Street-Lighting Standards and Urban Crime*

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Abstract

This paper studies whether improvements in the quality of urban infrastructure can enhance public safety. We examine an upgrade to China's urban street-lighting standard, which took effect in 2016 and revised requirements for luminance, pedestrian visibility, and coverage of road-related public spaces. We combine a city-year panel from 2013–2019 with text-based measures of adjudicated criminal cases extracted from first-instance court judgments. Exploiting cross-city differences in baseline exposure to the standard upgrade, we find that cities with greater exposure experience larger reductions in adjudicated criminal cases after the reform. The reductions are concentrated in offenses for which visibility and detection risk are likely to matter. An interquartile increase in exposure is associated with 23 fewer such criminal cases and 27 fewer offenders per million residents, roughly 10 percent of the sample means. In contrast, offenses that are less sensitive to visibility show little response. Complementary evidence from internet searches and household surveys indicates lower perceived safety concerns and greater nighttime activity, as well as increased labor supply among young women. The findings show that technical standards governing ordinary urban public goods can generate economically meaningful public-safety gains.

Keywords: urban infrastructure; street lighting; crime prevention; public safety; female labor supply
JEL Codes: O18; H54; K42; R58; J22

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1 Introduction

Urban crime is shaped not only by policing and punishment, but also by the physical environment in which residents travel, work, and interact. Streets, lighting systems, transit stops, and other ordinary public goods determine visibility, pedestrian flows, and the perceived safety of public space. These features are central to urban life: they affect the spatial distribution of crime, the use of streets after dark, and the extent to which residents can participate in nighttime work and consumption.[1] Yet much of the empirical evidence on crime prevention focuses on criminal justice interventions or localized environmental treatments. Less is known about whether citywide improvements in the quality, coverage, and operation of ordinary urban infrastructure can reduce crime.

This paper studies this question in the context of urban street lighting. Street lighting is a canonical example of crime prevention through environmental design. By increasing visibility and natural surveillance, lighting raises the probability that offenders are observed, identified, or apprehended, thereby increasing the expected cost of committing a crime (Jacobs, 1961; Jeffery, 1971; Newman, 1972; Clarke, 1983, 1995; Cozens et al., 2005; Cozens and Love, 2015). A large body of evidence finds that improved lighting can reduce crime, including evidence from randomized lighting deployments, daylight-saving-time variation, and rural electrification programs (Doleac and Sanders, 2015; Arvate et al., 2018; Chalfin et al., 2022*a*; Cook, 2022; Tealde, 2022).[2] In many urban systems, however, the relevant policy margin is no longer whether to install lighting on previously unlit streets. It is whether improvements in lighting quality, spatial coverage, and operating design generate additional safety benefits once basic street lighting infrastructure already exists.

We examine this margin using a nationwide upgrade to China's urban street lighting standards. On November 9, 2015, the Chinese government issued the *Standard for Lighting Design of Urban Road* (CJJ 45-2015), which took effect on June 1, 2016, and replaced the previous 2006 standard. The revised standard applies to newly built, expanded, and reconstructed urban street-lighting projects. Rather than simply making all streets brighter, it changes the quality and operation of street lighting along several dimensions relevant to safety: it updates luminance and illuminance requirements for motor-vehicle roads, introduces lighting requirements for pedestrian and bicycle routes that improve facial recognition and environmental awareness, and expands lighting coverage to public spaces such as parking facilities, bus stops, and tunnels.

Our empirical design exploits cross-city differences in baseline exposure to this national standard upgrade. We measure exposure using each city's cumulative number of street-lighting

[1] The importance of designing safe and accessible public space is also reflected in the United Nations 2030 Agenda for Sustainable Development. Target 11.2 calls for access to "safe, affordable, accessible and sustainable transport systems," with "special attention to the needs of those in vulnerable situations, women, children, persons with disabilities and older persons" (United Nations, 2015).

[2] For systematic reviews of lighting interventions on crimes, see Farrington and Welsh (2002), Welsh and Farrington (2008), and Welsh et al. (2022).

procurement contracts per 1,000 residents through the end of 2015. Cities with higher pre-policy procurement density had more active street-lighting investment and replacement margins to which the upgraded standard could apply. We construct a city-year panel from 2013 to 2019 and interact this predetermined exposure measure with an indicator for years from 2017 onward, the first full calendar year after implementation. City fixed effects absorb time-invariant differences across cities, while year fixed effects absorb national shocks and the common components of the standard upgrade. We also allow cities with different baseline GDP per capita and population density to follow differential trends.

To measure crime, we use first-instance criminal judgments from the China Judgments Online Database, following Ma et al. (2025). We extract court location, offender information, crime type, and time of occurrence from judgment texts, and aggregate cases to the city-year level. These data allow us to construct measures of adjudicated criminal cases by city, year, crime category, and time of day. The citywide scale of the outcome is important for a development setting: local improvements in safety may simply displace crime across nearby locations (Cornish and Clarke, 1987; Hesseling, 1994; Blattman et al., 2021; Chalfin et al., 2022*b*), while city-level outcomes capture net changes in the urban crime environment.

We find that cities with greater baseline exposure to the standard upgrade experience significantly larger post-policy reductions in adjudicated criminal cases for visibility-sensitive offenses. In our preferred specification, moving from the 25th to the 75th percentile of baseline exposure is associated with 23 fewer such cases and 27 fewer offenders per million residents after the policy, corresponding to declines of 9.9 percent and 9.5 percent relative to their respective sample means. The estimates are similar when we measure exposure using cumulative procurement contracts with price information or procurement expenditure.

The pattern of effects is consistent with a visibility-based mechanism. The reductions are concentrated in offenses for which visibility and detection risk should matter, including traffic-casualty offenses, robbery, larceny, violent crimes, public-security crimes, and drug-related crimes. By contrast, we find little evidence of effects on offenses less directly related to visibility on urban streets, including driving while intoxicated, fraud and extortion, economic crimes, bribery, gambling-related crimes, and social-administration crimes. We also find larger reductions for nighttime crimes than for daytime crimes, consistent with improved nighttime visibility playing an important role.

We provide several pieces of evidence supporting the identifying interpretation. Event-study estimates show no evidence of differential pre-trends in criminal cases across cities with different baseline exposure. The estimates are robust to alternative treatment definitions, controls for contemporaneous policy and economic shocks, flexible controls for city-specific trends, and an instrumental-variable specification using the density of local street-lighting producers. We also provide first-stage evidence from satellite nighttime luminosity measured at 1:30 a.m.: cities with greater baseline exposure experience larger post-policy increases in nighttime illumination, consistent with the procurement-based exposure measure capturing actual improvements in

lighting conditions. Finally, we show that the results are unlikely to be driven by surveillance cameras. The estimates remain robust to controlling for camera investment, and we find no evidence that camera deployment changes differentially across cities with different exposure to street lighting.

We then examine whether the standard upgrade affected perceived safety and behavior. Using household-level data from the China Family Panel Studies (CFPS) and city-level Baidu Index data, we find that higher-exposure cities experience improvements in perceived public security, declines in safety-related searches, and increases in searches related to nighttime activities. In contrast, we find no significant effect on a placebo search index unrelated to outdoor public-space safety. These patterns are consistent with lower perceived safety concerns and a greater willingness to use public space after dark.

The behavioral responses are concentrated among young women. Using individual-level CFPS data, we find that an interquartile increase in baseline exposure is associated with a 3.3 percentage point increase in labor force participation, a 3.8 percentage point increase in employment, a 2.3 percentage point increase in evening or night-shift work, and 3.7 additional weekly work hours among women aged 18–30. We also find increases in interpersonal trust and perceived helpfulness for this group. These results suggest that safer and better-lit public spaces may relax mobility and work constraints for individuals whose economic choices are especially sensitive to perceived risk.

The paper contributes to three strands of literature. First, it adds to work in urban economics on how the quality and operation of ordinary urban public goods affect public safety. Recent studies have emphasized the spatial organization of police infrastructure and the design of urban structure (Facchetti, 2025; Cosentino et al., 2026). We examine a different but pervasive urban policy instrument: the technical standards that govern the quality and operation of urban infrastructure. Much of urban policy operates through such standards, which regulate transportation systems, buildings, environmental quality, and public facilities (e.g., Ashenfelter and Greenstone, 2004; Kotchen and Grant, 2011; Jacobsen and Kotchen, 2013; Van Benthem, 2015; Levinson, 2016; Keiser and Shapiro, 2019; Hanlon and Heblich, 2022; Jacobsen et al., 2023). Although such standards shape everyday urban environments, their social returns are difficult to estimate because they are often adopted broadly and implemented gradually. We study a nationwide upgrade to urban street-lighting standards and show that raising technical standards to improve quality, coverage, and operation of existing infrastructure can generate economically meaningful reductions in crime.

Second, the paper contributes to the literature on place-based and environmental crime prevention. A growing body of research shows that changes in the built environment, including vacant-lot remediation, urban greening, housing improvements, neighborhood renewal programs, and urban development policies, can affect crime and neighborhood outcomes (Branas et al., 2011, 2018; Cook and MacDonald, 2011; Alonso et al., 2019; McMillen et al., 2019; South et al.,

2021; Wang et al., 2025).[3] Related work on crime prevention through environmental design emphasizes that physical environments influence criminal behavior by altering visibility, natural surveillance, perceived safety, and opportunities for offending (Cozens et al., 2005; Cozens and Love, 2015). Within this literature, a large body of evidence studies street lighting specifically and generally finds that improving lighting conditions reduces crime (Welsh and Farrington, 2008; Doleac and Sanders, 2015; Arvate et al., 2018; Chalfin et al., 2022*a*; Cook, 2022; Tealde, 2022; Welsh et al., 2022). We extend this literature in two ways. First, rather than studying localized lighting installations, outages, or experimental deployments, we examine a nationwide engineering-standard upgrade that changed the design and operation of urban lighting systems. Second, because our outcomes are measured at the city level, our estimates capture net changes in crime within cities rather than changes only around treated locations, allowing us to assess the overall urban effects of infrastructure improvements.

Third, the paper contributes to research on the broader social costs of crime and the returns to crime-prevention policy. Crime affects not only direct victims but also potential victims who alter their travel, work, consumption, and use of public space in response to perceived risk (Cullen and Levitt, 1999; Cohen, 2005; Rosenthal and Ross, 2010; Braakmann, 2012; Blanco and Ruiz, 2013; Chalfin, 2015; Janke et al., 2016; Mejía and Restrepo, 2016; Chalfin and McCrary, 2017; Fe and Sanfelice, 2022; Liang et al., 2025). By linking street-lighting improvements to adjudicated criminal cases, perceived safety, nighttime activity, and young women's labor supply, we show that urban safety investments can generate benefits beyond reductions in recorded crime. Our findings also contribute to the broader literature on gender differences in economic activity by highlighting safety constraints as an important factor shaping women's economic participation (Duflo, 2012; Goldin, 2014; Olivetti and Petrongolo, 2016; Blau and Kahn, 2017).[4] In addition, the paper adds to the growing empirical literature on crime in China, which has emphasized demographic, economic, and technological determinants of crime, by highlighting the role of urban public goods in crime prevention (Edlund et al., 2013; Cameron et al., 2019; Fang and Miao, 2025; Ma et al., 2025, 2026).

The rest of the paper proceeds as follows. Section 2 describes the institutional background, data, conceptual framework, and empirical strategy. Section 3 presents the main crime results and robustness checks. Section 4 examines perceived safety, nighttime activity, and individual behavioral responses. Section 5 concludes.

[3] One exception is Mitre-Becerril and MacDonald (2024), who find mostly null effects of urban development on crime.

[4] A growing body of evidence shows that safety concerns constrain women's mobility, schooling, employment, and time allocation (Hamermesh, 1999; Sabia et al., 2013; Chakraborty et al., 2018; Velásquez, 2020; Borker, 2021; Mishra et al., 2021; Siddique, 2022; Kondylis et al., 2025; Amaral et al., 2025; Chakraborty and Lohawala, 2026). Our findings indicate that making urban environments safer can alleviate these constraints.

2 Policy Background, Data and Research Design

2.1 Policy Background

We study the *Standard for Lighting Design of Urban Road* (CJJ 45-2015), issued by the Ministry of Housing and Urban-Rural Development on November 9, 2015 and implemented on June 1, 2016.[5] The revised standard replaced the previous 2006 standard (CJJ 45-2006) and applies to newly built, expanded, and reconstructed urban street-lighting projects. The stated objectives of the reform are to improve visibility for drivers and pedestrians, enhance traffic safety and public security, and improve the urban environment while maintaining energy efficiency and operational sustainability.

The standard does not simply increase overall brightness. Instead, it represents a comprehensive upgrade in the design, coverage, and operation of urban street-lighting systems. These changes are potentially relevant for crime because they affect three dimensions emphasized in the literature on environmental crime prevention: visibility, natural surveillance, and the availability of illuminated public spaces. We summarize the crime-relevant components of the reform below and provide additional technical details in Appendix C.[6]

Improved visibility on urban roads. The revised standard updates lighting requirements for urban roads, covering both motor-vehicle routes and pedestrian and bicycle routes. For motor-vehicle routes, the standard increases luminance and illuminance requirements for secondary arterial roads. These roads not only serve major traffic functions but also support important commercial activities, and therefore carry mixed flows of motor vehicles, bicycles, and pedestrians. Higher luminance and illuminance improve drivers' ability to identify obstacles, pedestrians, and vehicles during nighttime and low-visibility conditions.

For pedestrian and bicycle routes, the reform introduces several changes that apply to all road types and directly affect interpersonal visibility and public-space safety. First, it introduces semi-cylindrical illuminance requirements, which improve facial recognition of approaching pedestrians. Second, it increases vertical illuminance requirements, enhancing both facial recognition and awareness of the surrounding environment. Third, it introduces glare-control requirements to improve visual comfort and reduce visual impairment. These changes are particularly relevant for crimes in which offender recognition, victim awareness, or natural surveillance may affect the expected net returns to offending.

The reform also changes how lighting standards are determined. The previous standard assigned different lighting tiers according to city type and land-use categories, such as residential versus commercial areas. CJJ 45-2015 instead bases requirements more directly on actual traffic volume and road usage, allowing lighting intensity to better reflect the functional role of different

[5] Urban roads refer to roads within city boundaries, including urban freeways, arterial roads, secondary arterial roads, and branch roads, following the *Code for Design of Urban Road Engineering* (CJJ 37-2012). Intercity roads, such as national highways and expressways, are not covered by the standard.

[6] See also Li (2016) for a discussion by one of the lead drafters of the revision.

urban spaces.

Expanded coverage of illuminated road-related public spaces. The revised standard expands lighting requirements beyond roads themselves to include additional public spaces closely connected to urban mobility, including parking facilities, bus stops, and urban tunnels. These spaces are important locations for pedestrian movement and interaction but were previously subject to limited or less systematic lighting requirements. Expanding illumination to these areas increases the number of public spaces where visibility and natural surveillance can operate.

The standard also modifies lighting operation rules by raising the ambient-light threshold for activating road lights, causing lights to turn on earlier during twilight and other low-light periods. This change extends illumination during periods when travel activity remains substantial but visibility is deteriorating.

Summary. Overall, CJJ 45-2015 upgrades urban street-lighting along three crime-relevant margins: visibility, spatial coverage, and operating timing. Higher luminance and illuminance improve the ability of drivers and pedestrians to observe their surroundings and recognize others. New requirements for pedestrian and bicycle routes strengthen facial recognition and environmental awareness. Expanded coverage and earlier activation extend illumination to more locations and time periods. Together, these changes provide a plausible mechanism through which improvements in urban street-lighting infrastructure can influence crime and the use of public space.

2.2 Data

Crime Data. Our primary crime data come from the China Judgments Online Database (CJO), the official judicial disclosure platform established by the Supreme People's Court in late 2013 to enhance judicial transparency.[7] The database contains judicial documents from courts at all levels in China, including first-instance criminal judgments. Each document provides detailed case-level information, including the court, parties involved, factual background, legal classification, and final judgment.[8]

We collect all first-instance criminal cases occurring between 2013 and 2019 and use textual analysis to extract the court location, the timing of offenses, the number of offenders, and crime characteristics. We classify offenses according to whether the opportunity, commission, or concealment of the crime can plausibly be affected by street visibility and detection risk. We refer to these offenses as *visibility-sensitive crimes*. The category includes traffic-casualty offenses, robbery, larceny, violent crimes, public-security crimes, and drug-related crimes. By contrast, offenses such as driving while intoxicated (DWI),[9] fraud and extortion, economic

[7]The CJO is available at https://wenshu.court.gov.cn.

[8]China operates a four-tier judicial system consisting of more than 3,000 primary courts, over 400 intermediate courts, 31 provincial high courts, and the Supreme People's Court. First-instance cases are generally adjudicated by courts with jurisdiction over the location of the offense.

[9]Driving while intoxicated (DWI), defined in China as driving a vehicle with a blood alcohol concentration of

crimes, bribery, gambling-related crimes, and social-administration crimes are classified as *less visibility-sensitive crimes* and serve as negative-control outcomes.

The classification reflects the mechanism through which street lighting may affect crime. For example, robbery and larceny often occur in public spaces where darkness can reduce detection risk. Even for crimes occurring indoors, such as burglary, lighting can affect the approach, entry, and escape stages of offending by increasing the probability of observation. Similarly, some drug-related crimes involve street-level exchanges where visibility may influence anonymity and detection risk. Appendix Table A.1 reports the keyword mappings used in the classification.

We aggregate case-level observations to the city-year level and construct two primary crime measures: the number of criminal cases per 1,000 residents and the number of offenders involved in these cases per 1,000 residents.[10] To account for differences in city size, all outcomes are normalized using city population from the 2010 Population Census.

Street-lighting Exposure. We measure exposure to the 2016 street-lighting standard upgrade using government procurement records. The procurement data come from the China Government Procurement Database (CGP), maintained by China's Ministry of Finance.[11] We identify street-lighting procurement contracts using keyword-based textual analysis of procurement titles and descriptions.[12] For each contract, we extract the procurement date, contract value, and information on the purchasing government and winning supplier.

We focus on contracts issued by prefecture-level governments and aggregate procurement activity to the city level. Our baseline exposure measure is the cumulative number of street-lighting procurement contracts per 1,000 residents through the end of 2015. This measure captures cross-city differences in the extent to which local lighting infrastructure was exposed to the upgraded standard. As robustness checks, we construct two alternative measures: cumulative procurement contracts with reported prices and cumulative procurement expenditure, both normalized by population.

The procurement data provide broad coverage of municipal lighting investment. By 2015, the database contained 8,664 street-lighting procurement contracts nationwide, with a total value of approximately 12.1 billion RMB (roughly 1.97 billion USD). Because government procurement disclosure requirements were strengthened in 2015, using cumulative procurement through 2015 provides a comprehensive measure of pre-policy lighting investment.[13]

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80 mg/100 ml or above, is identified primarily through sobriety checkpoints and breathalyzer testing rather than through visual observation of the offender.

[10] To mitigate the influence of extreme values, such as a single case involving a massive syndicate of offenders, we winsorize the number of offenders per case at the 99.9th percentile prior to city-year aggregation.

[11] The CGP is available at https://www.ccgp.gov.cn.

[12] Detailed keyword definitions are reported in Panel A of Appendix Table A.2.

[13] The State Council issued the *Implementing Regulations of the Government Procurement Law* in December 2014, requiring procurement information to be publicly disclosed within two working days after contract signing. The regulation took effect in March 2015. Our results are robust to alternative treatment measures based on cumulative procurement through each year from 2010 to 2014.

Nighttime-light Data. To directly examine changes in nighttime illumination, we use satellite-based nighttime-light data (Elvidge et al., 2017; Chen et al., 2026). The dataset provides annual nighttime luminosity measures at a 500-meter resolution. This spatial resolution allows us to construct city-level measures from pixel-level observations. We focus on luminosity measured at 1:30 a.m. local time, when most commercial, residential, industrial, and decorative lighting is inactive. Therefore, nighttime luminosity at this hour primarily captures public lighting infrastructure, including street lighting.

Perceived Safety, Nighttime Activity, and Individual Outcomes. We combine city-level and individual-level data to examine behavioral responses beyond crime. First, we use the Baidu Index, the Chinese counterpart to Google Trends, to measure changes in perceived safety and nighttime activity. The index records relative search intensity for keywords on China's dominant search engine at the city level. We construct three measures: a safety-concern search index, an indoor-lighting search index as a placebo outcome, and a nighttime-activity search index. Detailed keyword definitions are reported in Panel B of Appendix Table A.2. Online search behavior has been widely used to study otherwise difficult-to-observe attitudes and behaviors (Choi and Varian, 2012; Stephens-Davidowitz, 2014).

Second, we use the China Family Panel Studies (CFPS), a nationally representative longitudinal survey administered by the Institute of Social Science Survey at Peking University. The CFPS follows approximately 16,000 households across 25 provinces and municipalities.[14] We use the 2016 and 2020 household waves to measure perceived neighborhood safety and the 2014–2020 individual waves to study labor market outcomes and social attitudes. The labor market outcomes include labor force participation, employment, evening or night-shift work, and weekly working hours. The social-attitude outcomes include interpersonal trust and perceived helpfulness. We also extract demographic characteristics, including age, ethnicity, marital status, health, education, urban/rural residence, and household income, as individual-level controls.

Other city-level characteristics used as controls, including baseline GDP per capita and population density in 2013, are obtained from the *China City Statistical Yearbooks*, published by the National Bureau of Statistics of China. These variables are measured prior to the policy reform and are interacted with year dummies in the baseline specification to account for differential trends associated with initial economic conditions and urban structure. Appendix Table A.3 reports summary statistics for all variables used in the empirical analysis. Panel A presents variables used in the baseline crime regressions, while Panel B reports variables used in the extension analyses in Section 4.

2.3 Conceptual Framework

To guide the empirical analysis, we use a simple framework based on the economic model of crime (Becker, 1968; Nagin, 2013; Draca and Machin, 2015). Let A denote ambient light

[14] The survey does not cover Xinjiang, Tibet, Qinghai, Inner Mongolia, Ningxia, and Hainan.

and let $N(A)$ denote nighttime use of streets and other public spaces. An individual commits a crime when the expected payoff from offending exceeds the payoff from legal activity:

$$U_c(A, N) = B(N) - P(A, N)T - C(A, N) > U(W), \tag{1}$$

where $B(N)$ denotes the benefit from a successful offense, $P(A, N)$ is the probability of detection and apprehension,[15] T is the expected punishment conditional on apprehension, $C(A, N)$ captures the search, effort, and other non-pecuniary costs of offending, and $U(W)$ is the payoff from legal work.

For offenses that rely on darkness, concealment, or anonymity, improved lighting lowers the expected payoff to crime through a deterrence channel. Holding public-space use fixed, better lighting raises the probability that offenders are observed, recognized, and apprehended:

$$\frac{\partial P(A, N)}{\partial A} > 0.$$

It may also raise the cost of offending by making reconnaissance, commission, and escape more difficult:

$$\frac{\partial C(A, N)}{\partial A} > 0.$$

These forces reduce the expected payoff from visibility-sensitive offenses. The framework therefore predicts larger reductions for crimes whose opportunities depend more heavily on darkness or anonymity, and smaller effects for offenses less directly related to visibility on urban streets. The net effect of improved lighting, however, is not mechanically negative. Better-lit streets may attract more residents to public spaces after dark. Greater nighttime activity can reinforce deterrence by increasing natural surveillance and the number of potential witnesses. At the same time, it may increase the number of potential victims or targets and reduce offender search costs.[16] In the notation above, lighting can affect crime both directly through P and C, and indirectly through $N(A)$. The sign of the total effect is therefore ambiguous ex ante and must be estimated empirically.

This framework yields three empirical predictions. First, if the deterrence and surveillance channels dominate, the effects should be concentrated in visibility-sensitive offenses, while less visibility-sensitive offenses should show weaker responses. Second, the effects should be stronger during nighttime or low-light periods, when the marginal increase in visibility is largest. Third, if lighting changes perceived safety and the use of public space, it may also affect nighttime activity and labor market behavior among groups more constrained by safety concerns.

[15] Classic work attributes part, although not most, of the urban crime premium to higher pecuniary returns to offending and lower probabilities of arrest or recognition (Glaeser and Sacerdote, 1999).

[16] This ambiguity is emphasized by Doleac and Sanders (2015) and Tealde (2022). It is also consistent with Tompson et al. (2023), who find that switching street lights off at midnight reduced nighttime theft from vehicles on treated street segments, while spatial displacement remained a concern.

The framework also clarifies the interpretation of our outcome measures. Judicial records reflect both underlying criminal activity and the probability that offenses are detected and adjudicated. Because improved lighting is likely to increase detection conditional on crime, this measurement channel would tend to raise recorded cases holding underlying criminal activity fixed. Therefore, reductions in adjudicated criminal cases provide conservative evidence of reductions in underlying criminal activity.

2.4 Empirical Strategy

Our empirical strategy exploits the nationwide rollout of CJJ 45-2015 and cross-city differences in exposure to the standard upgrade. We implement a continuous difference-in-differences (DiD) design, where exposure is measured by each city's cumulative number of street-lighting procurement contracts per 1,000 residents through the end of 2015.

The rationale for this exposure measure is that cities with greater pre-policy street-lighting investment had more active investment, replacement, and reconstruction margins to which the upgraded standard could apply, and therefore greater potential for improvement after implementation. Importantly, the treatment measure is predetermined with respect to the policy rollout and captures cross-city differences in exposure rather than the common national effect of the standard, which is absorbed by year fixed effects.

Specifically, we estimate:

$$(\text{Crime}/L)_{ct} = \beta_1 \log(\text{Light}/L)_c \times \text{Post}_t + (\mathbf{X}_c \times \delta_t)'\beta_X + \gamma_c + \gamma_t + \epsilon_{ct}. \tag{2}$$

The dependent variable, $(\text{Crime}/L)_{ct}$, denotes the city-year crime rate measured by the number of visibility-sensitive criminal cases or offenders per 1,000 residents. The treatment intensity, $\log(\text{Light}/L)_c$, is the log cumulative number of street-lighting procurement contracts per 1,000 residents through the end of 2015. Because lighting projects may require time for planning, construction, and implementation, we define Post_t as one for years 2017 onward.[17]

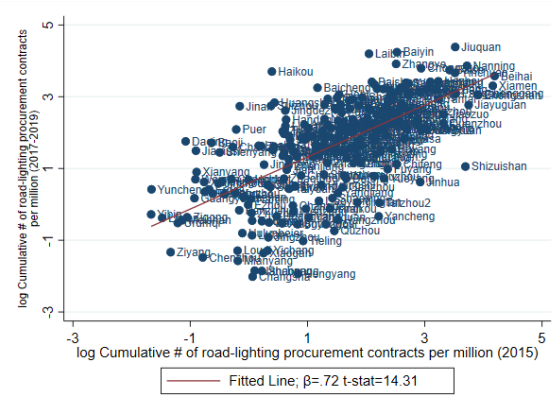
The vector $\mathbf{X}_c$ includes baseline city characteristics, specifically log GDP per capita and population density in 2013, interacted with a full set of year dummies δ_t. These interactions allow cities with different initial economic conditions and urban structures to follow differential trends. We use baseline rather than contemporaneous characteristics to avoid conditioning on variables potentially affected by the policy. City fixed effects γ_c absorb time-invariant local characteristics, while year fixed effects γ_t absorb aggregate shocks and the common component of the national standard upgrade. Standard errors are clustered at the city level.

2.5 Validation of Policy Exposure

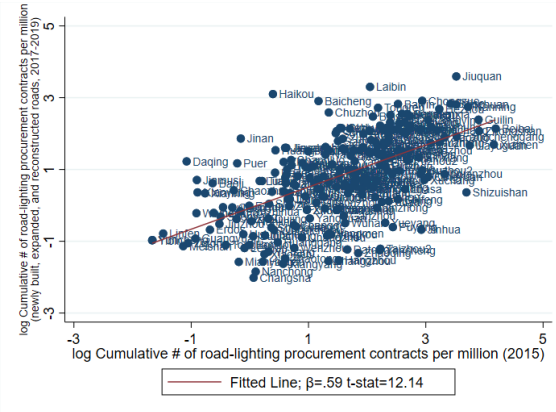
Our empirical design relies on the assumption that cities with greater baseline street-lighting procurement density experience larger improvements in lighting conditions after the implemen-

[17] Our baseline result remains unchanged when accounting for partial treatment exposure in 2016 (i.e., setting $\text{Post}_{2016} = 1/2$). See Column (2) of Appendix Table A.7 and the discussion in Section 3.3.

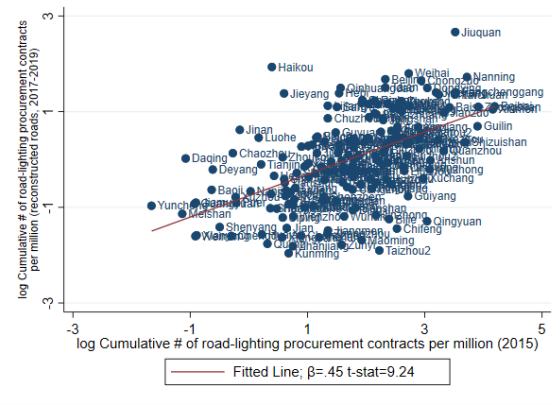
Figure 1: Pre-policy and Post-policy Street-Lighting Procurement Densities



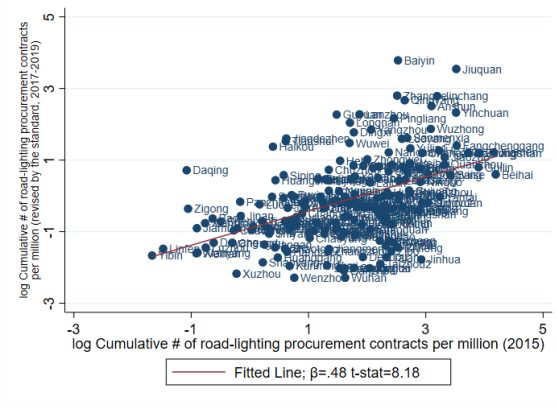
(A) Overall street-lighting procurement



(B) Newly built, expanded and reconstructed projects



(C) Reconstructed projects only



(D) Projects specified in new standard

Notes: This figure presents scatter plots of post-policy versus pre-policy street-lighting procurement densities. Across all panels, the horizontal axis presents the baseline treatment intensity, defined as the log cumulative number of street-lighting procurement contracts per million residents through the end of 2015. The vertical axis indicates the log cumulative number of street-lighting procurement contracts per million residents from 2017 to 2019. Specifically, the vertical axis captures all street-lighting procurements in Panel A, procurements for newly built, expanded, and reconstructed projects in Panel B, procurements exclusively for reconstructed projects in Panel C, and procurements for lighting categories specified in the new standard in Panel D.

tation of CJJ 45-2015. We provide two pieces of evidence supporting this interpretation.

First, baseline procurement density predicts subsequent street-lighting investment after the policy. Figure 1 plots post-policy procurement density against baseline exposure. Cities with higher pre-policy procurement density continue to exhibit higher levels of street-lighting investment after the reform. This persistence holds not only for overall street-lighting procurement (Panel A) but also for categories directly affected by the new standard, including newly built, expanded, and reconstructed street-lighting projects (Panels B and C), as well as categories specified in the new standard, such as pedestrian lighting, switch-control systems, tunnel lighting, and public parking lighting (Panel D).

Second, we directly examine whether greater policy exposure translated into improved nighttime illumination from 2013 to 2019. Using satellite nighttime luminosity measured at 1:30 a.m., we estimate the same specification with nighttime-light (NTL) intensity as the outcome.

Table 1: Street-Lighting Standard Upgrade and Nighttime Luminosity

Dep. Var.:	NTL/population			NTL/built-up area		
	(1) 97.5th (annual)	(2) 90th (annual)	(3) 90th (2013)	(4) 97.5th (annual)	(5) 90th (annual)	(6) 90th (2013)
$\log(\text{Light}/L)_c \times \text{Post}_t$	0.137**	0.110***	0.170***	6.773**	4.885***	7.550***
	(0.065)	(0.041)	(0.050)	(3.245)	(1.869)	(2.611)
City FE	Y	Y	Y	Y	Y	Y
Year FE	Y	Y	Y	Y	Y	Y
Baseline×Year dummies	Y	Y	Y	Y	Y	Y
Observations	1,862	1,862	1,862	1,841	1,841	1,841
R-squared	0.979	0.973	0.966	0.923	0.905	0.870

Notes: The unit of observation is the city-year, covering 2013–2019. The dependent variable is nighttime-light (NTL) intensity (per 1,000 residents) in Columns (1)–(3), and NTL intensity (per square kilometer of built-up area) in Columns (4)–(6). To better isolate lower-intensity public lighting from high-luminosity sources, such as major commercial, office, and industrial areas, we trim the brightest pixels within each city. Columns (1) and (4) exclude pixels above the 97.5th percentile of the city-level luminosity distribution, while Columns (2), (3), (5), and (6) exclude pixels above the 90th percentile. In Columns (1), (2), (4), and (5), the trimming thresholds are recalculated separately for each city-year. In Columns (3) and (6), the set of retained pixels is held fixed over time using each city's 2013 luminosity distribution. $\log(\text{Light}/L)_c$ is the log of the cumulative number of street-lighting procurement contracts per 1,000 residents through the end of 2015. Post_t equals one for 2017 and subsequent years and zero otherwise. All specifications include city and year fixed effects, as well as baseline log GDP per capita and population density interacted with a full set of year indicators. Standard errors clustered at the city level are reported in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

Because most commercial, residential, and industrial lighting is switched off by this hour, the measure primarily captures public infrastructure lighting.

To construct city-level measures, we aggregate pixel-level lighting data and normalize the sum by either the city's baseline population or built-up area. To better capture basic street lighting and ensure that our estimates are not driven by high-luminosity outliers such as large commercial and industrial zones, we truncate the brightest pixels within each city prior to aggregation. Table 1 reports the results. Columns (1)–(3) use NTL intensity (per 1,000 residents) as the dependent variable, while Columns (4)–(6) use NTL intensity (per square kilometer of built-up area). For each normalization, we apply increasingly strict truncations, excluding the top 2.5 percent (Columns 1 and 4) and 10 percent (Columns 2 and 5) of the brightest pixels, with thresholds computed separately for each city and year. To ensure the truncation mask does not respond to post-treatment increases in lighting, Columns (3) and (6) hold the truncated set fixed and exclude pixels that ranked in the top 10 percent of each city's 2013 baseline distribution.

Across all specifications, cities with greater baseline exposure experience larger increases in nighttime luminosity after the reform. These results provide direct evidence that the procurement-based exposure measure captures actual improvements in lighting conditions.[18]

[18]One potential concern with using satellite nighttime luminosity as a measure of lighting improvements is that tree canopies, an important component of urban ecosystems (Han et al., 2026), may obstruct the upward transmission of emissions from street lights, causing satellite-based measures to understate actual illumination. To address this concern, we control for city-level tree coverage using the China Annual Tree Cover Dataset (CATCD) constructed by Cai et al. (2024). This dataset is generated from Landsat satellite imagery using artificial intelligence algorithms to measure urban vegetation coverage. Appendix Table A.4 shows that controlling for tree coverage leaves the estimated effects of baseline street-lighting exposure on nighttime luminosity virtually unchanged

Table 2: Street-Lighting Standard Upgrade and Visibility-sensitive Crimes

Dep. Var.:	# of Cases per 1,000 residents				# of Offenders per 1,000 residents			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
$\log(\text{Light}/L)_c \times \text{Post}_t$	-0.015***	-0.014***	-0.014***	-0.008***	-0.018***	-0.016***	-0.017***	-0.009***
	(0.003)	(0.003)	(0.003)	(0.002)	(0.003)	(0.003)	(0.003)	(0.002)
City FE	Y	Y	Y	Y	Y	Y	Y	Y
Year FE	Y	Y	Y	Y	Y	Y	Y	Y
Baseline×Year dummies	N	Y	Y	Y	N	Y	Y	Y
Observations	1,862	1,862	1,813	1,813	1,862	1,862	1,813	1,813
R-squared	0.836	0.850	0.849	0.847	0.837	0.852	0.853	0.850
Mean of dep. var	0.232	0.232	0.233	0.233	0.283	0.283	0.284	0.284
IQR effects (% of mean)	10.8%	9.9%	10.3%	7.3%	10.6%	9.5%	10.2%	6.7%

Notes: The unit of observation is the city-year, covering 2013–2019. The dependent variable is the number of visibility-sensitive criminal cases per 1,000 residents in Columns (1)–(4) and the number of offenders involved in such cases per 1,000 residents in Columns (5)–(8). $\log(\text{Light}/L)_c$ denotes the log of cumulative street-lighting procurement per 1,000 residents through the end of 2015. Procurement is measured by the total number of contracts in Columns (1), (2), (5), and (6); the number of contracts for which procurement expenditure is reported in Columns (3) and (7); and total procurement expenditure in Columns (4) and (8). Post_t equals one for 2017 and subsequent years and zero otherwise. All specifications include city and year fixed effects. Columns (2)–(4) and (6)–(8) additionally include baseline log GDP per capita and population density, measured in 2013, each interacted with a full set of year indicators. The table also reports the mean of the dependent variable and the implied interquartile-range (IQR) effect as a percentage of the dependent variable mean, calculated as the absolute value of the estimated coefficient multiplied by the IQR of the corresponding treatment measure and divided by the dependent-variable mean. Standard errors clustered at the city level are reported in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

3 Effects on Urban Crime

3.1 Baseline Citywide Effects

Table 2 reports the baseline estimates from equation (2). The dependent variable is the number of visibility-sensitive adjudicated criminal cases per 1,000 residents in Columns (1)–(4) and the number of offenders involved in these cases per 1,000 residents in Columns (5)–(8). Columns (1)–(2) and (5)–(6) measure treatment intensity, $\log(\text{Light}/L)_c$, using the log cumulative number of street-lighting procurement contracts per 1,000 residents through the end of 2015. Columns (3) and (7) instead use the log cumulative number of contracts with price information per 1,000 residents, and Columns (4) and (8) use the log cumulative procurement expenditure per 1,000 residents. Columns (1) and (5) include city and year fixed effects only, while Columns (2)–(4) and (6)–(8) in addition include baseline city characteristics (log GDP *per capita* and population density) interacted with a full set of year dummies.

The estimates are negative and statistically significant across all specifications. Cities with greater baseline exposure to the street-lighting standard upgrade experience larger post-policy declines in visibility-sensitive criminal cases and offenders. In our preferred specifications, reported in Columns (2) and (6), an interquartile-range increase in baseline exposure—equivalent to moving from the 25th to the 75th percentile of cumulative street-lighting procurement contracts per 1,000 residents through the end of 2015—is associated with 23 fewer adjudicated criminal

and statistically significant. These results suggest that differential canopy blockage does not drive the observed relationship between policy exposure and satellite-measured illumination.

Table 3: Effects of the Street-Lighting Standard Upgrade by Crime Type

Dep. Var.:	# of Cases per 1,000 residents						
Panel A: Visibility-sensitive crimes							
	(1) Total	(2) Traffic-casualty	(3) Robbery	(4) Larceny	(5) Violence	(6) Public security	(7) Drug-related
$\log(\text{Light}/L)_c \times \text{Post}_t$	-0.014***	-0.002***	-0.001***	-0.003**	-0.001**	-0.001**	-0.006***
	(0.003)	(0.001)	(0.0002)	(0.001)	(0.001)	(0.0004)	(0.001)
City FE	Y	Y	Y	Y	Y	Y	Y
Year FE	Y	Y	Y	Y	Y	Y	Y
Baseline×Year dummies	Y	Y	Y	Y	Y	Y	Y
Observations	1,862	1,862	1,862	1,862	1,862	1,862	1,862
R-squared	0.850	0.760	0.788	0.872	0.855	0.611	0.770
Panel B: Less visibility-sensitive crimes							
	(1) Total	(2) DWI	(3) Fraud and extortion	(4) Economic	(5) Bribery	(6) Gambling-related	(7) Social admin.
$\log(\text{Light}/L)_c \times \text{Post}_t$	0.003	0.004	-0.0003	-0.0005	0.00001	0.0002	0.001
	(0.003)	(0.003)	(0.0003)	(0.0004)	(0.0001)	(0.0002)	(0.0005)
City FE	Y	Y	Y	Y	Y	Y	Y
Year FE	Y	Y	Y	Y	Y	Y	Y
Baseline×Year dummies	Y	Y	Y	Y	Y	Y	Y
Observations	1,862	1,862	1,862	1,862	1,862	1,862	1,862
R-squared	0.816	0.747	0.829	0.807	0.718	0.832	0.865

Notes: The unit of observation is the city-year, covering 2013–2019. The dependent variable is the number of adjudicated criminal cases per 1,000 residents in each crime category. Panel A reports estimates for visibility-sensitive offenses, while Panel B reports estimates for less visibility-sensitive offenses, which serve as negative-control outcomes. Column (1) of each panel aggregates all offenses classified within the corresponding group; the remaining columns report estimates for individual crime categories. Crime classifications are constructed using keyword matching, as detailed in Appendix Table A.1. $\log(\text{Light}/L)_c$ is the log of the cumulative number of street-lighting procurement contracts per 1,000 residents through the end of 2015. Post_t equals one for 2017 and subsequent years and zero otherwise. All specifications include city and year fixed effects, as well as baseline log GDP per capita and population density, measured in 2013, each interacted with a full set of year indicators. Standard errors clustered at the city level are reported in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

cases and 27 fewer offenders per million residents. These effects correspond to reductions of 9.9 percent and 9.5 percent relative to the respective sample means. For ease of interpretation, the bottom rows report the dependent-variable means and the implied IQR effect in each specification.

Several features of this result are worth emphasizing. First, the estimates are similar with and without baseline controls, suggesting that the result is not driven by differential trends associated with initial GDP per capita or population density. Second, the result is robust to measuring exposure using either procurement counts or procurement expenditure. Third, because the outcome is measured at the city-year level, the estimates capture net changes in adjudicated criminal cases within cities rather than changes only around treated road segments.

3.2 Effects by Crime Type

We next examine whether the reductions are concentrated in offenses for which street visibility should matter. Using the specification in Column (2) of Table 2, Table 3 estimates

effects separately by crime type. Panel A reports effects for visibility-sensitive categories, while Panel B reports effects for offenses less directly related to visibility on urban streets. These categories serve as negative-control outcomes: they should be less affected by the street lighting standard if the main estimates operate through visibility, detection risk, and natural surveillance rather than through broad changes in reporting, adjudication, or enforcement.[19]

The pattern supports a visibility-based interpretation. Panel A shows that greater exposure to the standard upgrade is associated with larger post-policy reductions in the pooled set of visibility-sensitive crimes (Column 1). The estimates in Columns (2)–(7) are negative and statistically significant for traffic-casualty offenses, robbery, larceny, violent crimes, public-security crimes, and drug-related crimes. These categories are plausibly affected by lighting because visibility can change driving conditions, offender detection risk, victim awareness, and the probability that offenders are observed or identified. These findings align well with those of previous studies (Doleac and Sanders, 2015; Smith, 2016; Bünnings and Schiele, 2021; Chalfin et al., 2022*a*; Tealde, 2022; Mitre-Becerril, 2026).

By contrast, Panel B shows little evidence of effects on offenses less directly connected to visibility on urban streets, including driving while intoxicated (DWI), fraud and extortion, economic crimes, bribery, gambling-related crimes, and social-administration crimes. The absence of comparable effects in these categories is difficult to reconcile with explanations based on a general decline in adjudication, reporting, or law-enforcement intensity. Instead, the results point to a more targeted change in crimes for which street lighting should affect the opportunity or expected cost of offending.[20]

3.3 Identification and Robustness Checks

The continuous difference-in-differences design compares post-policy changes across cities with different baseline exposure to the street-lighting standard upgrade. The key identifying assumption is that, absent the upgrade, cities with different baseline street-lighting procurement densities would have followed similar trends in visibility-sensitive crime after conditioning on fixed effects and controls. The main threat is that baseline procurement density may proxy for broader differences in urban development, public-security investment, administrative capacity, or other city characteristics that independently predict crime trends.

We address this concern in four ways. First, we examine pre-trends using an event-study specification. Second, we show that the estimates are robust to alternative treatment definitions, flexible controls for city-specific trends, population weights, alternative treatment timing, and sample restrictions. We also use an instrument for the baseline procurement intensity. Third, we control for contemporaneous economic and policy shocks that may be correlated with both

[19] Appendix Table A.5 reports analogous results for offenders. The full list of Chinese keywords and English translations used to classify crime types is provided in Appendix Table A.1.

[20] Appendix Table A.6 reports heterogeneity by offender characteristics. The estimated reductions are not concentrated in a single offender group; they appear across prior criminal-history status, gender, education, age cohort, and residency status.

baseline street-lighting procurement and crime. Finally, in the next subsection, we directly examine whether surveillance cameras, a salient public-safety technology in China, account for the results.

Event-study evidence. We estimate the following dynamic specification:

$$(\text{Crime}/L)_{ct} = \sum_{\tau \neq 2016} \beta_\tau \log(\text{Light}/L)_c \times \mathbf{1}\{t = \tau\} + (\mathbf{X}_c \times \delta_t)' \boldsymbol{\beta}_X + \gamma_c + \gamma_t + \epsilon_{ct}, \quad (3)$$

where $\mathbf{1}\{t = \tau\}$ is an indicator function that equals 1 if the observation year is τ, and 0 otherwise. The omitted year is 2016, the implementation year of CJJ 45-2015. The coefficients β_τ trace the relationship between baseline exposure and outcomes in each year relative to 2016.

Figure 2 reports the results. Panels A and B use visibility-sensitive criminal cases and offenders as outcomes, respectively. The pre-policy coefficients are close to zero and statistically insignificant, providing no evidence of differential pre-trends across cities with different baseline exposure. The coefficients become negative after implementation, with larger reductions in 2018 and 2019.

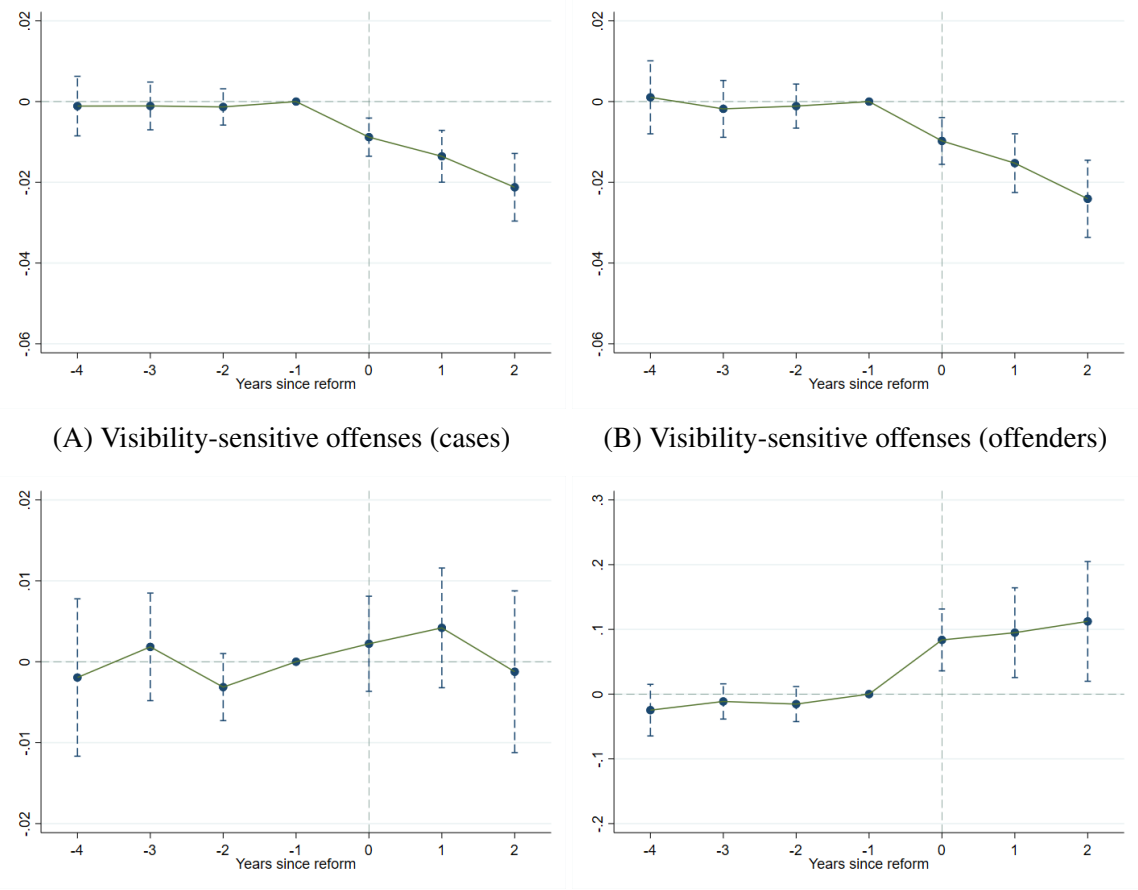
Panel C repeats the exercise for less visibility-sensitive criminal cases. The coefficients are small and statistically insignificant both before and after the policy, suggesting that higher-exposure cities were not simply experiencing broad declines in all types of adjudicated crime.

Panel D reports the corresponding event study for satellite nighttime luminosity. The post-policy coefficients increase after implementation, while the pre-policy coefficients are close to zero. This pattern complements the first-stage evidence in Section 2.5: baseline procurement exposure predicts subsequent improvements in nighttime illumination, and these improvements occur after the standard upgrade.

Alternative specifications and samples. Appendix Table A.7 reports a series of robustness checks. Column (1) adds city-specific linear trends. Column (2) treats 2016 as a partially treated year by setting $\text{Post}_{2016} = 1/2$, since the policy was implemented on June 1, 2016. Column (3) weights observations by population, recovering an average-resident rather than average-city effect. Column (4) excludes 4 municipalities and 27 provincial capitals, addressing the possibility that the estimates are driven by large cities with exceptional public-safety investments or crime dynamics. Column (5) excludes 2013, the launch year of the China Judgments Online database, to address concerns about incomplete early coverage. Column (6) replaces continuous exposure with a binary treatment indicator for cities above the median of baseline procurement density. Across these specifications, the estimates remain negative and statistically significant, consistent with the baseline finding.

As an additional robustness exercise, Column (7) reports an IV specification that instruments baseline street-lighting procurement density with the local density of street-lighting firms. The rationale for this instrument is based on the presumption that the availability of local street-lighting firms in the baseline year influences the financial costs associated with local governments procuring street-lighting equipment in subsequent years, as pointed out by Ma et al. (2026). The

Figure 2: Pre-trends and Dynamic Effects



(A) Visibility-sensitive offenses (cases)

(B) Visibility-sensitive offenses (offenders)

(C) Less visibility-sensitive offenses (cases)

(D) Nighttime luminosity (NTL/population)

Notes: The dependent variable is the number of visibility-sensitive criminal cases per 1,000 residents in Panel A, the number of offenders in visibility-sensitive cases per 1,000 residents in Panel B, the number of less visibility-sensitive criminal cases per 1,000 residents in Panel C, and satellite NTL intensity (truncated at 90th percentile) per 1,000 residents in Panel D. The omitted year is 2016. All regressions include city and year fixed effects, as well as baseline city-level controls interacted with a full set of year dummies. Standard errors are clustered at the city level. Error bars show 95 percent confidence intervals.

IV estimates remain negative; the estimate for criminal cases is statistically significant at the 10 percent level, while the estimate for offenders is significant at the 5 percent level. Columns (8)–(14) present the analogous estimates for offenders.

Contemporaneous confounders. Appendix Table A.8 examines whether the baseline estimates are driven by other policy or economic shocks correlated with baseline street-lighting procurement. We control for four potential confounders, separately and jointly. First, we control for landscape lighting procurement to account for local lighting projects that may alter the nighttime environment but are not part of the street-lighting standard.[21] Second, we control for fiscal expenditures on public security and social spending to account for contemporaneous

[21] We extract landscape lighting procurement records from the CGP database, using specific search keywords detailed in Panel A of Appendix Table A.2.

changes in law enforcement and public services.[22] Third, we control for city-level export shocks, which have been shown to affect local crime (Ma et al., 2025). Fourth, we control for exposure to the 2018–2019 US-China trade war, measured using city-level weighted-average tariff exposure following Chor and Li (2024). The estimated effects remain negative and statistically significant when these controls are included, both individually and jointly.

Falsification test. As a final check, Appendix Figure B.1 reports a permutation exercise in which treatment intensity is randomly reassigned across cities 500 times. The placebo estimates are centered around zero, while the baseline estimate lies in the lower tail of the placebo distribution. This test does not replace the identifying assumptions of the DiD design, but it shows that the estimated relationship is unlikely to arise mechanically from the empirical specification or from arbitrary cross-city assignments of exposure.

3.4 Surveillance Cameras as an Alternative Explanation

A natural concern is that the estimated decline in visibility-sensitive crimes reflects changes in surveillance-camera deployment rather than the street-lighting standard upgrade. This concern is especially relevant in China, where camera-based surveillance is an important component of local public-security infrastructure (Ma et al., 2026). Table 4 addresses this possibility using several tests focusing on criminal cases. Appendix Table A.9 reports analogous estimates for offenders.

Columns (1) and (2) examine whether the baseline estimates are robust to accounting for camera investment. Column (1) directly controls for cumulative camera procurement density.[23] Because contemporaneous camera investment may itself respond to crime or other policy changes, Column (2) instead controls for baseline camera procurement density interacted with a full set of year dummies. In both specifications, the estimated effect of the street-lighting standard remains negative and statistically significant, consistent with our baseline results.

Column (3) restricts the outcome to cases in which the judgment text does not explicitly cite on-site surveillance footage as evidence. This test should be interpreted cautiously, because the absence of a surveillance reference in the judgment does not necessarily imply the absence of camera coverage. Nevertheless, the estimate remains similar in this restricted sample, indicating that the baseline result is not mechanically driven by cases in which surveillance footage is explicitly used.

Columns (4) and (5) examine whether the policy exposure measure predicts changes in camera deployment or camera-assisted evidence. Column (4) uses new camera procurement density as the dependent variable and finds no significant relationship with baseline exposure to

[22] Public security expenditure includes all expenses by the people's armed police, prosecutorial system, court system, judicial system, and public security organs, while "social spending" is the sum of expenditure on public services, education, social security, medical services, and urban and rural affairs.

[23] We extract surveillance camera procurement records from the CGP database, using specific search keywords detailed in Panel A of Appendix Table A.2.

Table 4: Street-Lighting Standard Upgrade, Surveillance Cameras, and Crime

Dep. Var.:	# of Cases per 1,000			log(Camera)	Case share	# of Cases per 1,000
	(1) Control cum. camera	(2) Control baseline camera × Year dums.	(3) Drop case with camera	(4) Camera invest. flow	(5) With camera	(6) DDD: By baseline camera
$\log(\text{Light}/L)_c \times \text{Post}_t$	-0.015***	-0.008**	-0.013***	-0.044	0.001	-0.009***
	(0.003)	(0.004)	(0.003)	(0.041)	(0.002)	(0.003)
$\text{HighCamera}_c \times \log(\text{Light}/L)_c \times \text{Post}_t$						0.0002
						(0.006)
City FE	Y	Y	Y	Y	Y	Y
Year FE	Y	Y	Y	Y	Y	Y
Baseline×Year dummies	Y	Y	Y	Y	Y	Y
Observations	1,805	1,680	1,862	1,546	1,862	1,855
R-squared	0.848	0.848	0.829	0.758	0.860	0.849

Notes: The unit of observation is the city-year, covering 2013–2019. The dependent variable is the number of visibility-sensitive adjudicated criminal cases per 1,000 residents in Columns (1)–(3) and (6), the log number of newly awarded surveillance-camera procurement contracts per 1,000 residents in Column (4), and the share of adjudicated criminal cases explicitly citing surveillance footage as evidence in Column (5). $\log(\text{Light}/L)_c$ is the log of the cumulative number of street-lighting procurement contracts per 1,000 residents through the end of 2015. Post_t equals one for 2017 and subsequent years and zero otherwise. HighCamera_c is an indicator equal to one if a city's cumulative surveillance-camera procurement contracts per 1,000 residents through the end of 2013 exceed the sample median. Column (1) controls for the contemporaneous log cumulative number of surveillance-camera procurement contracts per 1,000 residents. Column (2) instead interacts baseline camera procurement density, measured in 2013, with a full set of year indicators. Column (3) excludes criminal cases in which the judgment explicitly cites on-site surveillance footage as evidence. Columns (4) and (5) test whether baseline exposure to the street-lighting standard predicts subsequent changes in camera procurement or the use of surveillance evidence, respectively. Column (6) estimates a triple-difference specification that tests whether the effect of the street-lighting standard upgrade varies with baseline camera density, with all constituent lower-order interaction terms included. All specifications include city and year fixed effects, as well as baseline log GDP per capita and population density, measured in 2013, each interacted with a full set of year indicators. Standard errors clustered at the city level are reported in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

the street-lighting standard. Column (5) uses the share of cases citing surveillance evidence as the outcome and again finds no significant differential change.

Finally, Column (6) tests for complementarities between street lighting and pre-existing camera infrastructure by interacting the baseline treatment with an indicator for cities above the median of baseline camera procurement density. The interaction term is small and statistically insignificant, while the estimated effect remains negative in low-camera cities.

To summarize, the evidence suggests that surveillance cameras are unlikely to be the primary driver of the estimated crime reductions. The results do not rule out all interactions between lighting and other public-safety technologies, but they show that the main estimates are robust to observed camera investment, are not accompanied by differential camera deployment, and do not depend on cities with high baseline camera intensity.

3.5 Visibility and the Timing of Crime

The crime-type results suggest that the standard upgrade reduced offenses for which visibility on urban roads should matter. We now provide a more direct test by examining whether the effects are stronger for crimes committed at night. This test follows directly from the mechanism: if improved lighting reduces crime by increasing visibility, detection risk, and

Table 5: Effects of the Street-Lighting Standard Upgrade by Time of Day

Dep. Var.:	# of Cases per 1,000			# of Offenders per 1,000		
	(1) Nighttime	(2) DDD	(3) DDD	(4) Nighttime	(5) DDD	(6) DDD
$\log(\text{Light}/L)_c \times \text{Post}_t$	-0.007***	-0.005***	-0.005***	-0.009***	-0.005***	-0.005***
	(0.002)	(0.001)	(0.001)	(0.002)	(0.001)	(0.001)
Night $\times \log(\text{Light}/L)_c \times \text{Post}_t$		-0.003***	-0.003***		-0.004***	-0.004***
		(0.001)	(0.001)		(0.001)	(0.001)
City FE	Y	Y	N	Y	Y	N
Year FE	Y	Y	N	Y	Y	N
City-by-time-of-day FE	N	N	Y	N	N	Y
Year-by-time-of-day FE	N	N	Y	N	N	Y
Baseline×Year dummies	Y	Y	Y	Y	Y	Y
Observations	1,862	3,724	3,724	1,862	3,724	3,724
R-squared	0.849	0.792	0.861	0.866	0.794	0.870

Notes: The unit of observation is the city-year in Columns (1) and (4), and the city-year-by-time-of-day cell in Columns (2)–(3) and (5)–(6), covering 2013–2019. The dependent variable is the number of visibility-sensitive adjudicated criminal cases per 1,000 residents in Columns (1)–(3), and the number of offenders involved in such cases per 1,000 residents in Columns (4)–(6). Columns (1) and (4) restrict the outcomes to offenses occurring at night. Columns (2)–(3) and (5)–(6) use observations disaggregated by time of day and estimate a triple-difference specification comparing nighttime and daytime offenses. Columns (2) and (5) include all constituent lower-order interaction terms, while Columns (3) and (6) instead incorporate city-by-time-of-day and year-by-time-of-day fixed effects. Night is an indicator equal to one for offenses occurring between 5:00 p.m. and 4:59 a.m.; offenses occurring between 5:00 a.m. and 4:59 p.m. constitute the daytime comparison group. $\log(\text{Light}/L)_c$ is the log of the cumulative number of street-lighting procurement contracts per 1,000 residents through the end of 2015. Post_t equals one for 2017 and subsequent years and zero otherwise. Columns (1), (2), (4), and (5) include city and year fixed effects. All specifications also include baseline log GDP per capita and population density, measured in 2013, each interacted with a full set of year indicators. Standard errors clustered at the city level are reported in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

natural surveillance, the effect should be larger during hours when ambient light is low.[24]

Table 5 reports the results. Columns (1) and (4) estimate the baseline specification using nighttime visibility-sensitive cases and offenders as outcomes. Both coefficients are negative and statistically significant.[25] Thus, higher-exposure cities experience larger post-policy declines in crimes committed at night.

Columns (2) and (5) compare nighttime and daytime offenses in a triple-difference framework. The coefficient on Night $\times \log(\text{Light}/L)_c \times \text{Post}_t$ is negative and statistically significant for both cases and offenders, indicating that the reduction is larger for nighttime offenses than for daytime offenses. Columns (3) and (6) use more demanding city-by-time-of-day and year-by-time-of-day fixed effects, and the estimates remain quantitatively similar. This differential timing strengthens the interpretation that improved nighttime visibility is an important mechanism.

The estimates also show reductions in daytime offenses. We interpret these effects cautiously.

[24] We classify each criminal case based on the time the offense was committed, as recorded in the judicial document. Cases in which any criminal offense was committed during nighttime hours are coded as crimes committed at night; cases in which all criminal offenses were committed during daytime hours are coded as crimes committed during the day. A crime committed during the day, however, may still involve stages that occur at night. For cases in which the judicial record specifies only the date but not the exact time, we assign the case to neither category. Such cases account for roughly 10% of the sample.

[25] The nighttime window covers 12 hours, whereas the baseline outcome is measured over the full 24-hour day (Columns 2 and 6 of Table 2). Scaling the nighttime coefficient in Columns (1) and (4) to a 24-hour equivalent yields an estimate of -0.014 and -0.018.

They may reflect temporal spillovers if better lighting affects reconnaissance, escape, or concealment outside the moment of commission.[26] They may also reflect changes in routine activity, perceived order, or informal surveillance that extend beyond nighttime hours. Prior reviews of street-lighting interventions similarly find that lighting improvements can reduce crime during both nighttime and daytime hours (Farrington and Welsh, 2002; Welsh and Farrington, 2008; Welsh et al., 2022).[27] Consistent with "broken windows" and informal social control theories (Wilson and Kelling, 1982; Sampson et al., 1997), better lighting may strengthen community cohesion and informal social control, generating spillover effects during daytime hours. The cleanest evidence for the visibility channel, however, is the differential decline in nighttime offenses.

Overall, the timing evidence supports a visibility-based mechanism: the standard upgrade increases nighttime illumination in higher-exposure cities, reduces crime categories most plausibly affected by visibility, and generates larger reductions for crimes committed at night.

4 Perceived Safety and Behavioral Responses

The preceding section shows that cities more exposed to the street-lighting standard upgrade experience larger reductions in adjudicated criminal cases. We now examine whether higher-exposure cities also exhibit changes in perceived safety and behavior. This analysis serves two purposes. First, it provides complementary evidence on the mechanism: if improved lighting makes public spaces safer, residents should report fewer safety concerns and show greater willingness to engage in nighttime activities. Second, it helps assess whether the policy generated broader behavioral responses beyond reductions in recorded crime.[28] We interpret these outcomes as suggestive evidence on perceptions and behavioral margins, rather than as direct measures of victimization or welfare.

4.1 Perceived Safety and Nighttime Activity

We first examine whether the standard upgrade affected perceived safety. We use two complementary sources. The first is a direct measure from the China Family Panel Studies (CFPS), which asks respondents to evaluate public security in their neighborhood on a five-point

[26] Consistent with this temporal-spillover interpretation, we find significant reductions in premeditated, non-impulsive violent offenses recorded as occurring during the daytime. These offenses are more likely to involve planning, target selection, and movements that extend beyond the recorded moment of commission, making them more plausibly affected by changes in nighttime visibility and public-space surveillance. By contrast, we find no significant effect on impulsive daytime violent offenses, for which the opportunity and commission are more likely to be contemporaneous. The difference between the two estimates is statistically significant (Z-test, $p < 0.01$).

[27] We also replicate the analysis from Section 3.4 to further rule out the possibility that surveillance cameras confound the estimated declines in crimes committed during the day. The results, reported in Appendix Table A.10, confirm that these daytime crime reductions are not mechanically driven by camera surveillance.

[28] A large body of evidence shows that the fear of victimization affects routine behavior, including defensive actions (Braakmann, 2012), physical activity (Janke et al., 2016), labor supply (Hamermesh, 1999; Velásquez, 2020), interpersonal trust (Blanco and Ruiz, 2013), residential choice (Cullen and Levitt, 1999), entrepreneurship (Rosenthal and Ross, 2010), and visits to local businesses (Fe and Sanfelice, 2022).

Table 6: Street-Lighting Standard Upgrade, Perceived Safety, and Search Behavior

Dep. Var.:	CFPS perceived safety dummy	Baidu Index per 1,000 residents		
	(1) Neighborhood safety	(2) Safety-concern	(3) Indoor-lighting	(4) Nighttime-activity
$\log(\text{Light}/L)_c \times \text{Post}_t$	0.024***	-0.510**	0.015	0.162**
	(0.007)	(0.241)	(0.070)	(0.082)
City FE	Y	Y	Y	Y
Year FE	Y	Y	Y	Y
Baseline×Year dummies	Y	Y	Y	Y
Observations	11,791	1,862	1,862	1,862
R-squared	0.112	0.847	0.948	0.943

Notes: Column (1) uses household-level data from the China Family Panel Studies (CFPS), while Columns (2)–(4) use city-year data from the Baidu Index. The CFPS sample includes households whose heads are aged 18–59 in the 2016 and 2020 survey waves; the neighborhood-safety question is not available in the 2014 and 2018 waves. The dependent variable in Column (1) is an indicator equal to one if the household head assigns the highest rating to neighborhood public security and zero otherwise. The specification additionally controls for the household head's age, ethnicity, marital status, health, education, urban or rural residence, and household income. Columns (2)–(4) cover 2013–2019. The dependent variables are the corresponding city-level Baidu search indices per 1,000 residents. The safety-concern search index in Column (2) is constructed from searches for "flashlight," "alarm device," "self-defense techniques," and "pepper spray." The indoor-lighting search index in Column (3), which serves as a negative-control outcome, is constructed from searches for "desk lamp," "pendant light," and "floor lamp." The nighttime-activity search index in Column (4) is constructed from searches for "late-night dining," "night market," "late-night street food," and "night running." $\log(\text{Light}/L)_c$ is the log of the cumulative number of street-lighting procurement contracts per 1,000 residents through the end of 2015. Post_t equals one for 2017 and subsequent years and zero otherwise. All specifications include city and year fixed effects, as well as baseline log GDP per capita and population density, measured in 2013, each interacted with a full set of year indicators. Standard errors clustered at the city level are reported in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

scale. We construct an indicator equal to one if the respondent reports the highest category and zero otherwise. This measure captures subjective assessments of neighborhood safety.

The second source is the city-level Baidu Index. We construct a safety-concern search index using keywords related to personal protection and safety concerns in public spaces.[29] If improved street lighting reduces perceived risk after dark, searches related to self-protection and outdoor safety concerns should decline. To distinguish this interpretation from general changes in internet search behavior, we also construct a placebo search index unrelated to outdoor public-space safety.[30]

Table 6 reports the results. Greater baseline exposure to the standard upgrade is associated with more favorable assessments of neighborhood public security in the CFPS (Column 1) and a significant decline in the safety-concern search index (Column 2). By contrast, the placebo search index shows no significant response (Column 3). These patterns are consistent with improved perceived safety rather than a broad change in search intensity or internet use.

We next examine whether residents show greater interest in nighttime activities. Using Baidu Index data, we construct a nighttime-activity index based on searches related to activities typically undertaken after dark, including late-night dining, night markets, late-night street food, and night running. The estimated effect is positive and statistically significant (Column 4).

[29] We construct the "safety-concern index" by aggregating searches for flashlight, alarm device, self-defense techniques, and pepper spray, which capture residents' concerns about personal safety in public spaces.

[30] In particular, an "indoor-lighting search index" is constructed by aggregating searches for desk lamp, pendant light, and floor lamp.

Taken together, the search results suggest that higher-exposure cities experience larger declines in safety concerns and greater interest in nighttime use of urban public space. Because search behavior is an indirect measure, we interpret this evidence as complementary to the crime results rather than as a direct measure of realized mobility.

4.2 Labor Supply

We then examine whether improved public-space safety affected labor supply. Fear of crime can raise the cost of commuting or working during evening and nighttime hours, and these costs may vary across demographic groups (Hamermesh, 1999; Velásquez, 2020). Prior evidence suggests that fear of victimization is especially pronounced among women and younger individuals (e.g., LaGrange and Ferraro, 1989; Ferraro and LaGrange, 1992; Bernhoft and Carstensen, 2008; Jackson, 2009; Gallup, 2025).[31] Motivated by this evidence, we estimate the effects of the standard upgrade separately by gender and age group, distinguishing young adults aged 18–30 from prime-age adults aged 31–59. The analysis uses individual-year data from the 2014–2020 waves of the CFPS and applies the same exposure-by-post design used in the city-level analysis.

Columns (1)–(4) of Table 7 report effects on labor force participation, employment, evening or night-shift work, and weekly working hours.[32] The estimates are concentrated among young women aged 18–30, as shown in Panel A.[33] For this group, an interquartile increase in baseline exposure is associated with a 3.3 percentage point increase in labor force participation, a 3.8 percentage point increase in employment, a 2.3 percentage point increase in evening or night-shift work, and 3.7 additional weekly working hours.[34] Relative to the corresponding sample means, these estimates imply increases of 4.7 percent, 5.6 percent, 10.9 percent, and 12.5 percent, respectively.

The estimates for other demographic groups are generally smaller and less precise. Panels B–D show no comparable pattern among young men, prime-age women, or prime-age men. This heterogeneity is consistent with the interpretation that improvements in nighttime safety are most consequential for groups whose work and commuting decisions are more constrained by perceived risk. A fully interacted specification reported in Appendix Table A.11 confirms that the labor-market responses among young women are generally larger than those for the

[31] Related empirical work shows that safety concerns affect women's labor market participation (Hamermesh, 1999; Sabia et al., 2013; Chakraborty et al., 2018; Velásquez, 2020), as well as travel decisions, educational choices, mental health, and sleep (Braakmann, 2012; Dustmann and Fasani, 2016; Janke et al., 2016; Borker, 2021).

[32] Evening or night-shift occupations are identified from CFPS occupation types using a text-based classification. We classify 29 of the 397 occupation types as evening/night-work occupations if they commonly involve evening service, rotating shifts, overnight staffing, or nighttime transportation, including restaurant service workers, hotel service workers, fitness and entertainment venue workers, air transportation service workers, firefighters, and nursing personnel.

[33] One exception is the estimated effect on labor force participation among prime-age men, which is marginally statistically significant.

[34] The interquartile range of baseline exposure is 1.564 in the CFPS sample and differs slightly from that in the baseline sample.

Table 7: Street-Lighting Standard Upgrade and Labor-Market and Social Outcomes

Dep. Var.:	LFP	Employment	Evening work	Work hours	Trust	Helpfulness
	(1)	(2)	(3)	(4)	(5)	(6)
Panel A: Women ($18 \leq Age \leq 30$)						
$\log(\text{Light}/L)_c \times \text{Post}_t$	0.021**	0.024**	0.015**	2.356***	0.032***	0.025***
	(0.010)	(0.010)	(0.007)	(0.709)	(0.011)	(0.009)
City FE	Y	Y	Y	Y	Y	Y
Year FE	Y	Y	Y	Y	Y	Y
Baseline×Year dummies	Y	Y	Y	Y	Y	Y
Individual controls	Y	Y	Y	Y	Y	Y
Observations	5,916	5,916	6,483	5,435	6,271	6,271
R-squared	0.159	0.153	0.088	0.121	0.084	0.066
Panel B: Women ($31 \leq Age \leq 59$)						
$\log(\text{Light}/L)_c \times \text{Post}_t$	-0.004	-0.002	0.001	0.009	-0.009	0.006
	(0.006)	(0.005)	(0.004)	(0.434)	(0.006)	(0.007)
City FE	Y	Y	Y	Y	Y	Y
Year FE	Y	Y	Y	Y	Y	Y
Baseline×Year dummies	Y	Y	Y	Y	Y	Y
Individual controls	Y	Y	Y	Y	Y	Y
Observations	22,726	22,726	22,545	18,177	22,605	22,548
R-squared	0.135	0.139	0.081	0.119	0.050	0.039
Panel C: Men ($18 \leq Age \leq 30$)						
$\log(\text{Light}/L)_c \times \text{Post}_t$	-0.003	-0.008	0.008	-1.037	0.022*	0.010
	(0.005)	(0.007)	(0.009)	(0.701)	(0.011)	(0.013)
City FE	Y	Y	Y	Y	Y	Y
Year FE	Y	Y	Y	Y	Y	Y
Baseline×Year dummies	Y	Y	Y	Y	Y	Y
Individual controls	Y	Y	Y	Y	Y	Y
Observations	5,092	5,092	5,740	4,492	5,396	5,396
R-squared	0.071	0.084	0.061	0.116	0.073	0.069
Panel D: Men ($31 \leq Age \leq 59$)						
$\log(\text{Light}/L)_c \times \text{Post}_t$	0.005*	0.004	-0.002	0.740	0.007	0.009
	(0.003)	(0.003)	(0.003)	(0.453)	(0.007)	(0.006)
City FE	Y	Y	Y	Y	Y	Y
Year FE	Y	Y	Y	Y	Y	Y
Baseline×Year dummies	Y	Y	Y	Y	Y	Y
Individual controls	Y	Y	Y	Y	Y	Y
Observations	22,255	22,255	22,175	17,172	22,040	22,005
R-squared	0.082	0.083	0.045	0.096	0.041	0.036

Notes: This table uses individual-level data on respondents aged 18–59 from the China Family Panel Studies (CFPS), 2014–2020. Panels A and B restrict the sample to women aged 18–30 and 31–59, respectively; Panels C and D report the corresponding samples for men. The dependent variables are defined as follows: Column (1) uses an indicator for labor force participation; Column (2) uses an employment indicator (including being temporarily away from work); Column (3) uses an indicator for evening or night-shift work; Column (4) uses weekly hours worked (winsorized at the 99.5th percentile within each year to limit the influence of extreme values); Column (5) uses an indicator for generalized trust (whether the individual believes that most people can be trusted); and Column (6) uses an indicator for perceived helpfulness (whether the individual believes that most people are helpful rather than selfish). $\log(\text{Light}/L)_c$ is the log of the cumulative number of street-lighting procurement contracts per 1,000 residents through the end of 2015. Post_t equals one for 2017 and subsequent years and zero otherwise. All specifications control for city and year fixed effects, baseline log GDP per capita and population density (measured in 2013) interacted with a full set of year indicators, and individual characteristics including age, ethnicity, marital status, health, education, urban/rural residence, and household income. Standard errors clustered at the city level are reported in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

other demographic groups.

The evening or night-shift result is particularly informative. Evening and nighttime jobs are likely to be more affected by safety concerns because they require commuting or working during hours when visibility is lower and streets are less crowded. The increase in evening or night-shift work therefore provides behavioral evidence consistent with the public-space safety mechanism. At the same time, we do not interpret the labor supply estimates as a direct welfare measure. Higher employment and work hours may reflect expanded opportunities, reduced perceived risk, or broader changes in local labor demand. The evidence is most useful in showing that the standard upgrade affects economically relevant behavior, especially among young women.

4.3 Social Trust and Perceived Helpfulness

Finally, we examine whether the standard upgrade affected social attitudes. Improved lighting may change not only actual exposure to crime but also the perceived social environment in public space. If residents feel safer and observe greater activity after dark, they may update beliefs about trust and mutual support. We study two CFPS measures. The first is interpersonal trust, equal to one if the respondent reports that most people can be trusted. The second is perceived helpfulness, equal to one if the respondent reports that most people are helpful rather than selfish.

Columns (5) and (6) of Table 7 report the results. Among young women, greater exposure is associated with significant increases in both interpersonal trust and perceived helpfulness. We also find a marginally significant increase in interpersonal trust among young men. The remaining estimates are small and statistically insignificant.

These results are consistent with a broader improvement in perceived public-space safety and social environment, with the most consistent effects again appearing among young women. These results complement the crime, search, and labor supply evidence by showing that the standard upgrade generates meaningful improvements in subjective perceptions as well as declines in recorded criminal cases.

5 Conclusion

This paper studies whether improvements in the quality of ordinary urban infrastructure can enhance public safety. We examine an upgrade to China's urban street-lighting standards, which revised requirements for luminance, pedestrian visibility, and coverage of road-related public spaces. Exploiting cross-city differences in baseline exposure to the standard upgrade, we find that more exposed cities experience larger post-reform declines in adjudicated criminal cases and offenders. The reductions are concentrated in visibility-sensitive offenses and are larger at night, while less visibility-sensitive offenses show little response. These patterns are consistent with improved lighting reducing criminal opportunities by increasing visibility, detection risk, and natural surveillance.

The effects extend beyond recorded crime. In more exposed cities, residents report fewer safety concerns and show greater interest in nighttime activities. Labor market responses are concentrated among young women, who experience higher labor force participation, employment, evening or night-shift work, and weekly working hours. These findings suggest that public-space safety affects not only victimization but also residents' ability to move through cities and participate in economic activity after dark.

The findings have several policy implications. First, urban infrastructure quality can serve as an important complement to traditional crime-prevention tools. Unlike punitive interventions that operate through deterrence and enforcement, improvements to the built environment can reduce criminal opportunities by changing visibility, surveillance, and the use of public space. Second, the benefits of infrastructure upgrades may extend beyond crime reduction by relaxing constraints on nighttime mobility and economic activity, particularly for groups whose behavior is more sensitive to perceived safety risks. For policymakers in developing and middle-income countries, the results highlight the potential social returns from improving the quality and management of basic urban public goods.

Several limitations remain. First, although our continuous difference-in-differences design provides evidence consistent with a causal interpretation, the treatment exposure is based on predetermined differences in street-lighting investment. Future research using more granular information on lighting conditions, road networks, or experimental variation could further isolate the causal effects of specific lighting improvements. Second, because CJJ 45-2015 is a multifaceted standard upgrade, we cannot separately identify the contribution of individual components, such as higher illumination requirements, expanded coverage, pedestrian lighting, or changes in operating rules. Future work could examine which design features generate the largest safety benefits. Third, the lack of detailed cost information prevents a formal cost-benefit analysis. Combining infrastructure expenditure data with estimates of avoided crime costs would allow future research to quantify the economic returns to urban lighting investments and compare them with alternative public-safety interventions.

CRediT Authorship Contribution Statement

Hong Ma: Writing – review & editing, Project administration, Funding acquisition, Conceptualization. **Jingxin Ning:** Writing – review & editing, Writing – original draft, Visualization, Validation, Software, Methodology, Investigation, Formal analysis, Data curation. **Yu Pan:** Writing – review & editing, Writing – original draft, Visualization, Validation, Software, Methodology, Investigation, Formal analysis, Data curation, Project administration, Conceptualization. **You Shan:** Writing – review & editing, Writing – original draft, Visualization, Validation, Software, Methodology, Investigation, Formal analysis, Funding acquisition, Data curation, Conceptualization.

Declaration of Generative AI and AI-assisted Technologies in the Manuscript Preparation Process

During the preparation of this work, the authors used OpenAI's ChatGPT and Anthropic's Claude for proofreading, rewriting, and improving the clarity and presentation of the manuscript. The authors reviewed and edited the output as needed and take full responsibility for the content of the paper.

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"Street Lighting Standards and Urban Crime"

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A Table Appendix

Table A.1: Keywords in Criminal Case Classification

Types	Chinese	English
Panel A: Visibility-sensitive crimes		
1 Traffic-casualty offenses	交通肇事	violating regulations governing traffic and transportation and thereby causing a serious accident
2 Robbery	抢劫 抢夺 聚众哄抢	robbing public or private property forcibly seizing public or private property gathering people to forcibly seize public or private property
3 Larceny	盗窃	stealing public or private property or committing theft repeatedly
4 Violent crimes	故意杀人 故意伤害 过失致人死亡 过失致人重伤 强奸 猥亵 拐卖妇女, 儿童 收买被拐卖的妇女, 儿童 聚众阻碍解救被收买的妇女, 儿童 绑架	intentionally committing homicide intentionally inflicting injury upon another person negligently causing death to another person negligently inflicting injury upon another person raping a woman or a child by violence, coercion or any other means acting indecently against a woman or a child abducting and trafficking in a woman or a child purchasing trafficked women and children organizing crowds to obstruct the rescue of purchased women and children kidnapping another person
5 Public-security crimes	放火 决水 爆炸 投放危险物质 破坏交通设施, 电力设备, 易燃易爆设备, 公用电信设施 非法制造, 买卖, 运输, 邮寄, 储存枪支, 弹药, 爆炸物 非法制造, 买卖, 运输, 储存危险物质 违规制造, 销售枪支 非法持有, 私藏枪支, 弹药 非法出租, 出借枪支 非法携带枪支, 弹药, 管制刀具, 危险物品危及公共安全	arson breaching a dike explosion spreading dangerous materials sabotaging transportation facility, electric power facility, explosive equipment or public telecommunications facility illegally manufacturing, trading in, transporting, mailing or storing any guns, ammunition or explosives illegally manufacturing, trading in, transporting or storing any dangerous materials violating the regulations on manufacturing or selling guns illegally possessing or concealing any guns or ammunition illegally leasing or loaning guns illegally entering a public place with any gun, ammunition, controlled cutting tool or any other dangerous tools and thereby endangering public security
6 Drug-related crimes	走私, 贩卖, 运输, 制造毒品 非法持有毒品 包庇毒品犯罪分子 窝藏, 转移, 隐瞒毒品, 毒赃 非法种植毒品原植物 非法买卖, 运输, 携带, 持有毒品原植物种子, 幼苗 非法提供麻醉药品或精神药品	smuggling, trafficking, transporting, or manufacturing drugs illegal possession of drugs harboring drug offenders harboring, transferring, or concealing drugs or illicit drug proceeds illegal cultivation of illicit drug plants illegal trading, transporting, carrying, or possessing seeds or seedlings of illicit drug plants illegally providing narcotic drugs or psychotropic substances
Panel B: Less visibility-sensitive crimes		
1 DWI	醉驾	driving while intoxicated
2 Fraud and extortion	诈骗 敲诈勒索	general fraud (excluding financial and contract fraud) extortion

Types	Chinese	English
3 Economic crimes	生产, 销售伪劣产品	producing and selling fake and substandard products
	假冒注册商标	counterfeiting registered trademarks
	销售假冒注册商标的商品	selling commodities bearing counterfeit registered trademarks
	非法制造, 销售非法制造的注册商标标识	illegally manufacturing or selling illegally manufactured representations of registered trademarks
	假冒专利	passing off patents
	侵犯著作权	infringing on copyrights
	侵犯知识产权	infringing on intellectual property rights
	虚报注册资本	falsely reporting registered capital
	虚假出资, 抽逃出资	falsely contributing capital or surreptitiously withdrawing contributed capital
	欺诈发行股票, 债券	fraudulently issuing stocks or bonds
	违规披露, 不披露重要信息	illegally disclosing or failing to disclose important information
	妨害清算	impeding liquidation
	隐匿, 故意销毁会计凭证, 会计账簿, 财务会计报告	concealing or intentionally destroying accounting vouchers, books, or financial reports
	虚假破产	fraudulent bankruptcy
	非法经营同类营业	illegally operating similar businesses
	签订, 履行合同失职被骗	being swindled due to dereliction of duty in signing or fulfilling contracts
	国有公司, 企业, 事业单位人员失职	dereliction of duty by personnel of state-owned enterprises or institutions
	徇私舞弊低价折股, 出售国有资产	converting state-owned assets into shares at a low price or selling them out of favoritism
	背信损害上市公司利益	breaching fiduciary duties to the detriment of listed companies' interests
	逃税	tax evasion
	抗税	resisting tax payment
	逃避追缴欠税	evading the recovery of tax arrears
	骗取出口退税	defrauding the government of export tax refunds
	虚开, 伪造, 出售, 持有伪造的发票	falsely issuing, forging, selling, or possessing forged invoices
	走私	smuggling
	损害商业信誉, 商品声誉	damaging commercial credibility or product reputation
	虚假广告	false advertising
	串通投标	collusive bidding
	组织, 领导传销活动	organizing or leading pyramid selling activities
	非法经营	illegal business operations
	伪造, 倒卖伪造的有价票证	forging or reselling forged valuable tickets
	倒卖车票, 船票	reselling train or ship tickets
	非法转让, 倒卖土地使用权	illegally transferring or reselling land use rights
	提供虚假证明文件	providing false evidentiary documents
	逃避商检	evading commodity inspection
	破坏社会主义市场经济秩序	disrupting the order of the socialist market economy
	伪造货币	counterfeiting currency
	擅自设立金融机构	establishing financial institutions without authorization
	伪造, 变造, 转让金融机构经营许可证, 批准文件	forging, altering, or transferring financial institutions' operating licenses or approval documents
	高利转贷	fraudulently obtaining loans and relending them at high interest rates
	骗取贷款, 票据承兑, 金融票证	fraudulently obtaining loans, bill acceptances, or financial instruments
	非法吸收公众存款	illegally absorbing public deposits
	伪造, 变造金融票证	forging or altering financial instruments
	妨害信用卡管理	disrupting credit card administration
	伪造, 变造国家有价证券	forging or altering state securities
	伪造, 变造股票, 公司, 企业债券	forging or altering stocks or corporate bonds
	擅自发行股票, 公司, 企业债券	issuing stocks or corporate bonds without authorization
	内幕交易, 泄露内幕信息	insider trading or leaking inside information
	利用未公开信息交易	trading on undisclosed information
	编造并传播证券, 期货交易虚假信息	fabricating and disseminating false information on securities or futures trading
	诱骗投资者买卖证券, 期货合约	luring investors into buying or selling securities or futures contracts
	操纵证券, 期货市场	manipulating securities or futures markets
	背信运用受托财产	breaching trust in utilizing entrusted property
	违法运用资金	illegally utilizing funds
	违法发放贷款	illegally granting loans
	吸收客户资金不入账	absorbing client funds without recording them in accounts
	违规出具金融票证	illegally issuing financial instruments
	对违法票据承兑, 付款, 保证	accepting, paying, or guaranteeing illegal bills
	逃汇	evading foreign exchange controls
	洗钱	money laundering
	金融诈骗	financial fraud
	集资诈骗	fundraising fraud
	贷款诈骗	loan fraud
	票据诈骗	financial bill fraud
	金融凭证诈骗	financial instrument fraud

Types	Chinese	English
	信用证诈骗	letter of credit fraud
	信用卡诈骗	credit card fraud
	有价证券诈骗	securities fraud
	保险诈骗	insurance fraud
	合同诈骗	contract fraud
4 Bribery	贪污	corruption
	受贿	accepting bribes
	行贿	offering bribes
	私分国有资产	dividing up state-owned assets in secret
	私分罚没财物	dividing up in secret the fines or confiscated property
5 Gambling-related crimes	赌博	organizing gambling for profit or engaging in professional gambling
	开设赌场	opening a casino
6 Social-administration crimes	妨害公务	obstructing official duties
	招摇撞骗	swindling and bluffing
	伪造, 变造, 买卖, 毁灭国家机关公文, 证件, 印章	forging, altering, buying, selling, or destroying official documents certificates, or seals of state organs
	伪造公司, 企业, 事业单位, 人民团体印章	forging seals of companies, enterprises, institutions or people's organizations
	伪造, 变造, 买卖身份证件	forging, altering, buying, or selling identity documents
	非法生产, 买卖警用装备	illegally, producing, buying, or selling police equipment
	非法获取国家秘密	illegally acquiring state secrets
	非法持有国家绝密, 机密文件, 资料, 物品	illegally possessing top-secret or classified state documents materials or items
	非法生产, 销售专用间谍器材, 窃听, 窃照专用器材	illegally producing or selling espionage eavesdropping or secret photographing equipment
	组织考试作弊	organizing cheating in examinations
	非法出售, 提供试题, 答案	illegally selling or providing examination questions or answers
	非法侵入, 破坏计算机信息系统	illegally intruding into or sabotaging computer information systems
	非法获取计算机信息系统数据	illegally acquiring data from computer information systems
	非法控制计算机信息系统	illegally controlling computer information systems
	帮助信息网络犯罪活动	assisting in cybercriminal activities
	聚众扰乱社会秩序	gathering a crowd to disturb social order
	组织, 资助非法聚集	organizing or funding illegal gatherings
	聚众扰乱公共场所秩序, 交通秩序	gathering a crowd to disturb order in public places or traffic order
	编造, 故意传播虚假信息	fabricating or intentionally disseminating false information
	聚众斗殴	gathering a crowd to engage in brawls
	寻衅滋事	picking quarrels and provoking trouble
	黑社会	organizing leading or participating in mafia-style organizations
	非法集会, 游行, 示威	illegal assembly, procession, and demonstration
	非法携带武器, 管制刀具, 爆炸物参加集会, 游行, 示威	illegally carrying weapons controlled knives or explosives to assemblies processions or demonstrations
	侮辱国旗, 国徽, 国歌	insulting the national flag emblem or anthem
	组织, 利用会道门, 邪教组织, 利用迷信破坏法律实施	organizing or using cults or superstition to undermine law implementation
	毁灭证据, 伪造证据, 妨害作证	destroying or forging evidence or obstructing testimony
	故意泄露国家秘密	intentionally leaking state secrets
	过失泄露国家秘密	negligently leaking state secrets
	披露, 报道不应公开的案件信息	disclosing or reporting case information that should not be public
	提供伪造, 变造的出入境证件	providing forged or altered exit-entry documents
	非法向外国人出售, 赠送珍贵文物	illegally selling or gifting precious cultural relics to foreigners
	非法行医	practicing medicine illegally
	危害珍贵, 濒危野生动物	endangering precious or endangered wild animals
	非法占用农用地	illegally occupying agricultural land
	非法采矿	illegal mining
	聚众淫乱	gathering to engage in licentious activities
	组织, 强迫, 引诱, 容留或介绍卖淫	arranging, forcing, luring, sheltering or procuring other persons to engage in prostitution

Notes: This table reports the Chinese keywords used for crime classification, along with their English translations. We categorize offenses into *visibility-sensitive crimes* (Panel A) and *less visibility-sensitive crimes* (Panel B). Notably, under Chinese law, personal drug use and minor for-profit gambling are classified as administrative violations rather than criminal offenses. Instead, criminal liability applies to the selling, smuggling, trafficking, transporting, or manufacturing of drugs, as well as providing premises for drug use. Similarly, criminal gambling offenses are limited to gathering crowds to gamble, engaging in professional gambling, or operating casinos. Therefore, we collectively refer to these offenses as "drug-related" and "gambling-related" crimes, respectively.

Table A.2: Keywords in Procurement Classification and Baidu Index Construction

Types	Chinese	English
Panel A: Keywords in Procurement Classification		
Street-lighting procurement	道路...照明	road . . . lighting
	照明...道路	lighting . . . road
	亮化	urban illumination
	路灯	street lighting
	夜间照明	nighttime lighting
	公共照明	public lighting
	城市照明设施	urban lighting facilities
	市政（城乡一体化）照明	municipal (urban–rural integrated) lighting
	路...照明	road . . . lighting
	室外...照明	outdoor . . . lighting
Landscape lighting procurement	夜景照明	nightscape lighting
	景观照明	landscape lighting
Surveillance camera procurement	摄像头	surveillance camera
	猫眼	peephole camera
	探头	surveillance probe
	视频监控	video surveillance
	电子监控	electronic surveillance
	监控设备	surveillance equipment
	天眼	Sky Eye
Panel B: Keywords in Baidu Index Construction		
Safety-concern	手电筒	flashlight
	报警器	alarm device
	防身术	self-defense techniques
	防身喷雾	pepper spray
Indoor-lighting (negative-control outcome)	台灯	desk lamp
	吊灯	pendant light
	落地灯	floor lamp
Nighttime-activity	夜宵	late-night dining
	夜市	night market
	大排档	late-night street food
	夜跑	night running

Notes: This table reports the Chinese keywords used for procurement classification (Panel A) and Baidu Index construction (Panel B). Ellipses (. . .) indicate wildcard matching, allowing the two terms to be separated by intervening characters in procurement titles or descriptions.

Table A.3: Summary Statistics: Variables Used in Regressions

	Obs	Mean	Std	Min	Max
Panel A: Baseline Variables					
# of Visibility-sensitive criminal cases per 1,000 residents	1862	0.232	0.115	0.013	0.965
# of Offenders in visibility-sensitive cases per 1,000 residents	1862	0.283	0.141	0.016	1.142
Cum. # of street-lighting procurement contracts per 1,000 residents as of 2015	266	0.008	0.010	0.0002	0.066
Cum. # of street-lighting procurement contracts w/ prices per 1,000 residents as of 2015	259	0.007	0.009	0.0001	0.060
Street-lighting procurement expenditure per 1,000 residents as of 2015	259	9943.92	14925.95	0.697	96854.41
log GDP per capita in 2013	266	10.554	0.627	9.037	12.456
Population density in 2013	266	0.049	0.058	0.0002	0.585
# of Traffic-casualty cases per 1,000 residents	1862	0.035	0.017	0	0.222
# of Robbery cases per 1,000 residents	1862	0.007	0.007	0	0.052
# of Larceny cases per 1,000 residents	1862	0.089	0.058	0.006	0.461
# of Violent cases per 1,000 residents	1862	0.049	0.025	0	0.191
# of Public-security cases per 1,000 residents	1862	0.008	0.011	0	0.225
# of Drug-related cases per 1,000 residents	1862	0.045	0.048	0	0.589
# of Less visibility-sensitive cases per 1,000 residents	1862	0.201	0.125	0.007	0.844
# of DWI cases per 1,000 residents	1862	0.092	0.088	0	0.663
# of Fraud and extortion cases per 1,000 residents	1862	0.024	0.014	0	0.151
# of Economic cases per 1,000 residents	1862	0.016	0.014	0	0.113
# of Bribery cases per 1,000 residents	1862	0.002	0.002	0	0.021
# of Gambling-related cases per 1,000 residents	1862	0.011	0.013	0	0.102
# of Social-administration cases per 1,000 residents	1862	0.045	0.028	0	0.267
# of Visibility-sensitive cases w/o camera evidence per 1,000 residents	1862	0.203	0.100	0.004	0.901
Share of visibility-sensitive cases involving surveillance evidence	1862	0.122	0.076	0	0.667
# of Nighttime visibility-sensitive cases per 1,000 residents	1862	0.121	0.066	0.009	0.668
# of Daytime visibility-sensitive cases per 1,000 residents	1862	0.083	0.040	0	0.337
NTL intensity per 1,000 residents (truncated at 90th)	1862	1.413	2.773	0	21.991
NTL intensity per square kilometer of built-up area (truncated at 90th)	1841	43.500	86.063	0	754.051
Cum. # of camera procurement contracts per 1,000 residents	1805	0.025	0.053	0	0.545
# of Camera procurement contracts per 1,000 residents	1546	0.007	0.011	0	0.185
Panel B: Extension Analyses					
Neighborhood safety	11,791	0.202	0.401	0	1
Safety-concern search index per 1,000 residents	1862	10.907	6.924	0	72.693
Nighttime-activity search index per 1,000 residents	1862	4.439	4.791	0	32.677
Indoor-lighting search index per 1,000 residents	1862	4.774	3.948	0	33.141
Labor force participation for women aged 18–30	5,916	0.697	0.460	0	1
Employment for women aged 18–30	5,916	0.669	0.471	0	1
Evening work for women aged 18–30	6,483	0.216	0.411	0	1
Work hours for women aged 18–30	5,435	29.418	27.056	0	112
Trust for women aged 18–30	6,271	0.586	0.493	0	1
Helpfulness for women aged 18–30	6,271	0.741	0.438	0	1
Labor force participation for women aged 31–59	22,726	0.794	0.405	0	1
Employment for women aged 31–59	22,726	0.783	0.412	0	1
Evening work for women aged 31–59	22,545	0.130	0.336	0	1
Work hours for women aged 31–59	18,177	31.320	27.227	0	112
Trust for women aged 31–59	22,605	0.523	0.499	0	1
Helpfulness for women aged 31–59	22,548	0.696	0.460	0	1
Labor force participation for men aged 18–30	5,092	0.950	0.218	0	1
Employment for men aged 18–30	5,092	0.924	0.266	0	1
Evening work for men aged 18–30	5,740	0.113	0.317	0	1
Work hours for men aged 18–30	4,492	47.535	23.680	0	112
Trust for men aged 18–30	5,396	0.607	0.489	0	1
Helpfulness for men aged 18–30	5,396	0.696	0.460	0	1
Labor force participation for men aged 31–59	22,255	0.943	0.232	0	1
Employment for men aged 31–59	22,255	0.934	0.248	0	1
Evening work for men aged 31–59	22,175	0.064	0.245	0	1
Work hours for men aged 31–59	17,172	45.466	24.565	0	112
Trust for men aged 31–59	22,040	0.568	0.495	0	1
Helpfulness for men aged 31–59	22,005	0.683	0.465	0	1

Notes: This table reports summary statistics for the key variables used in our empirical analysis. Panel A lists the variables included in the baseline regressions, while Panel B covers those used in the extension analyses in Section 4. Detailed variable definitions and data sources are provided in Section 2.2.

Table A.4: Street-Lighting Standard Upgrade and Nighttime Luminosity, Accounting for Tree Canopy Coverage

Dep. Var.:	NTL/population (truncated at)			NTL/built-up area (truncated at)		
	(1) 97.5th (annual)	(2) 90th (annual)	(3) 90th (2013)	(4) 97.5th (annual)	(5) 90th (annual)	(6) 90th (2013)
$\log(\text{Light}/L)_c \times \text{Post}_t$	0.136**	0.110***	0.170***	6.777**	4.888***	7.552***
	(0.065)	(0.040)	(0.050)	(3.211)	(1.844)	(2.591)
City FE	Y	Y	Y	Y	Y	Y
Year FE	Y	Y	Y	Y	Y	Y
Baseline×Year dummies	Y	Y	Y	Y	Y	Y
Observations	1,862	1,862	1,862	1,841	1,841	1,841
R-squared	0.979	0.974	0.966	0.924	0.907	0.871

Notes: This table reports the effects of the standard upgrade on nighttime-light (NTL) intensity at 1:30 a.m., controlling for city-level tree canopy coverage. The unit of observation is the city-year, covering 2013–2019. The dependent variable is NTL intensity (per 1,000 residents) in Columns (1)–(3), and NTL intensity (per square kilometer of built-up area) in Columns (4)–(6). To better isolate lower-intensity public lighting from high-luminosity sources, such as major commercial, office, and industrial areas, we trim the brightest pixels within each city. Columns (1) and (4) exclude pixels above the 97.5th percentile of the city-level luminosity distribution, while Columns (2), (3), (5), and (6) exclude pixels above the 90th percentile. In Columns (1), (2), (4), and (5), the trimming thresholds are recalculated separately for each city-year. In Columns (3) and (6), the set of retained pixels is held fixed over time using each city's 2013 luminosity distribution. $\log(\text{Light}/L)_c$ is the log of the cumulative number of street-lighting procurement contracts per 1,000 residents through the end of 2015. Post_t equals one for 2017 and subsequent years and zero otherwise. All specifications include city and year fixed effects, as well as baseline log GDP per capita and population density interacted with a full set of year indicators. Standard errors clustered at the city level are reported in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

Table A.5: Effects of the Street-Lighting Standard Upgrade by Crime Type, Offender-Level Estimates

Dep. Var.:	# of Offenders per 1,000 residents						
Panel A: Visibility-sensitive crimes							
	(1) Total	(2) Traffic-casualty	(3) Robbery	(4) Larceny	(5) Violence	(6) Public security	(7) Drug-related
$\log(\text{Light}/L)_c \times \text{Post}_t$	-0.016***	-0.002***	-0.001***	-0.004**	-0.001*	-0.001**	-0.006***
	(0.003)	(0.001)	(0.0003)	(0.002)	(0.001)	(0.0005)	(0.001)
City FE	Y	Y	Y	Y	Y	Y	Y
Year FE	Y	Y	Y	Y	Y	Y	Y
Baseline×Year dummies	Y	Y	Y	Y	Y	Y	Y
Observations	1,862	1,862	1,862	1,862	1,862	1,862	1,862
R-squared	0.852	0.761	0.754	0.861	0.845	0.628	0.773
Panel B: Less visibility-sensitive crimes							
	(1) Total	(2) DWI	(3) Fraud and extortion	(4) Economic	(5) Bribery	(6) Gambling-related	(7) Social admin.
$\log(\text{Light}/L)_c \times \text{Post}_t$	0.002	0.004	-0.001*	-0.0004	0.0001	0.0004	0.001
	(0.004)	(0.003)	(0.001)	(0.001)	(0.0001)	(0.0005)	(0.001)
City FE	Y	Y	Y	Y	Y	Y	Y
Year FE	Y	Y	Y	Y	Y	Y	Y
Baseline×Year dummies	Y	Y	Y	Y	Y	Y	Y
Observations	1,862	1,862	1,862	1,862	1,862	1,862	1,862
R-squared	0.849	0.748	0.821	0.819	0.674	0.839	0.854

Notes: The unit of observation is the city-year, covering 2013–2019. The dependent variable is the number of offenders involved in adjudicated criminal cases per 1,000 residents in each crime category. Panel A reports estimates for visibility-sensitive offenses, while Panel B reports estimates for less visibility-sensitive offenses, which serve as negative-control outcomes. Column (1) of each panel aggregates all offenses classified within the corresponding group; the remaining columns report estimates for individual crime categories. Crime classifications are constructed using keyword matching, as detailed in Appendix Table A.1. $\log(\text{Light}/L)_c$ is the log of the cumulative number of street-lighting procurement contracts per 1,000 residents through the end of 2015. Post_t equals one for 2017 and subsequent years and zero otherwise. All specifications include city and year fixed effects, as well as baseline log GDP per capita and population density, measured in 2013, each interacted with a full set of year indicators. Standard errors clustered at the city level are reported in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

Table A.6: Effects of the Street-Lighting Standard Upgrade by Offender Characteristics

Dep. Var.:	# of Offenders per 1,000 residents				
	(1)	(2)	(3)	(4)	(5)
	Without record	With record	Male	Female	Low-educated
$\log(\text{Light}/L)_c \times \text{Post}_t$	-0.013***	-0.003**	-0.014***	-0.002***	-0.015***
	(0.002)	(0.001)	(0.003)	(0.0005)	(0.003)
Observations	1,862	1,862	1,862	1,862	1,862
R-squared	0.829	0.866	0.852	0.768	0.839
	(6)	(7)	(8)	(9)	(10)
	High-educated	Aged 18–30	Aged 31–59	Migrant	Local
$\log(\text{Light}/L)_c \times \text{Post}_t$	-0.001*	-0.007***	-0.008***	-0.007***	-0.009***
	(0.001)	(0.002)	(0.002)	(0.002)	(0.002)
Observations	1,862	1,862	1,862	1,862	1,862
R-squared	0.546	0.846	0.815	0.898	0.836
City FE	Y	Y	Y	Y	Y
Year FE	Y	Y	Y	Y	Y
Baseline×Year dummies	Y	Y	Y	Y	Y

Notes: The unit of observation is the city-year, covering 2013–2019. The dependent variable is the number of offenders involved in visibility-sensitive adjudicated criminal cases per 1,000 residents. $\log(\text{Light}/L)_c$ is the log of the cumulative number of street-lighting procurement contracts per 1,000 residents through the end of 2015. Post_t equals one for 2017 and subsequent years and zero otherwise. We estimate separate regressions for different demographic subgroups: individuals without and with prior criminal records (Columns 1–2), males and females (Columns 3–4), individuals with junior high school education or below and those with higher education (Columns 5–6), age groups 18–30, and 31–59 (Columns 7–8), and migrants and locals (Columns 9–10). All specifications include city and year fixed effects, as well as baseline log GDP per capita and population density, measured in 2013, each interacted with a full set of year indicators. Standard errors clustered at the city level are reported in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

Table A.7: Robustness: Alternative Specifications and Samples

Dep. Var.:	# of Cases per 1,000 residents						
	(1) City linear trend	(2) $\text{Post}_{2016} = 1/2$	(3) Population weighted	(4) Drop big city	(5) 2014–2019 sample	(6) Two-group DiD	(7) IV estimation
$\log(\text{Light}/L)_c \times \text{Post}_t$	-0.008***	-0.014***	-0.009**	-0.015***	-0.014***		-0.039*
	(0.003)	(0.003)	(0.004)	(0.003)	(0.003)		(0.021)
$\text{Treat}_c \times \text{Post}_t$						-0.022***	
						(0.008)	
Observations	1,862	1,862	1,862	1,645	1,596	1,862	1,862
R-squared	0.919	0.857	0.848	0.861	0.868	0.846	-
First-stage F-stat							10.9
Dep. Var.:	# of Offenders per 1,000 residents						
	(8) City linear trend	(9) $\text{Post}_{2016} = 1/2$	(10) Population weighted	(11) Drop big city	(12) 2014–2019 sample	(13) Two-group DiD	(14) IV estimation
$\log(\text{Light}/L)_c \times \text{Post}_t$	-0.008**	-0.016***	-0.011**	-0.018***	-0.015***		-0.053**
	(0.003)	(0.004)	(0.005)	(0.003)	(0.003)		(0.026)
$\text{Treat}_c \times \text{Post}_t$						-0.024***	
						(0.009)	
Observations	1,862	1,862	1,862	1,645	1,596	1,862	1,862
R-squared	0.922	0.857	0.849	0.861	0.873	0.849	-
First-stage F-stat							10.9
City FE	Y	Y	Y	Y	Y	Y	Y
Year FE	Y	Y	Y	Y	Y	Y	Y
Baseline×Year dummies	Y	Y	Y	Y	Y	Y	Y

Notes: The unit of observation is the city-year, covering 2013–2019. The dependent variable is the number of visibility-sensitive adjudicated criminal cases per 1,000 residents in Columns (1)–(7), and the number of offenders involved in such cases per 1,000 residents in Columns (8)–(14). $\log(\text{Light}/L)_c$ is the log of the cumulative number of street-lighting procurement contracts per 1,000 residents through the end of 2015. Post_t equals one for 2017 and subsequent years and zero otherwise, while Post_{2016} is coded as 1/2 in Columns (2) and (9) to reflect partial treatment timing in 2016 following Liu and Lu (2015). Columns (1) and (8) control for city-specific linear time trends. Columns (3) and (10) report population-weighted estimates. Columns (4) and (11) drop major cities, including 4 municipalities (Beijing, Tianjin, Shanghai, Chongqing) and 27 provincial capitals. Columns (5) and (12) exclude the year 2013. Columns (6) and (13) report the results of a two-group DiD regression, where the treatment (control) group is defined as cities with $\log(\text{Light}/L)_c$ above (below) the median. Columns (7) and (14) employ the log number of street-lighting firms per 1,000 residents established through the end of 2015 as an instrument for $\log(\text{Light}/L)_c$ following Ma et al. (2026). All specifications include city and year fixed effects, as well as baseline log GDP per capita and population density, measured in 2013, each interacted with a full set of year indicators. Standard errors clustered at the city level are reported in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

Table A.8: Robustness: Controlling for Confounding Effects

Dep. Var.:	# of Cases per 1,000 residents				
	(1)	(2)	(3)	(4)	(5)
	Landscape lighting	Fiscal expenditure	Export slowdown	US-China trade war	All
$\log(\text{Light}/L)_c \times \text{Post}_t$	-0.014***	-0.010***	-0.014***	-0.014***	-0.011***
	(0.003)	(0.003)	(0.003)	(0.003)	(0.003)
Observations	1,862	1,533	1,827	1,862	1,519
R-squared	0.850	0.850	0.849	0.850	0.850
Dep. Var.:	# of Offenders per 1,000 residents				
	(6)	(7)	(8)	(9)	(10)
	Landscape lighting	Fiscal expenditure	Export slowdown	US-China trade war	All
$\log(\text{Light}/L)_c \times \text{Post}_t$	-0.016***	-0.012***	-0.016***	-0.016***	-0.013***
	(0.004)	(0.004)	(0.003)	(0.003)	(0.004)
Observations	1,862	1,533	1,827	1,862	1,519
R-squared	0.853	0.854	0.853	0.853	0.853
City FE	Y	Y	Y	Y	Y
Year FE	Y	Y	Y	Y	Y
Baseline×Year dummies	Y	Y	Y	Y	Y

Notes: The unit of observation is the city-year, covering 2013–2019. The dependent variable is the number of visibility-sensitive adjudicated criminal cases per 1,000 residents in Columns (1)–(5), and the number of offenders involved in such cases per 1,000 residents in Columns (6)–(10). $\log(\text{Light}/L)_c$ is the log of the cumulative number of street-lighting procurement contracts per 1,000 residents through the end of 2015. Post_t equals one for 2017 and subsequent years and zero otherwise. Columns (1) and (6) control for the log cumulative number of landscape lighting procurement contracts per 1,000 residents. Columns (2) and (7) control for the log of fiscal expenditures on public security and "social spending" per 1,000 residents, where public security expenditure includes all expenses by the people's armed police, prosecutorial system, court system, judicial system, and public security organs, and "social spending" is the sum of expenditure on public services, education, social security, medical services, and urban and rural affairs. Columns (3) and (8) include a measure of export slowdown following Ma et al. (2025), defined as the annual change in city-level manufacturing exports per 1,000 residents. Columns (4) and (9) account for city-level exposure to the 2018–2019 US–China trade war. Following Chor and Li (2024), we construct weighted averages of US tariffs on Chinese exports and Chinese retaliatory tariffs on US imports, with weights given by each product's exports to (imports from) the United States as a share of the city's total exports (imports) in 2017, the year prior to the trade war. Finally, Columns (5) and (10) include all the aforementioned confounding factors. All specifications include city and year fixed effects, as well as baseline log GDP per capita and population density, measured in 2013, each interacted with a full set of year indicators. Standard errors clustered at the city level are reported in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

Table A.9: Street-Lighting Standard Upgrade, Surveillance Cameras, and Crime, Offender-Level Estimates

Dep. Var.:	# of Offenders per 1,000			Offender share	# of Offenders per 1,000
	(1) Control cum. camera	(2) Control baseline camera × Year dums.	(3) Drop case with camera	(4) With camera	(5) DDD: By baseline camera
$\log(\text{Light}/L)_c \times \text{Post}_t$	-0.017***	-0.009**	-0.015***	0.001	-0.011***
	(0.004)	(0.004)	(0.003)	(0.002)	(0.004)
$\text{HighCamera}_c \times \log(\text{Light}/L)_c \times \text{Post}_t$					-0.0001
					(0.007)
City FE	Y	Y	Y	Y	Y
Year FE	Y	Y	Y	Y	Y
Baseline×Year dummies	Y	Y	Y	Y	Y
Observations	1,805	1,680	1,862	1,862	1,855
R-squared	0.851	0.852	0.832	0.844	0.853

Notes: The unit of observation is the city-year, covering 2013–2019. The dependent variable is the number of offenders involved in visibility-sensitive adjudicated criminal cases per 1,000 residents in Columns (1)–(3) and (5), and the share of offenders involved in adjudicated criminal cases explicitly citing surveillance footage as evidence in Column (4). $\log(\text{Light}/L)_c$ is the log of the cumulative number of street-lighting procurement contracts per 1,000 residents through the end of 2015. Post_t equals one for 2017 and subsequent years and zero otherwise. HighCamera_c is an indicator equal to one if a city's cumulative surveillance-camera procurement contracts per 1,000 residents through the end of 2013 exceed the sample median. Column (1) controls for the contemporaneous log cumulative number of surveillance-camera procurement contracts per 1,000 residents. Column (2) instead interacts baseline camera procurement density, measured in 2013, with a full set of year indicators. Column (3) excludes criminal cases in which the judgment explicitly cites on-site surveillance footage as evidence. Column (4) tests whether baseline exposure to the street-lighting standard predicts subsequent changes in the use of surveillance evidence. Column (5) estimates a triple-difference specification that tests whether the effect of the street-lighting standard upgrade varies with baseline camera density, with all constituent lower-order interaction terms included. All specifications include city and year fixed effects, as well as baseline log GDP per capita and population density, measured in 2013, each interacted with a full set of year indicators. Standard errors clustered at the city level are reported in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

Table A.10: Street-Lighting Standard Upgrade, Surveillance Cameras, and Daytime Crime

Dep. Var.:	# of Cases per 1,000			Case share	# of Cases per 1,000
	(1) Control cum. camera	(2) Control baseline camera × Year dums.	(3) Drop case with camera	(4) Share with camera	(5) DDD: By baseline camera
$\log(\text{Light}/L)_c \times \text{Post}_t$	-0.005***	-0.003**	-0.005***	-0.001	-0.003**
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
$\text{HighCamera}_c \times \log(\text{Light}/L)_c \times \text{Post}_t$					-0.001
					(0.002)
Observations	1,805	1,680	1,862	1,862	1,855
R-squared	0.836	0.836	0.835	0.671	0.838
Dep. Var.:	# of Offenders per 1,000			Offender share	# of Offenders per 1,000
	(6) Control cum. camera	(7) Control baseline camera × Year dums.	(8) Drop case with camera	(9) Share with camera	(10) DDD: By baseline camera
$\log(\text{Light}/L)_c \times \text{Post}_t$	-0.006***	-0.004***	-0.005***	-0.001	-0.003**
	(0.001)	(0.001)	(0.001)	(0.001)	(0.001)
$\text{HighCamera}_c \times \log(\text{Light}/L)_c \times \text{Post}_t$					-0.001
					(0.002)
Observations	1,805	1,680	1,862	1,862	1,855
R-squared	0.837	0.837	0.835	0.661	0.838
City FE	Y	Y	Y	Y	Y
Year FE	Y	Y	Y	Y	Y
Baseline×Year dummies	Y	Y	Y	Y	Y

Notes: The unit of observation is the city-year, covering 2013–2019. The dependent variable is the number of visibility-sensitive adjudicated criminal cases committed during daytime hours per 1,000 residents in Columns (1)–(3) and (5), and the share of daytime adjudicated criminal cases explicitly citing surveillance footage as evidence in Column (4). Columns (6)–(10) repeat the estimations in Columns (1)–(5) using the corresponding offender-based measures. $\log(\text{Light}/L)_c$ is the log of the cumulative number of street-lighting procurement contracts per 1,000 residents through the end of 2015. Post_t equals one for 2017 and subsequent years and zero otherwise. HighCamera_c is an indicator equal to one if a city's cumulative surveillance-camera procurement contracts per 1,000 residents through the end of 2013 exceed the sample median. Columns (1) and (6) control for the contemporaneous log cumulative number of surveillance-camera procurement contracts per 1,000 residents. Columns (2) and (7) instead interact baseline camera procurement density, measured in 2013, with a full set of year indicators. Columns (3) and (8) exclude criminal cases in which the judgment explicitly cites on-site surveillance footage as evidence. Columns (4) and (9) test whether baseline exposure to the street-lighting standard predicts subsequent changes in the use of surveillance evidence. Columns (5) and (10) estimate a triple-difference specification that tests whether the effect of the street-lighting standard upgrade varies with baseline camera density, with all constituent lower-order interaction terms included. All specifications include city and year fixed effects, as well as baseline log GDP per capita and population density, measured in 2013, each interacted with a full set of year indicators. Standard errors clustered at the city level are reported in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

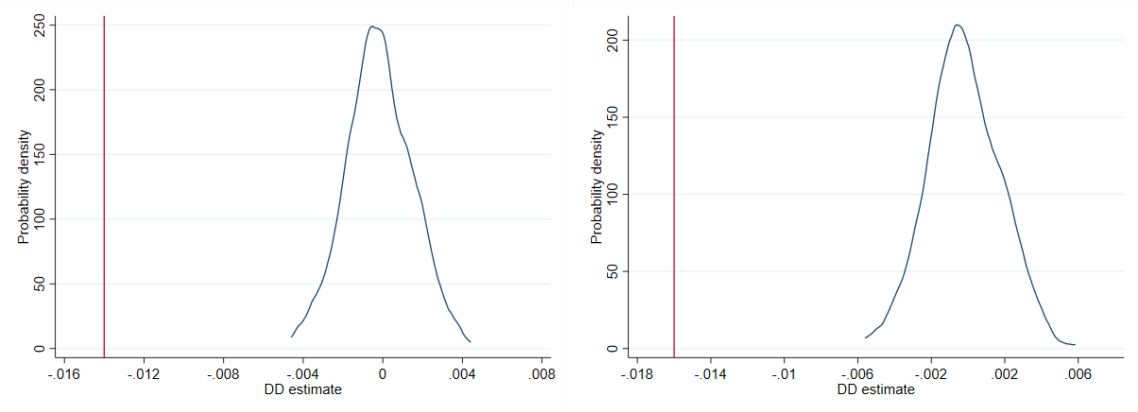
Table A.11: Testing for Differential Treatment Effects across Demographic Groups

Dep. Var.:	LFP	Employment	Evening work	Work hours	Trust	Helpfulness
	(1)	(2)	(3)	(4)	(5)	(6)
$\log(\text{Light}/L)_c \times \text{Post}_t$	0.021**	0.024**	0.015**	2.356***	0.032***	0.025***
	(0.010)	(0.010)	(0.007)	(0.708)	(0.011)	(0.009)
Women (31–59) $\times \log(\text{Light}/L)_c \times \text{Post}_t$	-0.025**	-0.026**	-0.013*	-2.347***	-0.041***	-0.019*
	(0.010)	(0.011)	(0.008)	(0.766)	(0.012)	(0.011)
Men (18–30) $\times \log(\text{Light}/L)_c \times \text{Post}_t$	-0.024**	-0.032***	-0.007	-3.394***	-0.010	-0.015
	(0.011)	(0.011)	(0.011)	(0.838)	(0.013)	(0.015)
Men (31–59) $\times \log(\text{Light}/L)_c \times \text{Post}_t$	-0.016	-0.020*	-0.016**	-1.616*	-0.025**	-0.016
	(0.010)	(0.011)	(0.007)	(0.817)	(0.012)	(0.011)
City FE	Y	Y	Y	Y	Y	Y
Year FE	Y	Y	Y	Y	Y	Y
Baseline×Year dummies	Y	Y	Y	Y	Y	Y
Individual controls	Y	Y	Y	Y	Y	Y
Observations	55,989	55,989	56,943	45,276	56,312	56,220
R-squared	0.185	0.184	0.093	0.181	0.055	0.044

Notes: This table uses individual-level data on respondents aged 18–59 from the CFPS, 2014–2020. We estimate a full interaction model to test for heterogeneous effects across gender and age groups (young: 18–30; prime-age: 31–59). With young women as the reference group, the first row reports their specific treatment effect, while the triple interaction terms in the subsequent rows report the differential effects for the other three groups relative to young women. The dependent variables are defined as follows: Column (1) uses an indicator for labor force participation; Column (2) uses an employment indicator (including being temporarily away from work); Column (3) uses an indicator for evening or night-shift work; Column (4) uses weekly hours worked (winsorized at the 99.5th percentile within each survey year to limit the influence of extreme values); Column (5) uses an indicator for generalized trust (whether the individual believes that most people can be trusted); and Column (6) uses an indicator for perceived helpfulness (whether the individual believes that most people are helpful rather than selfish). $\log(\text{Light}/L)_c$ is the log of the cumulative number of street-lighting procurement contracts per 1,000 residents through the end of 2015. Post_t equals one for 2017 and subsequent years and zero otherwise. All specifications control for city and year fixed effects, baseline log GDP per capita and population density (measured in 2013) interacted with a full set of year indicators, and individual controls including age, ethnicity, marital status, health status, educational attainment, urban/rural residence, and household income. Standard errors clustered at the city level are reported in parentheses. *** p<0.01, ** p<0.05, * p<0.1.

B Figure Appendix

Figure B.1: Distribution of Placebo Estimates from the Falsification Test



(A) Visibility-sensitive offenses (cases) (B) Visibility-sensitive offenses (offenders)

Notes: This figure presents the kernel density of estimated coefficients from 500 placebo simulations in which treatment intensity is randomly assigned across cities. Panel A uses the number of visibility-sensitive criminal cases per 1,000 residents as the dependent variable, while Panel B uses the number of offenders in these cases per 1,000 residents. The vertical lines denote the baseline estimates reported in Columns (2) and (6) of Table 2.

C Policy Background

This appendix provides additional details on the 2015 revision of China's national street lighting standard. The *Standard for Lighting Design of Urban Road* (CJJ 45-2015) was issued on November 9, 2015 and took effect on June 1, 2016, replacing CJJ 45-2006.[35] Under China's government procurement framework, government-procured projects must comply with applicable national and industry standards. As a national industry standard, CJJ 45-2015 therefore establishes the technical requirements for the design, construction, and acceptance of government-procured street-lighting projects, including new construction, expansions, and renovations. The revision is a multifaceted upgrade of lighting requirements for motor-vehicle routes, pedestrian and bicycle routes, and road-related public spaces.

C.1 Motor-Vehicle Route Lighting

We begin by describing how CJJ 45-2015 revises the lighting requirements for motor-vehicle routes. Table C.1 summarizes the lighting requirements specified in CJJ 45-2015 for motor-vehicle routes on urban freeways, arterial roads, secondary arterial roads, and branch roads, where values separated by a slash denote the lower and higher tiers of lighting requirements, respectively. The standard specifies seven design parameters: the average road-surface luminance, the overall uniformity of luminance, the longitudinal uniformity of luminance, the average road-surface illuminance, the uniformity of illuminance, glare restriction, and the surround ratio.[36] Relative to CJJ 45-2006, CJJ 45-2015 makes two changes.

Table C.1: Lighting Requirements for Motor-vehicle Routes under CJJ 45-2015

Class	Road Type	Road Surface Luminance			Road Surface Illuminance		Glare	Surround Ratio
		Average Luminance (cd/m^2) Maintained	Overall Uniformity Minimum	Longitudinal Uniformity Minimum	Average Illuminance (lx) Maintained	Uniformity Minimum	Threshold Increment (%) Maximum init.	Minimum
I	Freeways and arterial roads	1.5/2.0	0.4	0.7	20/30	0.4	10	0.5
II	Secondary arterial roads	1.00/1.50*	0.4	0.5	15/20*	0.4*	10	0.5
III	Branch roads	0.5/0.75	0.4	—	8/10	0.3	15	—

Notes: Values separated by a slash (e.g., 1.5/2.0) denote lower and higher tiers of lighting requirements. Asterisks mark the parameters revised in CJJ 45-2015 relative to CJJ 45-2006.

Lighting requirements. It raises the lighting requirements for the motor-vehicle routes of secondary arterial roads. Roads of this class connect arterial roads and branch roads, typically

[35] The full text of the revised standard is available at the Ministry of Housing and Urban-Rural Development website: https://www.mohurd.gov.cn/ (last accessed August 2026).

[36] *Luminance* refers to the amount of light reflected from the road surface toward an observer's eye and captures how bright the road appears to drivers. *Illuminance* refers to the amount of light falling on the road surface per unit area. The *surround ratio* measures lighting conditions in the area adjacent to the carriageway. A higher surround ratio improves visibility near the road edge and helps drivers detect pedestrians, cyclists, and other potential hazards.

carry substantial traffic, and serve adjacent commercial and residential activities. Moreover, they often have less complete infrastructure and more mixed traffic involving motor vehicles, bicycles, and pedestrians. Compared with CJJ 45-2006, CJJ 45-2015 raises the maintained average illuminance for this road class from 10/15 lx (lower/higher tier) to 15/20 lx, increases the maintained average luminance from 0.75/1.00 cd/m^2 to 1.00/1.50 cd/m^2, and raises the minimum illuminance uniformity from 0.35 to 0.4.

Classification scheme. The standard changes the criteria for selecting the lower and higher tiers within each road class. Under CJJ 45-2006, this selection was based primarily on the city's characteristics and scale. CJJ 45-2015 instead links it to traffic volume, aligning lighting requirements more directly with traffic intensity.

C.2 Pedestrian and Bicycle Route Lighting

For pedestrian and bicycle routes, the changes in CJJ 45-2015 are as follows:

Lighting requirements. Building on the three illuminance criteria specified in CJJ 45-2006, namely average horizontal illuminance, minimum horizontal illuminance, and minimum vertical illuminance (Table C.2), CJJ 45-2015 introduces broader lighting requirements.

First, the standard upgrade introduces a minimum semi-cylindrical illuminance requirement (Column 4 of Table C.3). Semi-cylindrical illuminance measures the light incident on a vertical half-cylinder oriented toward an approaching observer, and it captures the illumination available for recognizing facial features and identifying approaching individuals at a distance (Caminada and Van Bommel, 1984; Rombauts et al., 1989; Van Bommel, 2014).

Second, the standard raises the minimum vertical illuminance requirements (Column 3 of Table C.3). Vertical illuminance quantifies the light falling on vertical surfaces and thus determines how well pedestrians can perceive upright objects in their surroundings; it also supports facial recognition (Boyce and Rea, 1990; Edwards and Gibbons, 2008; Van Bommel, 2014).

Third, the standard imposes new glare limits (Table C.4), specifying maximum luminous intensity at high emission angles ($\geq 70°$, $\geq 80°$, $\geq 90°$, and $> 95°$). By restricting upward and high-angle light emissions, these limits reduce visual discomfort, attenuate disability glare, and improve effective visibility for both pedestrians and drivers while also mitigating light pollution.

Fourth, to conserve energy and reduce light pollution without compromising safety, the standard slightly adjusts the requirements for average and minimum road surface illuminance (Table C.3).

Classification scheme. CJJ 45-2006 classified pedestrian and bicycle routes jointly by functional zone (commercial versus residential) and by pedestrian flow (high, medium, or low), and set lower and higher requirement tiers accordingly (Table C.2). CJJ 45-2015 replaces this with a single classification based on pedestrian flow, supplemented by a separate category for commercial pedestrian streets and commercial areas (Table C.3), thereby aligning lighting

requirements more closely with actual usage intensity.

Table C.2: Lighting Requirements for Pedestrian and Bicycle Routes under CJJ 45-2006

Nighttime Pedestrian Flow	Area	Average Road Surface Illuminance Maintained	Minimum Road Surface Illuminance Maintained	Minimum Vertical Illuminance Maintained
High-flow roads	Commercial	20	7.5	4
	Residential	10	3	2
Medium-flow roads	Commercial	15	5	3
	Residential	7.5	1.5	1.5
Low-flow roads	Commercial	10	3	2
	Residential	5	1	1

Table C.3: Lighting Requirements for Pedestrian and Bicycle Routes under CJJ 45-2015

Class	Road Type	(1) Average Road Surface Illuminance Maintained	(2) Minimum Road Surface Illuminance Maintained	(3) Minimum Vertical Illuminance Maintained	(4) Minimum Semi-cylindrical Illuminance Maintained
1	Commercial pedestrian streets; roads with high pedestrian traffic in downtown or commercial areas; mixed-use entrance roads of residential areas connected to urban motorways	15	3	5	3
2	Roads with relatively high traffic flow	10	2	3	2
3	Roads with moderate traffic flow	7.5	1.5	2.5	1.5
4	Roads with relatively low traffic flow	5	1	1.5	1

Table C.4: Glare Limits for Pedestrian and Bicycle Routes under CJJ 45-2015

Class	Maximum Luminous Intensity $I_{\max}$ (cd/1000 lm)			
	$\geq 70^\circ$	$\geq 80^\circ$	$\geq 90^\circ$	$> 95^\circ$
1	500	100	10	< 1
2	–	100	20	–
3	–	150	30	–
4	–	200	50	–

C.3 Expanded Coverage of Road-Related Public Spaces

Beyond raising lighting requirements on the roadways themselves, CJJ 45-2015 widens the set of road-related public spaces subject to lighting regulation. First, it introduces new lighting requirements for facilities that were previously uncovered, including elevated roads, public parking facilities, bus stops along transit routes, dedicated roadside parking bays, and urban

tunnels. Second, it revises and strengthens existing provisions for grade-separated interchanges, pedestrian underpasses, waterfront roads, tree-lined roads, residential-area roads, and pedestrian crossings. Because these spaces are precisely the places where pedestrians wait, walk, and transfer, extending the standard to them improves visibility in locations that were previously dark, even where the adjacent roadways are well lit.

CJJ 45-2015 also revises the operating rules for street-lighting systems. Whereas CJJ 45-2006 required lighting systems to be switched on when natural illuminance fell to 15 lx, CJJ 45-2015 raises this threshold to 30 lx for urban freeways and arterial roads, and 20 lx for secondary and branch roads.

C.4 Others

Finally, CJJ 45-2015 expands the range of permitted lighting technologies and strengthens energy-efficiency requirements. It explicitly permits light-emitting diode (LED) sources for street lighting, provided that both the LED sources and luminaires meet specified performance standards. At the same time, it lowers the maximum allowable lighting power density (LPD), which caps electricity consumption per unit of illuminated road area.