverty alleviation, which contributed to reduced pressure on croplands and facilitated reforestation.

This study contributes to the literature in three critical ways. It provides empirical evidence linking poverty alleviation to forest conservation, diverging from previous research that focused predominantly on tropical forests (Alix-Garcia et al., 2013; Malerba, 2020; Wunder, 2001). It enriches the discourse on inequality and environmental impacts, demonstrating that reducing income inequality through poverty alleviation can enhance forest cover. This aligns with the Environmental Kuznets Curve (EKC) hypothesis, which posits that environmental degradation declines as income rises. It addresses a gap in understanding the direct effects of poverty alleviation on ecosystem services, offering robust evidence that poverty reduction supports ecosystem benefits such as carbon storage, with the value of these benefits substantially exceeding the costs of poverty alleviation.

This study establishes a clear link between rural poverty alleviation and forest conservation, addressing the dual challenges of poverty and climate change. The findings highlight a sustainable development pathway where poverty reduction and environmental conservation reinforce each other, enhancing rural well-being while supporting global ecological goals.

## Jessie Lu (Columbia University)

**Title: Damages from the Emerald Ash Borer: Invasive Species, Urban Forest Loss, and Inequality**

**Abstract:** This paper leverages the semi-exogenous shock of the Emerald Ash Borer (EAB), an invasive ash tree killing beetle, to examine whether social inequality increased or decreased the severity of beetle's impact on urban forests in the city of Chicago. This paper first examines the effect of the beetle on ash tree removal and overall tree cover using both difference-in-difference and event study specifications. I find that despite having more trees susceptible to infection, neighborhoods with more ash trees do not have more ash trees removed following the initial appearance of EAB. This is consistent

with the idea that the spread of the beetle is not fully exogenous as exposure to the beetle is non-random due to the underlying network of trees in the city as well as the existing adaptive capacity of neighborhoods. To address this, this paper uses a network SIR model to simulate the natural spread of the beetle, which reveals discrepancies between expected and realized tree removals and potentially indicates shadow adaptation---if fewer ash trees are removed than expected, this could suggest that areas were able to adequately protect their trees against the EAB shock. I find that such areas with plausibly higher adaptation tend to be areas with more white households, higher incomes, and higher educational attainment, suggesting that EAB seems to have been less harmful to more privileged areas with the resources to adapt. Overall, this paper underscores the importance of adaptive behavior in the impact of exogenous ecological shocks, arguing for increased use of ecological models to properly understand counterfactuals in econometric analysis.

## Tiemeng Ma (Penn State University)

**Title: From Local Shocks to Regional Impacts: Economic Consequences of Public Safety Power Shutoffs in California on Western U.S. Residents and Sectors** *(joint with Karen Fisher-Vanden and Joseph M. Perla)*

**Abstract:** California has faced unprecedented wildfires, causing severe loss of life and billions in property and infrastructure damage. While public safety power shutoffs (PSPSs) aim to mitigate utility-associated wildfire ignition risks in California by pre-emptive interruption of electricity supplies, they carry substantial economic implications.

This study investigates the economic impacts of PSPS events in California and their spillover effects across the Western Electricity Coordinating Council (WECC) region. It develops a regional general equilibrium model at the commuting zone (CZ) level, integrating circuit-level PSPS event data, county-level social accounting matrices (SAMs), and energy consumption data. The model examines both the direct costs of power interruptions and the indirect effects on residential welfare and sectoral production within a general equilibrium framework under various shock scenarios, including income shock, productivity shock, and combined shocks. It also accounts for heterogeneous impacts across household income groups and economic sectors, providing a comprehensive analysis of the economic and welfare consequences of power disruptions.

The results show that for California, low-income households initially face disproportionate direct costs, with their Value of Lost Load (VoLL) reaching \$2.2/kWh per household, but general equilibrium effects shift the largest welfare declines to high-income households (up to 0.74%). The manufacturing and mining sectors suffer the largest production losses of –1.22% and –5.88% respectively, while the utility sector shows resilience due to increased demand and adaptive measures. PSPS events in

California also affect other WECC states, with lower and middle-income households facing greater impacts. Sectoral effects vary due to production reallocation. Moreover, PSPS impacts show significant regional disparities within California and across Western states. Northeastern California faces severe welfare and production losses. Inter-state analysis reveals complex economic linkages, with some states showing resilience due to increased demand and adaptive measures.

This work emphasizes the importance of system feedbacks, underscores the importance of considering both regional interdependence and local heterogeneity when developing comprehensive wildfire risk policies.

## Tara Mittelberg (University of Wisconsin-Madison)

**Title: The Impact of the "Forced Labor Dirty List" on Agricultural Transactions in Brazil** *(joint with Marin Skidmore, Juliana Brandão, Lisa Rausch, and Holly Gibbs)*

**Abstract:** The cattle sector is a major perpetrator of labor exploitation in Brazil, accounting for nearly a third of the 60,000 workers ever rescued from "conditions analogous to slavery", which the Penal Code defines as those that subject a worker to arduous working days, degrading working or living conditions, restricted movement, or debt bondage. The Ministry of Labor maintains the "Dirty List", a public registry of employers that have been found to have used modern slave labor (MSL). The list is available online and is updated every six months, allowing consumers and companies to boycott firms with known cases of MSL. In the cattle sector, 75% of export-certified slaughterhouses signed sustainable supply chain Cattle Agreements (CAs) promising not to purchase cattle from ranchers on the Dirty List.

We used data from millions of cattle transactions in the Brazilian Amazon to address the question: How did the public Dirty List combined with private-sector sustainable sourcing commitments impact the business opportunities of ranchers who employed MSL? Specifically, we used an event study approach with property and time fixed effects to estimate how ranchers changed their sales behavior before, during, and after they appeared on the Dirty List. Our detailed transaction records allowed us to isolate how appearing on the Dirty List impacted how much and to whom ranchers sold cattle. Our study spans the period 2011-2022 and includes the Brazilian Legal Amazon states of Pará, Mato Grosso, Rondônia, and Tocantins, where 41% of the people ever rescued from MSL in Brazil were located (SmartLab 2024).

We found that ranchers did not change their total sales volumes when they went on the Dirty List, but significantly altered their destinations of sale. Dirty Listed ranchers halved direct sales to CA slaughterhouses, indicating that these buyers monitored and blocked non-compliant direct suppliers. However, Dirty Listed ranchers continued to sell cattle to non-CA slaughterhouses at pre-listing levels (representing around 25% of total sales volume). They also increased sales to other ranchers by the same magnitude as

they decreased sales to CA slaughterhouses. Many of the ranchers who purchased from Dirty Listed ranchers then quickly went on to sell cattle to CA slaughterhouses, suggesting that sanctioned ranchers laundered cattle through clean ranches to continue to access CA slaughterhouses. Finally, with export-level shipment data from a subset of our study years, we demonstrate that both domestic and international supply chains were likely contaminated with cattle raised by Dirty Listed ranchers.

Our results provide novel quantitative evidence linking MSL in upstream suppliers in Brazil's cattle sector to international supply chains. We present the first causal tests that track how employers sanctioned for using MSL respond to and circumvent anti-slavery policies. Our results highlight the importance of comprehensive monitoring to keep supply chains free of labor exploitation.

## Theresa Ng'andu (University of Wisconsin-Madison)

**Title: Development, Flooding and Child Health Outcomes in Zambia**

**Abstract:** Climate change predictions for sub-Saharan African countries indicate heavy precipitation and pluvial flooding. This means that if African countries do not engage in effective city planning as urbanization increases, these extreme weather conditions could be economically costly and hinder sustainable development. Thus, as urbanization in the form of infrastructure development and residential housing rises in African cities and is hailed as an indicator of economic growth, such development needs close monitoring and should be sustainably planned.  This is the case for Zambia, which has had rapid population and urbanization growth rates in the last decade, with buildings now extending to historical forest reserves and conservation areas by the issuance of presidential instruments to degazette these areas for commercial and residential development. At the same time, Zambia has seen an increase in the occurrence of (flash) floods, which can contribute to the spread of diseases such as malaria and waterborne diseases such as cholera, dysentery, and typhoid. In this project, I use a fixed effects model to answer the following research question: does development as measured by impervious surfaces in Zambian cities increase flooding?  And does this development-induced flooding increase the incidence of diseases such as malaria and waterborne diseases such as cholera, typhoid, and dysentery?

I examine how flooding in a ward (the smallest administrative unit)  has changed from 2012 to 2019. I leverage the fact that population and economic activity largely determine where development occurs and control for these variables in the estimation of the impact of impervious surfaces on flooding over time in municipal wards within cities. I compare areas with at least some impervious surface (greater than zero percent) versus areas with no impervious surface (equal to zero %). With the fixed effects estimation, preliminary results show that areas with some impervious surface have, on average, 6% more flood events than areas with no impervious surfaces. Within areas with impervious surface areas greater than 0%, however, I find that the percent of impervious

surface area decreases the number of floods: a percentage point increase in impervious surface area decreases the number of floods by 3%. I intend to use the estimates from the impervious surfaces and flooding to establish a link between flooding and diseases as the next step in the project.

My work, which focuses on a non-disaster type of flooding, contributes to the literature related to poor urban management and flooding (Mbow et al. 2008), impervious surface cover and flooding (Blum et al. 2020), and climatic impact of rapid urbanization as shown by simulations done by S. Huang et al. (2023). I also aim to establish a causal link between development-induced flooding, and diseases such as malaria, cholera, typhoid, and dysentery in children in Zambia. This extension to flooding and disease will add to the existing literature on flooding increasing health care costs (Liu et al., 2023), and reducing child immunization rates (Chandir et al., 2023), and the role of (stagnant) water on diseases (Bergreen and Mattisson, 2024, working paper).

## Lucas Perez (Paris School of Economics)

**Title: Air Ball and Air Quality: How Pollution Affects Workers' Productivity in the Short and Long Run**

**Abstract:** Air pollution has well-documented negative effects on human health, even at relatively low levels. It can cause subclinical symptoms such as fatigue and cognitive impairment, leading to economic costs by reducing workers' productivity. This impact is not limited to outdoor workers, as fine particulate matter (PM2.5) can penetrate buildings and affect indoor workers. While much research has examined the productivity costs of air pollution, little is known about workers' ability to adapt to long-term exposure. Understanding this adaptation is crucial for measuring the full social cost of air pollution.

This paper aims to answer two research questions: (1) What are the effects of PM2.5 shocks on indoor workers' productivity? (2) Does productivity adapt to pollution in the long run? Measuring individual productivity is difficult, as large panels of workers performing identical tasks are rare. Professional basketball players in the National Basketball Association (NBA) provide a unique dataset to overcome these difficulties. I analyze over 500,000 observations of a routine, high-precision task: free throw shooting. Free throws are always taken from the same distance without interference, and performance is easily measured (either made or missed). The characteristics of this shot are comparable to many settings where indoor workers are highly trained to perform a routine task that requires accuracy.

The NBA is a unique setting to study long-term adaptation. At the beginning of their career, players are exogenously assigned to teams through a draft, meaning their initial exposure to air pollution is random. This exogenous variation allows me to test whether

players exposed to higher pollution early in their careers develop greater resilience to pollution shocks over time.

A challenge is that pollution exposure may be measured with noise due to player mobility on game days. As a solution, I use wind direction as an instrumental variable. Moreover, endogeneity in the long-run analysis arises because the NBA lottery favors weaker teams, creating a correlation between city pollution and team success. Then, I develop a novel instrument using draft lottery odds. A player who is selected by a given city in the draft could have been selected by a different city if the draw in the lottery had been different. I compute the difference between the expected air pollution a player could face before the draft and the pollution in the city that selected him. The difference between the two is random as it results from one draw in the lottery.

Results indicate that a 10 µg/m3 increase in PM2.5 reduces free throw success by 1%. Moreover, players exposed to higher pollution early in their careers show reduced sensitivity to pollution shocks over time, suggesting long-term adaptation. This suggests that they gradually adjust to performing under pollution-induced symptoms.

This paper contributes to the interdisciplinary dialogue on sustainable development by examining the intersection of environmental economics, public health, and labor productivity. I use environmental science, econometric methods, and sports analytics to provide new evidences about air pollution effects on human performance and long-term adaptation.

## Wenge Rao (Peking University, CUNY Baruch College)

**Title: Multi-Objective Land Use Optimization Incorporating Renewable Energy Potential Under Climate Change** (*joint with Zehao Shen and Gang He*)

**Abstract:** This study presents a multi-objective land use optimization framework designed to integrate renewable energy potential while addressing climate change impacts. Using Yunnan Province, China, as a case study, we estimate ecosystem service values (ESV) and economic values (ECV) based on localized agricultural data, photovoltaic energy potential, and land use patterns from 1990, 2009, and 2019. Permanent basic agricultural land and photovoltaic-suitable areas were identified to minimize land-use conflicts. A multi-objective genetic algorithm (NSGA-II) was employed to maximize ESV and economic outputs while minimizing water consumption under constraints that align with carbon-neutral goals. The results demonstrate optimized land-use plans that align renewable energy development with sustainable land management, mitigating conflicts among agricultural, conservation, and urban needs. This approach exemplifies the potential of integrated planning to achieve sustainable development objectives under climate change.

## Robert Reinhardt (University of Paris 1 - Pantheon Sorbonne)

**Title: Non-linear Responses to Climate Shocks in Sub-Saharan African Cities**

**Abstract:** Sub-Saharan African cities are among the fastest growing in the world but face significant climatic risks. This study investigates how exposure to extreme climate events has shaped the economic, demographic, and physical growth of 5,821 cities in the region between 2000 and 2020. Using high-resolution remote sensing data combined with a dynamic panel and event study approach, we find that climate-driven shocks lead to accelerated informal settlement expansion and reduced economic growth, particularly in medium-sized cities, which exhibit low resilience to these shocks and higher poverty. In addition, these shocks fuel food price inflation, highlighting welfare implications. Finally, the paper documents heterogeneous responses to a chosen set of shocks depending on the location of businesses and households within cities. These findings emphasize the need for urban policies also in mid-sized cities that enhance resilience to climate risks, particularly through improved adaptation to heat and through economic support for vulnerable urban populations.

## Maxime Roche (Imperial College London)

**Title: Extreme weather and child malnutrition in Sub-Saharan Africa: Exploring drivers and moderators**

**Abstract:** Nutrition in early life is paramount for child growth and development. There are concerns that climate change may slow or reverse progress against child malnutrition, particularly in Sub-Saharan Africa. The growing literature on climate and nutrition mostly relies on cross-sectional health survey data usually precluding the identification of causal relationships. Several mechanisms have been hypothesized but none have been established as clear pathways.

This study aims to: (1) examine the impact of extreme weather on child malnutrition; (2) explore physiological effects and impacts on food consumption as drivers; and (3) investigate household income, own food production, and food prices as pathways. It is based on 18 waves of nationally representative panel data from the Living Standards Measurement Study Integrated Surveys on Agriculture (LSMS-ISA) — covering Ethiopia, Malawi, Nigeria, Tanzania, and Uganda — and collected between 2008 and 2019. Households' geocoordinates are matched with ECMWF ERA5's 0.1° x 0.1° gridded hourly weather data. The sample size is 14,826 households, including 18,804 children aged 3–36 months, spread over 1,548 repeatedly surveyed grids.

The main specification consists of child-level multi-way panel fixed effect regressions exploiting the randomness of weather variation. The dependent variables are child stunting (height-for-age Z-score <–2SD, chronic malnutrition) and wasting (weight-for-height Z-scores <–2SD, acute malnutrition), based on WHO standards. The

main independent variables are four bins that count the mean monthly hours that fall ≤22°C (base), (22-27]°C, (27-32]°C, and >32°C. Two exposure periods are set: the lifetime of the child (chronic) and the last 90 days before anthropometric measurements (acute). For chronic malnutrition, the analysis includes cluster x year x month-of-year fixed effects. In contrast to previous research, repeatedly surveyed LSMS-ISA clusters at a small geographic level allow for estimating the causal impact on acute malnutrition using cluster x year and cluster x month-of-year fixed effects. The analysis additionally controls for in-utero months weather (chronic), precipitation, and household and child sociodemographic characteristics.

An additional 100 hours above 32°C in mean monthly lifetime exposure increases the probability of stunting by 11.5 pp (+28.9%). The effects do not decrease with age, aligned with the evidence that shocks to chronic malnutrition are largely irreversible. Results show limited effects of recent heat exposure on wasting. A specification using a Standardized Precipitation Evapotranspiration Index finds similar results for droughts.

Preliminary results indicate that heat exposure does not impact reported food insecurity. Impacts on total calorie intake and nutrient adequacy will be further analyzed using reported household food consumption. Children's food intake is reduced during illness. Results show that the likelihood of diarrhea increases with recent droughts. Finally, an additional 100 hours above 32°C in mean monthly exposure in the last 90 days reduces the proportion of active household members by 2.7%.

This study will rely on the LSMS-ISA information on households' harvested quantities and yields to investigate the impact on own food production. Finally, it will match households' geocoordinates with the World Food Programme's monthly local market price data and use a multi-way panel fixed effect two-stage least square approach to disentangle between local demand-driven and long-run supply-driven food price effects. These results will be available by the time of the conference.


## Josh Romo (Stanford University)

**Title: Advances in Emissions Measurement and Air Quality Impact Quantification from the U.S. Oil and Gas Industry** *(joint with Evan Sherwin, Philippine Burdeau)*

**Abstract:** "What gets measured gets managed." Measurement-informed emissions inventories are becoming the benchmark for leadership in emissions quantification and reduction. Furthermore, the reduction of methane emissions from the oil and gas sector has been identified as a "low-hanging fruit" for climate change mitigation, and recent advancements in emissions monitoring technology have enabled the use of measurement data at an unprecedented scale. These improvements present a critical opportunity to enhance our understanding and quantification of emissions and air quality damages from the oil and gas industry.

Traditional "bottom-up" emissions inventories, such as the EPA's Greenhouse Gas Reporting Program, have been shown to underestimate regional methane emissions. Recent work has focused on developing methodologies to incorporate relevant measurement data—especially for high-volume, short-duration emissions events—into regional emissions inventories. The increasing availability of emissions data across various spatial and temporal scales also enables a more robust analysis of environmental justice impacts from the industrial sector.

Integrated assessment models (IAMs) have been utilized to quantify damages from criteria air pollutant emissions in the oil and gas sector. By incorporating measurement-informed emissions and gas composition estimates into these models, we can potentially improve the quantification of air quality damages and better inform policy and mitigation strategies.

This talk will present recent advancements in methane emissions measurement, relevant policy drivers, and ongoing research efforts in the Brandt lab at Stanford. Specifically, it will highlight results from controlled-release testing of emissions monitoring technologies, the development of improved hybrid regional emissions distributions, and enhanced estimation of natural gas composition. Additionally, preliminary results of facility-specific emissions simulations for midstream infrastructure and associated air quality impacts will be discussed.


**Serkan Sargin** (University of North Carolina at Chapel Hill)

**Title: Pathways to improve electricity reliability and decarbonization in Myanmar by 2050** *(joint with Hang Dal, Kensuke Yamaguchi, Yuen Yoong Leong, and Noah Kittner)*

**Abstract:** Achieving a low-carbon power sector is a shared goal among the Association of Southeast Asian Nations (ASEAN) member states, including Myanmar, which has committed to a 48% reduction in power sector greenhouse gas (GHG) emissions by 2030 (Nationally Determined Contribution 2021).  Facing persistent challenges such as energy shortages, outdated infrastructure, and limited investment-compounded by political and macroeconomic instabilities-this study explores viable pathways for Myanmar's electricity sector to achieve near zero emissions by 2050 while enhancing energy reliability and meeting growing demand.

The study uses the Low Emission Analysis Platform (LEAP) and the Next Energy Modeling Optimization (NEMO) tool to develop and analyze three scenarios for Myanmar's energy future. Scenario development incorporated diverse stakeholder perspectives, including those from WWF and other civil and academic organizations, to explore realistic and sustainable energy pathways.

This study models Myanmar's energy future to 2050 using three scenarios. The Existing Policies Pathway (EPP) scenario projects energy demand, supply mix, and emissions based on current policies and targets. Building on the EPP, the Optimized Existing

Policies Pathway (OEPP) scenario optimizes generation capacity expansion for enhanced reliability and cost efficiency. Finally, the Optimized More Ambitious Pathway (OMAP) scenario prioritizes energy efficiency and electrification, constraining fossil fuel use to explore renewable energy's potential to achieve near-zero power sector emissions by 2050.

Preliminary findings suggest that under current energy policies EPP scenario, Myanmar faces significant electric grid reliability challenges between 2040 and 2050 without additional infrastructure investment. A projected -43% critical reserve margin by 2050 indicates severe power shortages and frequent nationwide outages, primarily due to the retirement of aging natural gas power plants.

While the OEPP scenario improves energy reliability and cost efficiency, it relies heavily on natural gas capacity expansion, resulting in a substantial increase in GHG emissions. Recent natural gas supply chain challenges, evidenced by a decline in state-owned natural gas power plant capacity factors to approximately 5% between 2022 and 2024, and variable operation of private facilities, raise concerns about the vulnerability of this natural gas-dependent strategy.

In contrast, the OMAP scenario offers the most effective pathway to deep decarbonization, leveraging a mix of hydro, solar, geothermal resources, complemented by battery storage. The OMAP scenario tests the grid resilience of Myanmar's power sector under a significant increase in electricity demand, which triples from 43.26 TWh in the EPP to 115.76 TWh by 2050. Despite this increase, the OMAP scenario reduces power sector GHG emissions from 7,154 thousand metric tons of $CO_2$ equivalent in the OEPP scenario to just 0.73 thousand metric tons, demonstrating a substantial decarbonization impact.

## Bhavyaa Sharma (University of California, Santa Cruz)

**Title: How Climate Awake Are Financial Markets?** *(joint with Galina Hale and Anirban Sanyal)*

**Abstract:** Climate risks are now acknowledged by policymakers, financial market practitioners, and academics as a potentially material threat to financial markets and financial stability. As physical manifestations of climate change become more apparent, shall we expect massive asset repricing and financial destabilization? The answer to this question crucially depends on whether climate risks are properly priced-in already in different asset classes. Climate-related events are unique in that they are drawn from a distribution that shifts and becomes more disperse over time, making belief formation a crucial component of asset pricing. We simulate the response of asset prices to climate disasters using the rare events asset pricing framework based on Gabaix (2012) to quantify "fully priced in" response in various structures of subjective belief formation. We survey the empirical literature on the pricing of physical climate risk in equity and

fixed income markets to evaluate whether the estimates imply fully priced-in response across different belief formation structures.

## <u>Costanza Tomaselli</u> (Imperial College London, Business School; Yale University)

**Title: Powering Through: Finance Access and Labor Dynamics in the Face of Energy Uncertainty** *(joint with Armando Rangel Colina)*

**Abstract:** This study examines the impact of energy disruptions—both price increases and blackouts—on firms' profitability, labor market outcomes, and financial behavior in Mexico. The research seeks to answer two key questions: (i) how do rising energy prices affect firms' profitability, labor decisions, and access to finance, particularly for energy-intensive and highly leveraged firms? and (ii) what are the effects of blackouts on firms' performance and financial constraints, using control regions without blackouts as a benchmark? Given Mexico's increasing role in global supply chains, its reliance on imported energy, and its exposure to frequent blackouts, this study provides insights into the broader economic consequences of energy disruptions.

The significance of this research lies in its contribution to understanding the intersection between energy shocks, financial constraints, and labor dynamics in a developing economy. Energy-intensive firms, which are often among the most productive, may face severe profitability declines due to energy price hikes or power outages, affecting employment levels and financial stability. In particular, firms with limited financial access may struggle to absorb higher energy costs, leading to layoffs, capital reallocation, or, in extreme cases, bankruptcy. Similarly, disruptions in the electricity supply can exacerbate these financial strains, affecting firm performance and labor market reallocation. Given the increasing global reliance on electricity, particularly with the rise of AI-driven industries and electrified transport, the findings of this study have important implications for policymakers and businesses in emerging markets.

The empirical analysis employs a difference-in-differences (DiD) approach, leveraging exogenous energy price shocks and blackout events as quasi-natural experiments to estimate their causal impact on firms. Additionally, given the non-random nature of blackouts, an instrumental variable (IV) approach is implemented using weather-related and infrastructure-based instruments to account for potential endogeneity. I also implement a structural model to estimate the counterfactual of Mexico having more reliable source of energy, i.e. more solar as opposed to a carbon intensive energy sector. The study draws on a unique combination of micro-level firm data from Banco de México's Economic Laboratory, including commercial loans, firm-level financials (Orbis), credit applications, energy prices at the node level (CENACE), and labor market data (IMSS and EMAER).

Preliminary results suggest that energy price increases disproportionately affect energy-intensive and financially constrained firms, leading to lower profitability and

increased borrowing needs. However, firms in financially underserved regions are less able to secure loans, making them more likely to cut costs through layoffs or reduced production. Blackouts further exacerbate these challenges, with affected regions experiencing larger drops in productivity and financial stability compared to unaffected areas. The findings underscore the importance of financial access in mitigating the adverse effects of energy disruptions and highlight the risks that energy shocks pose to long-term economic growth, firm survival, and labor mobility.

## Felipe Verástegui (Columbia University)

**Title: Sustainable Investment Strategies with Real Asset Trades**

**Abstract:** What strategy should a sustainable investing fund adopt to reduce emissions without inducing firms to excessively engage in the reallocation of industrial pollution? We show that the strategy choice determines the distribution of reallocation risk across the pool of productive assets. Our competitive equilibrium model predicts that complying with sustainable targets affects downstream consumption markets, creating strategic complementarity or substitution in compliance decisions, which depends on the mass of environmentally concerned investors. Financing frictions lead to leakage trades, where assets shift from compliant to non-compliant firms, with negative implications for clean technology adoption and welfare. We demonstrate that limiting to green screening strategies is suboptimal under worst-case scenarios of ex-post firm-investor matches in the presence of leakage buyers. Unconventional strategies, such as reduction or investment screening, can effectively mitigate the reallocation of industrial pollution.

## Chang Wang (University of Michigan)

**Title: Carbon emissions regulation, input-output networks, and firm dynamics: The case of a low-carbon-zone pilot in China** (*joint with Xiangyu Shi*)

**Abstract:** Input-output linkages among sectors and firms are largely overlooked when assessing regulatory policies. Using a carbon emissions regulation in China as an example, we find that the regulation facilitates the transition to green technologies and reduces entry and carbon emissions in the regulated sectors with large carbon emissions. We also find unintended spillovers via the input-output network, resulting in more entry and innovation in the downstream sectors; and less entry and innovation in the upstream sectors. These facts can be rationalized by a firm-dynamics model with input-output linkages. The results of quantitative exercises are much different when taking input-output linkages into account.

**Yuting Wang** (Queen Mary University of London)

**Title: Beliefs, Information Trust, and Air Pollution**

**Abstract:** This paper examines how the quality of emission disclosures influences public beliefs about pollution and trust in reported data. I focus on a nationwide platform that provides daily emission records for all municipal Waste-to-Energy (WtE) plants in China. I combine emission data from 2020 to 2022 with a second-hand housing dataset spanning 92 cities. I estimate pollution beliefs using a residential sorting model where households base housing choices on perceived pollution exposure and the reliability of disclosed information. I find that, in most cities, pollution is perceived as higher when emission records are flawed, compared to when they are valid. I then explore possible sources of the prevalent "over-perception," including plant manipulation and city-specific characteristics. Such divergence, however, can be mitigated by enhancing long-run information quality, defined as the valid rate of emission records over the three years. Finally, I estimate an average marginal willingness-to-pay of $4.13 for a 1% improvement in information quality within a reference period. The substantial substitution effect between information quality and distance to the plant reveals that better-informed households are more willing to live closer to WtE plants, suggesting reduced local opposition to these facilities.

This paper makes three key contributions to the literature. First, it extends research on public responses to pollution information by incorporating household beliefs into an expected utility model, emphasizing how information quality, rather than quantity, shapes beliefs and trust. Second, it contributes to the literature on data quality in pollution disclosure by showing that improving information quality is essential not only for regulatory compliance but also for building public trust. Finally, it adds to research on public opinion regarding undesirable facilities by empirically estimating how information disclosure influences beliefs and public acceptance, offering a more objective alternative to survey-based approaches.

**Yile Xiao** (University of Michigan)

**Title: Reducing Collusion at a Cost: Analyzing the Effects of Randomized Environmental Inspections in China** *(joint with Mengdi Liu and Bing Zhang)*

**Abstract:** Effective regulatory enforcement is critical for ensuring public policy efficiency. However, enforcement efforts often face significant challenges due to limited government capacity, and crucially, collusion between regulators and the entities they oversee. Randomly assigning inspectors and subjects is considered a method to reduce the chances of collusion between supervisors and the entities they regulate. Our paper identifies and quantifies a crucial mechanism in regulatory design: while random assignment of inspectors successfully reduces collusion, the efficiency gains from this reduction are ultimately outweighed by losses in enforcement effectiveness. Using a

comprehensive dataset of over 160,000 environmental inspection records from China between 2016-2019, we find that randomized inspections addressed 16% fewer environmental issues and issued 39% fewer violations compared to routine inspections. The randomization process restricts inspectors' ability to prioritize high-risk firms, thereby reducing the likelihood of targeting noncompliant enterprises. We have 3 main contributions. First, we identify and empirically document a novel trade-off mechanism in regulatory design: the anti-corruption benefits of randomization versus the costs of reduced inspector specialization and targeting ability. Second, our findings challenge the conventional wisdom that randomized inspections are strictly superior to routine ones by showing that the efficiency losses from reduced expertise (16% fewer environmental issues addressed and 39% fewer violations issued) outweigh the gains from reduced collusion. Third, We provide a nuanced analysis of the conditions under which this trade-off mechanism operates, demonstrating that random assignment becomes more effective when collusion risk is elevated (in large enterprises and low-transparency regions).