Dear Selection Committee,

I am writing to express my enthusiastic interest in the Review of Economics and Statistics Fellowship in connection with the NBER Summer Institute. I received my PhD in Economics from the University of Technology Sydney in 2020, and my research lies at the intersection of health economics, law and economics, and applied econometrics. I am particularly drawn to the sessions on Economics of Crime and Economics of Health—areas where my work contributes a distinctive interdisciplinary lens grounded in empirical rigour.

My perspective is shaped by deep domain expertise in addiction policy, pharmacological knowledge of opioids, and extensive experience in evaluating health interventions using quasi-experimental methods. For example, my recent work includes a study forthcoming in *The Journal of Law and Economics* that investigates the long-term effects of Australia's heroin drought using a triple-difference design informed by addiction science. Another paper, published in *Economic Inquiry* (2025), revisits and extends prior work on naloxone access laws, combining economic modelling with pharmacological insights to assess policy impacts on opioid-related ER admissions. Both studies reflect my broader commitment to using tools from economics to inform and evaluate pressing public health challenges.

Alongside my economics work, I am part of the Faculty of Medicine and Health at the University of Sydney, where I collaborate closely with clinicians, NSW Health, and public health researchers. I currently work within a clinical trial centre and have contributed as a lead analyst on multiple trials, including the *ENCORE Trial*—a national cluster-randomised trial published in the *International Journal of Nursing Studies* (2024). My ongoing work also involves Bayesian trial design and the integration of economic evaluation within clinical research pipelines. I serve on the editorial board of the *International Journal of Drug Policy*, which reflects my active role in interdisciplinary health policy discourse.

My broader research program includes work on randomised judicial assignment and drug sentencing (*JEBO*, 2022), spatial effects of supervised injection rooms (*Regional Science and Urban Economics*, 2023), and the role of imputed rents in intergenerational mobility (*Journal of Housing Economics*, 2020). A methodological paper currently under review at *Nature Communications* introduces robust inference tools for cluster

trials, contributing to the advancement of empirical techniques used widely in health and policy economics.

I am excited by the opportunity to engage with the NBER Summer Institute community and to contribute to sessions that marry applied microeconomics with pressing policy issues. I believe my background, spanning economics, public health, and clinical trials, equips me to offer a distinctive, practice-informed perspective that complements the Institute's tradition of empirical excellence.

Thank you for your time and consideration.

Warm regards,

Sergey Alexeev

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Sergey Alexeev

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Main research interests

Microeconomist with experience in clinical trials, biostatistics and quasi-experiments.

Formal education

PhD in Economics 2015 – 2020
University of Technology Sydney (UTS)
Committee: Prof Siminski P., Prof Hafalir I., Dr Tomoeda K., A/Prof Stavrunova O.
Examiners: Prof Walker I., Prof Foster G.

Master's in Economics 2013 – 2014
York University

Master's in Finance 2009 – 2011
University of Paris Dauphine

Bachelor's in Finance (Honours) 2005 – 2009
Graduate School of Management (GSOM), Saint Petersburg State University (SPbU)
Exchange semester at the University of Dublin, Trinity College

Publications

Dual-edged benefits of drug policing: a quarter century's lesson from a heroin drought
The Journal of Law and Economics (with Prof Weatherburn D.) 2026

A closer look at Doleac and Mukherjee (2022) and the effects of naloxone access laws on opioid ER admissions
Economic Inquiry 2025

Transforming nursing assessment in acute hospitals: A cluster randomised controlled trial of an evidence-based nursing core assessment (the ENCORE trial)
International Journal of Nursing Studies (with Prof Douglas C. et al.) 2024

Harm reduction or amplification? The adverse impact of a supervised injection room on housing prices
Regional Science and Urban Economics (with Dr Liang J.) 2023

Wage equation misrepresents gay wage discrimination: overlooked evidence from Russia
International Journal of Manpower 2022

Fines for illicit drug use do not prevent future crime: evidence from randomly assigned judges
Journal of Economic Behavior and Organization (with Prof Weatherburn D.) 2022

Technical change and wage premiums amongst skilled labor: evidence from the economic transition
Economics of Transition and Institutional Change 2022

Changes in and correlates of Australian public attitudes toward illicit drug use
Drug and Alcohol Review (with Prof Weatherburn D.) 2022

The Australian ready-to-drink beverages tax missed its target age group
International Journal of Drug Policy (with Prof Weatherburn D.) 2021

The role of imputed rents in intergenerational income mobility in three countries
Journal of Housing Economics 2020

Selected works under review

Cluster trials inference with CARE
Nature Communications (under review; with Prof Morton R.)

Further findings on the intergenerational transmission of alcohol consumption
Health Economics (R&R)

Cannabis use worsens the gender pay gap
Journal of Population Economics (R&R)

Editorial, reviewer roles and memberships

Editorial Board Member: International Journal of Drug Policy

Memberships: Sigma X (invited), Econometrics society

Reviewer: International Journal of Manpower; International Journal of Public Opinion Research; Journal of Economic Behavior & Organization; International Journal of Drug Policy; American Economic Review

Computer literacy

R; Stata; Python; SQL; Gauss; Matlab; Mathematica; Unix; LaTeX; MS Office Suite

Selected media coverage (click here for more)

Richmond injecting room shaved $60,000 off nearby house prices: study The Age	2023
Richmond's controversial supervised injecting room becomes permanent 7NEWS (TV interview)	2023
Support for legalising marijuana in Australia nearly doubles over six years Theguardian.com	2021
COVID-19 and Australia's housing crisis: how the intergenerational impact can go undetected Austaxpolicy.com	2021
Australia's current alcohol tax system impedes public health policy Austaxpolicy.com	2021
Comparing the effects of homeownership on intergenerational income mobility Voxeu.org	2019

Recent employment

Senior Research Fellow: University of Sydney (USYD)	07/2022 – now
Research Fellow: University of New South Wales (UNSW)	03/2020 – 07/2022
Australian Postgraduate Researcher (APR): NSW Department of Education	08/2019 – 01/2020
Casual Academic/Research Assistant: UTS	08/2016 – 02/2020
Private Tutor	08/2015 – 06/2016
Tutor: GSOM, SPbU	08/2014 – 06/2015
Teaching Assistant: York University	09/2013 – 06/2014

Selected grants

Vaccination uptake using modern peer effect models (Partnership with NSW Health)
The Health Outcome and Post-incarceration Evaluation (https://hope.alexeev.pw/)
Improved Analytical Tools for Innovative Randomised Experiments (DECRA)

Accepted presentations

2022: USYD (Business School, MPP seminar); UNSW (NDARC, seminar)
2023: ANU (TTPI, seminar); Unimelb (MSPGH, seminar); Unimelb (HILDA Conference); SPbU (Economy & Management Conference); UNSW (CEPAR, seminar); Deakin (14th APCC, paper accepted)
2024: UTS (AGEW24, workshop); Monash (13th AusWEHE, workshop); Edinburgh (ICTMC, poster accepted); Sydney (45th AHES, paper accepted); Brisbane (13th HSR, poster accepted)
2025: UOW (AGEW25, paper accepted)

Referees

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John Smithin: Professor Emeritus, York University	JSmithin@yorku.ca
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Dual-edged benefits of drug policing: a quarter century's lesson from a heroin drought

Keywords: Heroin Shortage | Supply-Side Drug Policies | Crime Deterrence | Addiction | Triple Difference Design | Harm Reduction | Becker-Murphy Model
JEL: I18 | K42 | H76 | D12 | C21 | C23 | J18

Sergey Alexeev[a,1] and Don Weatherburn[b]

The paper is accepted for publication in *The Journal of Law and Economics*
First draft: June 1, 2022 | Current version: February 10, 2025 | Latest version: here | Bibtex to copy

We develop a strong triple difference design, with variation across crimes and areas, to quantify the impact of Australia's 2001 heroin shortage on crime, providing precise and uniform evidence on both the immediate and long-term effects of drug law enforcement. Applying the design to 25 years of monthly postcode data, we show that crime experiences an 8.4% surge in the first month, followed by a 1% decrease every 13 months, resulting in a cumulative 22% reduction over 18 years. This translates to an annual saving of approximately AUD 2.21 billion from crimes averted, highlighting that the benefits of supply-side drug policies are significant and often underestimated due to their delayed realization. We conclude that supply-side policies have a more substantial role in reducing drug-related harm than is conventionally assumed.

Significance Statement

This study delivers the most comprehensive empirical evaluation of the Australian heroin shortage to date, leveraging 25 years of complete crime incident data and a robust triple-difference design. By precisely isolating both immediate and long-term effects, our findings reveal that sustained supply-side interventions can achieve significant reductions in drug-related crime and generate substantial societal benefits. These results challenge prevailing assumptions about the limitations of drug law enforcement, offering valuable insights for policymakers navigating the complex trade-offs between prevention and harm reduction strategies.

1. Introduction

The 2001 Australian heroin shortage stands as a landmark natural experiment for understanding how drug markets shape human behavior. Around Christmas 2000, heroin purity plummeted by over 75%, prices tripled, and overdose deaths fell by 64% nationwide — a shockwave that permanently disrupted one of the world's most entrenched illicit markets (Weatherburn et al. 2003; Weatherburn and Rahman 2021). This unprecedented shortage was largely attributed to a law enforcement effort, which successfully disrupted heroin supply chains (Degenhardt et al. 2005). Unlike transient drug busts or localized crackdowns, this was a sustained, nationwide supply reduction with effects lasting years. For social scientists, it presents a rare opportunity to test foundational theories across disciplines.

For economics, the question is whether a permanent drug price shock alters addictive behavior. Becker and Murphy's (1988) rational addiction model suggests that addicts respond only to lasting price shifts, but real-world tests of this theory are scarce. For criminology, the focus is on whether supply-side interventions reduce crime or merely displace it. Critics argue that crackdowns shift crime spatially or temporally (Mazerolle, Soole, and Rombouts 2006), but Australia's isolation prevented a supply rebound, allowing for the isolation of deterrence effects. For addiction science, the inquiry is whether supply shocks can disrupt addiction cycles. While harm reduction strategies like supervised injection sites save lives, they rarely curb overall use (Marshall et al. 2011). However, Australia's shortage saw a 37% surge in treatment admissions, challenging the prevailing emphasis on harm reduction over prevention (Degenhardt, Day, and Hall 2004).

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Declarations of interest: none

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Despite its significance, the shortage has largely escaped rigorous econometric scrutiny. For decades, studies relied on fragmented crime proxies or simplistic time-series models, producing equivocal conclusions about its societal impact (Appendix B, Moore and Schnepel 2021). Only recently has this begun to change. Moore and Schnepel (2024) (henceforth MS) broke new ground by applying contemporary quasi-experimental methods to the shortage. Their effort is commendable, yet their working paper piqued our interest for their choice of data. Rather than using reported crime statistics, they rely on the NSW Reoffending Database (ROD, Hua and Fitzgerald 2006).

As the name suggests, the ROD was explicitly designed to study recidivism, tracking individuals — not crimes — over time. Its hierarchical structure records only the most severe charge per court case, omitting ancillary offenses. For instance, a defendant prosecuted for homicide after committing a robbery to fund drug use would appear in the ROD solely as a homicide statistic. This design choice, while logical for analyzing reoffending, renders the database ill-suited for studying crime incidence. It systematically excludes the very offenses — theft, burglary, fraud — most tightly linked to heroin dependency, truncating the empirical picture of drug-related crime.

Even more critically, the study equates prosecutions with crime frequency — a fraught assumption. Prosecutions depend not only on underlying crime rates but also on investigative capacity and forensic advancements. Many crimes — indeed, most for some crime types — are left unsolved. The number of prosecutions reflects not just criminal activity but also the ability of police to identify suspects and gather sufficient evidence. Around the time of the heroin shortage, New South Wales (NSW) implemented mandatory DNA testing for prison inmates (Dunsmuir et al. 2008), a policy mirrored in U.S. states (Doleac 2017). This reform dramatically increased clear-up rates for crimes like robbery and break-and-enter, decoupling prosecution trends from actual offending.

The divergence is stark. Between 2004 and 2008, robbery prosecutions rose by 39.6% even as reported incidents fell by 10.8%; burglary prosecutions climbed 4.9% while recorded offenses dropped by 41.4%. Some trends are illustrated in Figures 1 to 3, which plot the contrasting trajectories of reported crimes and prosecutions for burglary, theft, and robbery. The widening gap reflects shifts in policing — not criminal behavior — yet MS treat prosecutions as a neutral proxy for crime.

Figure 1. Divergence of reported and prosecuted crimes — burglaries

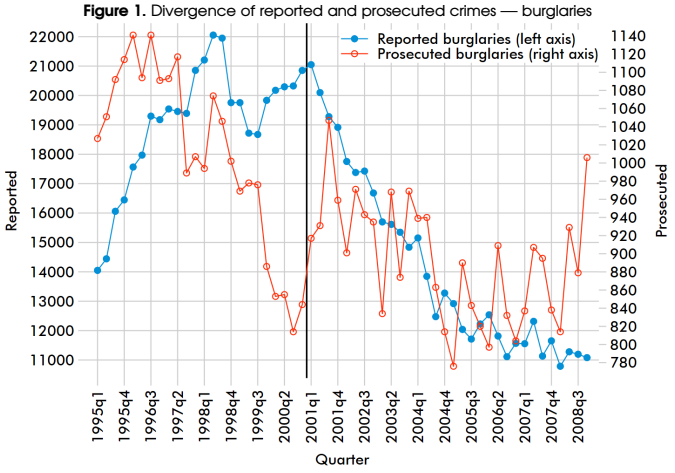


Figure 2. Divergence of reported and prosecuted crimes — thefts

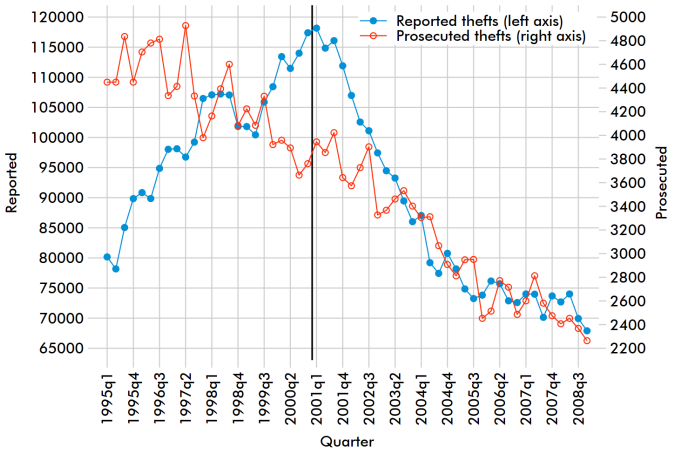
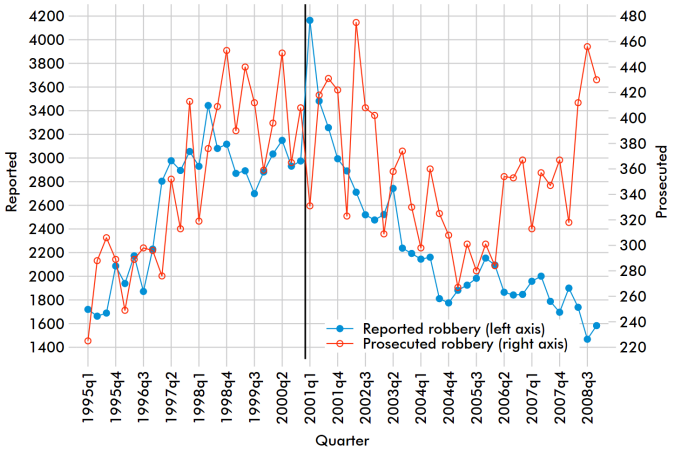


Figure 3. Divergence of reported and prosecuted crimes — robbery



Notes: The figure plots the total number of reported (left axis) and prosecuted (right axis) crimes. The vertical line indicates the onset of the shortage.
Source: BOCSAR reported and cleared crime data: 1995q1 – 2008q4.

This paper complements and extends MS. While their study relies on ROD, designed to track recidivism, we draw on the complete record of crime incidents maintained by the same agency — the NSW Bureau of Crime Statistics and Research (BOCSAR). By selecting the dataset best suited to our research question, we avoid the truncation bias inherent to the ROD and provide a more comprehensive picture of the heroin shortage's effects. Our dataset captures all reported crimes at the postcode level over 25 years, regardless of investigative outcomes, ensuring a comprehensive and unbiased view of criminal behavior during and after the shortage.

By combining this high-quality data with a novel triple difference (TD) design, we disentangle the immediate displacement effects of the shortage — such as short-term crime spikes as users sought alternative means to fund their addiction — from its long-term deterrence benefits, including sustained reductions in crime as users entered treatment or reduced consumption. Our TD design, informed by criminological theory, addiction science, and institutional knowledge of the heroin shortage, leverages spatial and crime-type variations to isolate causal effects with precision. This approach builds on and refines prior research, offering the most rigorous empirical framework to date for evaluating supply-side drug policies.

The Australian heroin shortage is arguably the best natural experiment for studying supply-side drug policies, and our study provides the most definitive examination of its impacts. By integrating a high-quality natural experiment, a comprehensive crime dataset, and a strong research design, we establish a new benchmark for assessing the long-term efficacy of drug policy interventions. Our results demonstrate that supply-side strategies, when evaluated rigorously and sustained over time, can yield significant societal dividends. This contribution underscores the importance of matching data and methodology to the research question and highlights the value of interdisciplinary collaboration in understanding drug policy impacts and institutional dynamics.

2. Theoretical considerations

A. The microeconomic perspective. In their rational account of drug use, Becker and Murphy (1988) framed addiction as a forward-looking optimization problem. Utility from an addictive good, $c(t)$, depends on its consumption and the level of addiction, $S(t)$. Addiction evolves as $\dot{S}(t) = c(t) - \delta S(t)$, increasing with consumption and declining when use stops. Users balance addictive and non-addictive goods while discounting future utility in a standard manner. The key insight is that users treat addictive goods like any other good with intertemporal utility, adjusting consumption based on current and anticipated future prices. A central policy insight from the model is that users respond to permanent price changes, implying that temporary policies like police crackdowns, which only increase current prices, do not decrease usage. Such measures might even reduce future prices by encouraging stockpiling, thus having little to no impact on drug use, unlike permanent interventions (Becker, Grossman, and Murphy 2017).

The rational addiction model overlooked certain addiction behaviors. Wertenbroch (1998, 2003) pointed out that rational, time-consistent addicts should buy in bulk for efficiency, yet they often buy small amounts to control consumption. Gruber and Kőszegi (2001, 2004) extended the rational model to include time-inconsistent users who desire to quit but lack willpower. Unlike Becker and Murphy (1988), where higher prices harm users' welfare, in these models, they benefit by aiding self-control, as evidenced by Gruber and Mullainathan (2005) showing cigarette taxes increase smoker happiness. Other research has questioned the assumption that individuals with substance use disorders start with full awareness of consequences (Slovic 2000b, 2000a; Kip Viscusi 2000). Loewenstein (1999) demonstrated that potential users underestimate addiction risk due to underrating craving's power. Consequently, Laibson (2001) and Bernheim and Rangel (2004) introduced models with cue-conditioned craving, where environmental triggers cause craving spikes in ex-addicts (i.e., an increase in $S(t)$). This aligns with the post-shortage surge in treatment admissions, as reduced triggers and the price increase prompt re-optimization of long-term drug use.

Focusing on the heroin shortage, the uniform prediction from these models is that a permanent increase in heroin prices will not lead to an immediate reduction in consumption. For some time, drug users will exhibit price inelasticity, continuing their consumption levels due to addiction ($\delta > 0$). However, after realizing the price increase is permanent and the ongoing consumption is unsustainable, they will re-optimize and reduce use. While the rational theory does not specify the duration of this inelastic period, literature on withdrawal (Haskell 2022) suggests that for heroin, this inelasticity might last up to two months, after which the most acute craving subsides. Thus, the effect of the heroin shortage will manifest a bidirectional dynamic. In the first two months, we might expect to see effects in the opposite direction of what long-term price increases would predict.

B. The criminological perspective. The rational theory of addiction does not directly address heroin's impact on crime or the specific offenses committed by heroin users. However, Goldstein (1985), writing three years earlier, introduced a framework distinguishing the psychopharmacological and economic-compulsive effects of drug use. Heroin stands out within this framework as a drug with distinct behavioral consequences along these dimensions.

Pharmacological effects refer to crimes directly caused by the ingestion of specific substances. For instance, alcohol consumption, shown in experimental studies to increase aggression (Exum 2006), has also been consistently linked to violence in observational research. Prolonged use of psychostimulants, like cocaine and methamphetamine, similarly heightens aggressive and violent behavior (McKetin et al. 2020; McKetin et al. 2014; Darke, Lappin, and Farrell 2019). In contrast, heroin, as a depressant, rarely induces violence except during withdrawal. Economic-compulsive effects refer to crimes committed to fund drug purchases, including theft, robbery, shoplifting, fraud, motor vehicle theft, and, in some jurisdictions, sex work. These offenders align most closely with the rational model of addiction, which depicts drug users as forward-looking agents optimizing consumption. Economic-compulsive offenders must secure sufficient income to sustain their addiction.

In-depth interviews reveal three key facts: firstly, heroin's incapacitating effects make functional use challenging, with no users meeting controlled substance use criteria, leading to financial instability without stable employment (Draus, Roddy, and Greenwald 2010); secondly, dependent users must inject heroin two to three times a day, all year round, which is very expensive (Dobinson and Poletti 1988); and thirdly, users acknowledge that these circumstances lead them to commit property crimes to sustain their drug use (Sutherland et al. 2015).

This pattern is consistent across various studies: dependent heroin users commit more instrumental crimes on days they use heroin (Ball et al. 1982; Ball, Shaffer, and Nurco 1983). Property crime arrest rates drop for heroin users in opioid replacement therapy (Lind et al. 2004; Bukten et al. 2013). Silverman and Spruill (1977) linked higher heroin prices to increased property crimes like robbery and burglary, with similar findings in other time series analyses (Chilvers and Weatherburn 2003; Morgan 2014). It follows that the impact on instrumental crime of changes in heroin price, purity and availability should be larger.

3. Methods and data

A. Empirical Design. To establish a credible counterfactual for evaluating both the short-term and long-term effects of the Australian heroin shortage on crime, we employ a TD approach leveraging variation across postcodes, crime types, and time. We distinguish between postcodes with high historical levels of heroin use (treated areas) and those with low levels (comparison areas). Our key innovation is the separation of instrumental crimes (committed for financial gain) from expressive crimes (motivated by emotional release) within each postcode, a distinction rooted in classic criminological theories (e.g., Feshbach 1964; Youngs, Ioannou, and Eagles 2016).

As initially postulated by Goldstein (1985) and reviewed earlier, heroin, being a central nervous system depressant, does not prompt users to engage in expressive crimes during intoxication, unlike psychostimulant intoxication.

Instead, heroin users predominantly engage in instrumental crimes due to the drug's high cost, second only to cocaine. They typically prefer non-violent acquisitive crimes to avoid the risk of incarceration, which would cut off their drug supply.

Previous studies on the Australian heroin shortage (Moffatt et al. 2005; Chilvers and Weatherburn 2003; Conroy and Degenhardt 2004) corroborate these observations, showing no significant impact on violent crimes such as homicide or assault but clear effects on robbery and property crimes. This real-world behavior is also archetypically reflected in 'The Wire,' a show renowned for its accurate depiction of drug and crime issues within the complex institutions of modern cities. Characters like John and Bubbles epitomize the everyday knowledge among specialists in clinical and law enforcement settings, routinely engaging in instrumental crimes like theft to sustain their heroin use but never resorting to violent crimes.

This design addresses limitations inherent to simpler difference-in-differences (DD) strategies, which fail to account for unobserved heterogeneity such as postcode-level cultural norms toward violence, time-varying economic conditions, or spatial differences in drug market dynamics (e.g., competing drug availability). For instance, a DD comparing high- versus low-heroin-use postcodes could conflate the shortage's effects with static spatial differences (e.g., subcultures normalizing property crime), dynamic confounders (e.g., localized policing surges), or substitution effects from markets with easier access to methamphetamine. By introducing a third dimension the TD design differences out these sources of bias.

The TD design neutralizes unobserved spatial heterogeneity: even if high-heroin postcodes exhibit unique cultural or economic conditions (e.g., normalized acquisitive crime), these static differences are differenced out by comparing relative changes between instrumental and expressive crimes within postcodes over time. Seasonal trends (e.g., summer spikes in theft) or policy shocks (e.g., DNA testing reforms) are absorbed through postcode-by-month and crime-type-by-month fixed effects, ensuring identification relies solely on the heroin shortage's differential impact on economically motivated offenses.

As another example, consider a hypothetical scenario where high-heroin postcodes coincidentally have easier access to methamphetamine substitutes. While such markets could theoretically alter crime patterns (e.g., increased stimulant-driven violence), our postcode-by-crime-type fixed effects absorb time-invariant differences in how local drug markets influence specific crime categories. The design isolates the heroin shortage's differential impact over time by focusing on relative changes between instrumental and expressive crimes within postcodes, regardless of baseline drug availability. This ensures that persistent spatial differences — whether in cultural norms, policing practices, or substitute drug markets — are differenced out.

A third example is spillover effects — such as displaced criminal activity from high- to low-use areas — that would violate DD's stable unit treatment value assumption. Our TD design is robust to these limitations by exploiting the additional crime-type contrast. For example, if gentrification reduced property crime generally in high-heroin areas, this trend would equally affect instrumental and expressive crimes, differencing out in the TD estimator. Similarly, localized policing efforts likely influence both crime types proportionally, leaving the relative effect on instrumental crimes intact.

This logic of a looser association between heroin use, violence, and differential spatial exposure has also been effectively utilized within a TD framework by Alexeev (2025), building on the observation by Doleac and Mukherjee (2022) that violence is not typically an expected outcome of opioid abuse.

B. Data. The monthly crime data used in this study spans 456 unique postcodes from January 1995 to December 2019. These data were sourced from the NSW BOCSAR (2022a), with population figures provided by the Australian Bureau of Statistics. Table 1 presents descriptive statistics, categorizing crimes into instrumental and expressive

types, with classifications informed by consultations with NSW criminal lawyers and BOCSAR specialists. Detailed definitions of specific crimes, along with legal notes, are available on the BOCSAR glossary website (2022b).

The key criterion here is that the crimes we count as expressive are rarely committed as a source of income, whereas the crimes we count as instrumental are (in Australia) quintessentially committed to raising cash or exchange for drugs. We exclude prostitution from our analysis since, in NSW, soliciting prostitution is legal, provided through a regulated industry that ensures drug-free services, thus removing the opportunity for drug users to engage in this market to fund their habits. The descriptive statistics highlight the prevalence of zeros at our spatial level. This granularity results in the rarity of reported crimes for the types studied, reflecting that, at such a refined spatial scale, crime occurrences are inherently sparse — a phenomenon likely true for any crime type at this level.

Table 1. Descriptive statistics

	N	Min	Med	p75	p95	p99	Max	Mean ↓	SD
Expressive crimes									
Manslaughter	114,204	0	0	0	0	0	7	0.002	0.05
Attempted murder	114,204	0	0	0	0	1	7	0.012	0.118
Domestic violence	114,204	0	3	6	17	32	113	4.798	6.656
Non-domestic violence	114,204	0	4	9	24	48	191	6.931	10.653
Malicious damage to property	114,204	0	11	22	52	94	288	16.667	19.076
Instrumental crimes									
Robbery with a firearm	114,204	0	0	0	1	2	13	0.113	0.435
Robbery with a weapon not a firearm	114,204	0	0	0	2	5	47	0.441	1.341
Robbery with other weapon	114,204	0	0	1	4	10	104	0.774	2.279
Receiving or handling stolen goods	114,204	0	0	2	7	17	159	1.596	3.884
Steal from person	114,204	0	0	2	7	18	486	1.921	10.266
Steal from retail store	114,204	0	1	4	20	45	187	4.348	9.611
Steal from dwelling	114,204	0	3	6	16	26	68	4.782	5.474
Break and enter no-dwelling	114,204	0	2	6	19	38	180	5.161	8.247
Other theft	114,204	0	4	9	27	55	857	8.261	20.303
Break and enter dwelling	114,204	0	5	13	35	64	222	10.051	13.375
Steal from motor vehicle	114,204	0	6	14	38	74	378	11.173	16.77
Total (all crime)	1,827,264	0	1	5	21	46	857	4.533	11.065

Notes: Crime counts on postcode level by crime type.
Source: BOCSAR offence data (2022a): 1995m1 – 2011m12.

C. Regression model. The heroin shortage that began in January 2001 serves as our intervention point. We implement a TD design using an exponential model estimated with the Poisson Pseudo Maximum Likelihood (PPML, Silva and Tenreyro 2022) estimator and postcode clustered errors. The model is:

$$\ln Y_{itc} = \delta_{ct} + \gamma_{it} + \upsilon_{ic} + \sum_{t \neq t'} \beta_t \left(D_i^1 \cdot D_c^2 \cdot \tau_t \right), \quad [1]$$

where Y_{itc} represents the crime count for crime type i, in month t, and postcode c. The fixed effects δ_{ct}, γ_{it}, and υ_{ic} capture postcode-month, crime-month, and crime-postcode interactions, respectively, controlling for treatment spillovers. The extensive use of these interacted fixed effects results in a total of 125,855 unique effects, calculated across 17 crime types, 300 months, and up to 456 postcodes. This computation requires approximately 20 hours on a CPU ranked in the 91.7th percentile of performance, as measured by UserBenchmark, when utilizing Stata's `ppmlhdfe` command (Correia, Guimarães, and Zylkin 2020). The treatment variable $D_i^1 \cdot D_c^2$, indicating instrumental crimes in high heroin use postcodes, is interacted with monthly indicators τ_t, excluding December 2000, allowing β_t to capture dynamic crime changes post-shortage and to test the common trend assumption.

We prefer PPML for our TD design because it relies on comparing ratios of trends rather than differences, as in the case of OLS estimator (Wooldridge 2023). In our setting, the common trend assumption is more likely to hold for ratios rather than differences. Another reason for favoring PPML is that crime is a zero-inflated limited dependent variable. While OLS remains unbiased and consistent with robust standard errors under typical conditions, it may not fully account for the nonnegative nature of the dependent variable, potentially leading to inefficiencies or predictions outside the feasible range (Ch. 18, Wooldridge 2010).

In analyzing postcode-level data, adjusting for population to infer individual effects is often preferred. PPML inherently weights observations by variance, making additional population weighting redundant, which is another advantage of PPML in our context (Charnes, Frome, and Yu 1976). For this reason, Stata does not allow analytical weights for PPML. Including population as a covariate also leads to collinearity with area-month effects, given that the population remains constant conditional on these effects. Finally, our TD approach identifies the average treatment

effect on the treated. As instrumental crimes are likely to bear the full effects of the shortage, we may also be identifying the average treatment effect of the shortage on crime.

4. Identifying assumptions

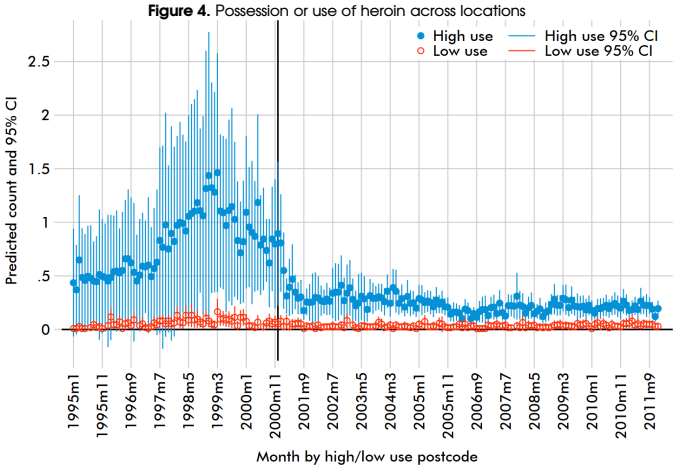
A. Separating postcodes. Our TD design requires us to separate postcodes into high and low-heroin-use areas. The advantage of our setting is that it has been well-established that in NSW, there is a strong temporal association between heroin overdose rates and arrests for the use or possession of heroin (Moffatt, Wan, and Weatherburn 2012). This relationship, validated through correlations with emergency room admissions data, allows us to use arrest data as a reliable proxy for heroin use exposure.

In an ideal design, we would aim to balance treated and untreated postcodes to maximize statistical power. However, using post-treatment heroin information to define treatment would make our treatment variable endogenous, undermining causal inference. Thus, we calculate the sum of crime rates for possession or use of heroin from 1995m1 to 2000m12, prior to the heroin shortage, for each postcode. We then determine the median of this sum across all postcodes, classifying those above this median as 'high heroin use' and those below as 'low heroin use.'

To provide data-driven validation for this classification, we fit a PPML model to heroin crime data, categorizing postcodes by our high and low-use definitions. Figure 4 displays the predicted average counts of these crimes. Reassuringly, what we term Low use postcodes predict essentially zero counts of heroin-related incidents throughout the period, highlighting that all heroin use is concentrated in High use areas.

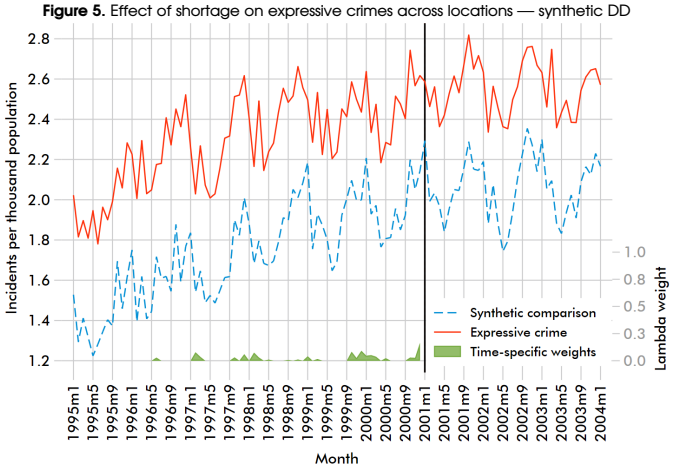
For instance, during the peak of the heroin epidemic, High use postcodes averaged up to 1.5 monthly postcode-level incidents (rising to 2.7 at the upper bound of the 95% confidence interval), highlighting a markedly distinct criminological environment. The corresponding IRR translates to roughly 650% higher crime rates, with the upper edge of the 95% confidence interval reaching an IRR of 15. The substantial variability in heroin use within high-use postcodes, as reflected by the wide confidence intervals, underscores their capacity to represent a broad spectrum of heroin use patterns. This approach credibly divides NSW into two groups: one largely untouched by heroin use and its associated challenges and the other bearing the full brunt of its impact.

Figure 4. Possession or use of heroin across locations



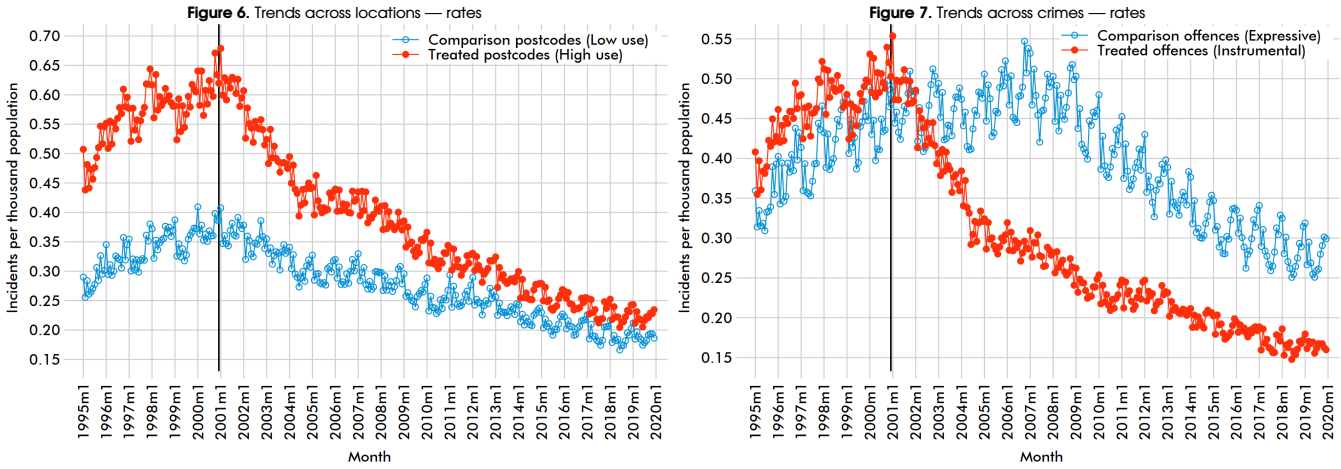
Notes: Predictions from a PPML regression of heroin crimes on treated and untreated postcodes, with interactions by monthly indicators. Population is included as a covariate, and errors are clustered at the postcode level. Black solid line indicates the heroin shortage onset.
Source: BOCSAR offence data (2022a): 1995m1 – 2011m12.

Figure 5. Effect of shortage on expressive crimes across locations — synthetic DD



Notes: Generate using statistical package by Clarke et al. (2023). Black solid line indicates the heroin shortage onset.
Source: BOCSAR offence data (2022a): 1995m1 – 2011m12.

B. Separating crimes. Having credibly identified areas to capture variation in treatment exposure, we now leverage this distinction to affirm that expressive crimes indeed serve as a reliable comparison category. The rationale that



Notes: Collapsing data into monthly rates by location (left) and crime type (right). Black solid line indicates the heroin shortage onset.
Source: BOCSAR offence data (2022a): 1995m1 – 2019m12.

expressive crimes are less influenced by the heroin shortage than instrumental crimes logically stems from the unique pharmacological and economic-compulsive effects of heroin, which affect users' behavior differently.

To provide empirical validation for this next building block of our design, we employ a synthetic DD framework (Arkhangelsky et al. 2021), which offers the most reliable estimates for shorter-term effects, while our TD approach is better suited for capturing long-term impacts due to its integration with well-understood institutional dynamics. The synthetic DD method is particularly valuable here, allowing us to validate our assumptions without relying on the TD framework itself.

In our synthetic DD analysis, the dataset was restricted to expressive crimes, with treatment units defined as those in high heroin use postcodes following the heroin shortage. Figure 5 shows that the actual time series for expressive crimes (red line) and its synthetic comparison (blue dashed line) are nearly identical, showing no change at the onset of the heroin shortage (black vertical line). The minimal time-specific weights (green area) suggest that the common trend is naturally satisfied with minimal additional modifications needed, giving further credibility to our results.

C. Examining pre-trends. We now discuss the two canonical assumptions of the TD design. First, the no-anticipation assumption — that postcodes do not adjust behavior in anticipation of the shock — holds particularly strongly in our setting. For this assumption to fail, heroin users would need to systematically anticipate the nationwide shortage and differentially adjust their behavior across postcodes and crime types in a way that mimics the bidirectional dynamics of our results. This is implausible given the sudden, unanticipated nature of the shock, which even law enforcement agencies did not foresee (Weatherburn et al. 2003). Second, the common trend assumption holds if it holds for at least one subsumed DDs design or if the bias in both DDs has the same direction (Olden and Møen 2022). We show that the latter condition is satisfied when implementing our TD design using PPML estimations. However, for OLS DD, we find that the bias goes in the opposite direction. Moreover, neither of the DD designs, whether using OLS or PPML, exhibits a common trend motivating our TD.

We begin by examining the raw monthly averages of crime rates for treated and untreated postcodes (Figure 6) and across crime types (Figure 7). However, it is challenging to distinguish visually whether the common trend holds. In Figure 8, we employ OLS DD to estimate the difference in trends between treated and untreated postcodes. The results indicate that the common trend is absent, with a downward bias in the pre-treated period. Similarly, when examining the DD across crime groups in Figure 9, we find that the common trend is also biased, albeit in

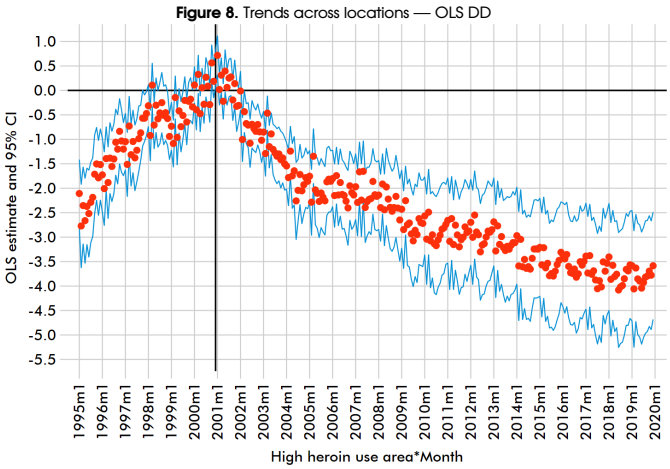


Figure 8. Trends across locations — OLS DD

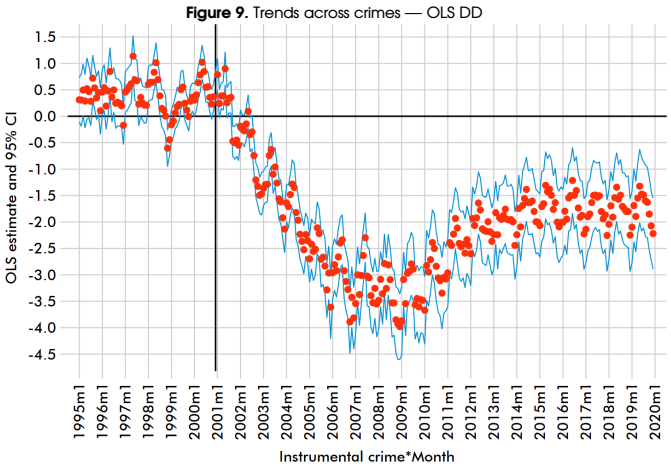


Figure 9. Trends across crimes — OLS DD

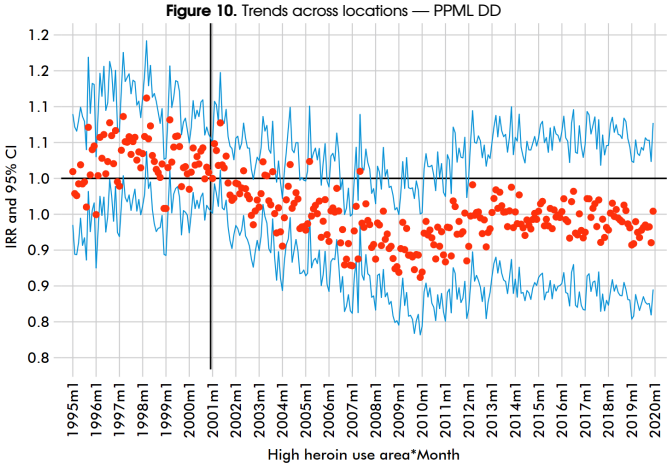


Figure 10. Trends across locations — PPML DD

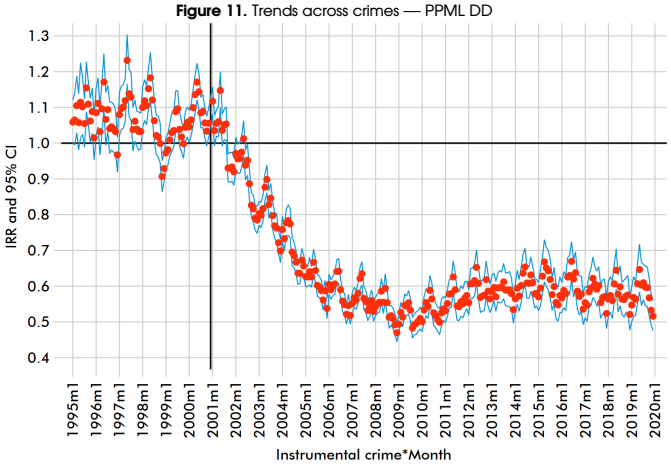


Figure 11. Trends across crimes — PPML DD

Notes: The top row shows DD via an OLS two-way fixed effects model, while the bottom row applies PPML to the same model. The left column uses variation across locations, the right column across crime types. Errors are clustered by postcode. Black solid line indicates the heroin shortage onset. *Source:* BOCSAR offence data (2022a): 1995m1 – 2019m12.

the opposite direction. Furthermore, the estimated trend suggests that crime rates increase after 2009, which has unclear criminalogical justification and probability highlights the limitations of DD for the long term evidence.

Given the biases observed in the OLS DD estimates, we transition to the PPML implementation of DDs. The results across locations, presented in Figure 10, show that the bias is upward rather than downward, as in the case of OLS DD. Moreover, when examining the PPML DD across crime groups in Figure 11, we find that the pre-treatment bias is also upward, matching the upward bias observed in the DD across locations supporting the common trend for our PPML TD.

As a side note, even if DD satisfied the common trend assumption, it would not be appropriate for evaluating long-term effects. As discussed in Section 3A, DD is particularly susceptible to unobserved heterogeneities in our setting, which are even more likely to confound results over a longer horizon. The divergence in crime trends after 2009, which lacks any criminological or institutional rationale, highlights this limitation.

5. Results

A. Main triple difference. Figures 12 to 15 showcase our PPML TD model results. Treatment effects are aggregated at monthly, quarterly, and semi-annually, offering a uniform comparison for assessing both short-term and long-term impacts of the heroin supply drop on crime. All models feature identical interacted fixed effects, with only the time aggregation of the focal triple interaction varying.

Examining the long-term effects of the heroin shortage, Figures 12 and 13 detail the half-year and quarterly

impacts on crime rates. The half-year effects in Figure 12 reveals a gradual decline in crime post-2000, with the first statistically significant estimate in 2002h1 indicating a 10% reduction relative to 2000h2. This downward trend continues with a marked drop of -18.78% in early 2009 and -22.71% in late 2018. The half-year estimates smooth out shorter-term fluctuations, providing a clearer view of long-term trends. The common trend assumption is strongly supported, with a p-value of 0.91 on a null that pre-treatment coefficients are jointly equal to zero.

In contrast, the quarterly effects in Figure 13 provides a more nuanced view of medium-term impacts, highlighting cyclical variations obscured by half-yearly data. The common trend assumption holds strong, with a p-value of 0.87. The first quarter of 2001 shows a non-significant increase of 4.79%. This is succeeded by a first significant -13.29% decrease by the second quarter of 2002. The data reveal stronger effects (lower IRR) during the second and third quarters (Australian winter) compared to the first and fourth (Australian summer). Notably, these seasonal patterns persist even with the inclusion of exhaustive month interacted fixed effects in our regression model. These findings resonate with studies indicating that higher temperatures correlate with increased crime rates (Awaworyi Churchill, Smyth, and Trinh 2023; Ranson 2014; Heilmann, Kahn, and Tang 2021).

These fluctuations highlight the utility of half-year estimates for understanding long-term effects, as they mitigate the noise of shorter-term variations. Increasing the frequency of treatment effect estimates, as seen in the quarterly data, escalates the uncertainty. However, as the period lengthens, the estimates stabilize, indicating a sustained reduction in crime rates.

The monthly treatment effects in Figures 14 and 15 provide a detailed view of the heroin shortage's short-term

Figure 12. The effects of supply drop on crime — half-year effects

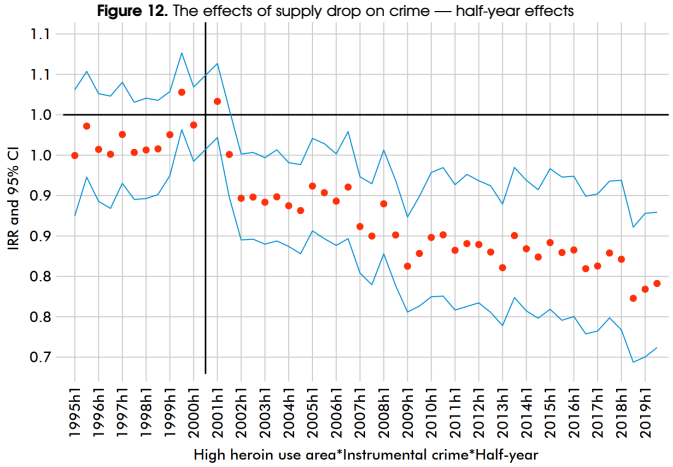


Figure 13. The effects of supply drop on crime — quarter effects

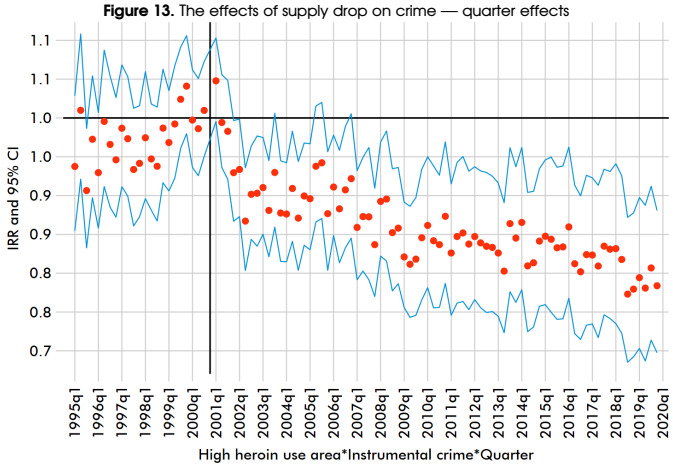


Figure 14. The effects of supply drop on crime — monthly effects

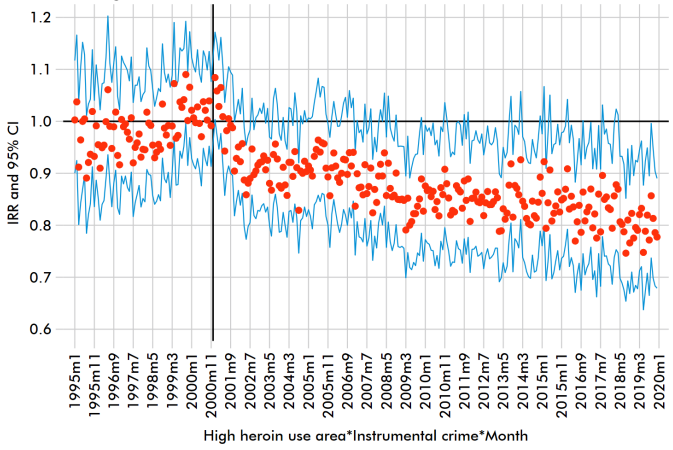
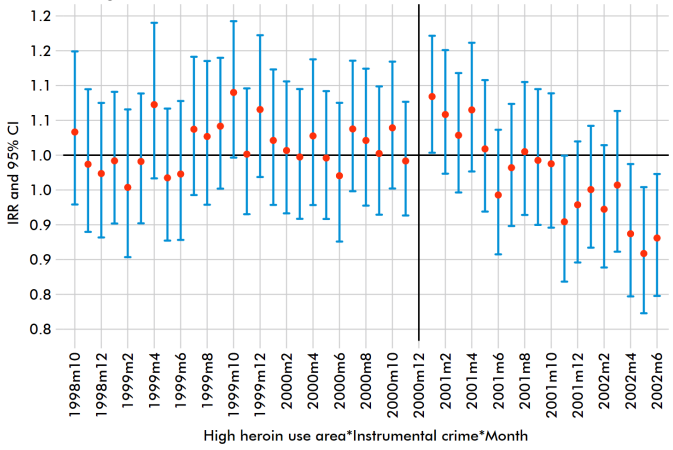


Figure 15. The effects of supply drop on crime — short-term effects



Notes: Black solid line indicates the heroin shortage onset. Pre-shortage period is omitted, serving as the base for comparison. Figure shows IRR (percent change, centered at 1) and 95% CI from Model [1].
Source: BOCSAR offence data (2022a): 1995m1 – 2019m12.

impact on crime rates. In January 2001, the first month post-shortage, crime surged by 8.42% (IRR: 1.0842, 95% CI: 1.0034 to 1.171). Pre-shortage, the trend is stable with coefficients centered around zero, supporting the causal interpretation of post-shortage estimates. Post-shortage, crime rates show a gradual decline with volatility, taking about 18 months to consistently fall below the initial increase. By November 2001, crime reduction first exceeded the initial spike with an IRR of 0.904, though December 2001, with the onset of summer, saw a slight rebound (IRR: 0.928). From April 2002, with an IRR of 0.887, crime rates remained below pre-shortage levels, indicating a sustained reduction.

The monthly analysis confirms a stronger impact of the heroin shortage on crime during Australian winters, with an average IRR of 0.85 compared to 0.89 in summer, indicating a 4% greater crime reduction in winter. This context suggests that had the shortage started in winter, the 8.42% crime increase in January 2001 might have been different by 4-5 percentage points, though the direction is speculative.

At the outset, we noted our TD strategy aims to provide credible estimates of both short-term and long-term effects of the heroin shortage on crime, while mitigating confounding factors. For instance, in July 2008, NSW introduced restrictions on licensed premises, significantly reducing assaults, particularly in areas like Kings Cross (Menéndez, Tusell, and Weatherburn 2015). This location-specific policy likely influenced expressive crimes in certain locales. However, our design's use of relative changes in crime groups across postcodes ensures robustness against such interventions, enhancing the validity of our estimates by isolating the heroin shortage's impact from other policy effects during our study period.

B. Crime type and monetary estimates. Above, we pooled data for all crimes to analyze the treatment's dynamic effect. Now, we focus on individual crimes by pooling time, as shown in Table 2. We started with a standard discrete TD model (column Discrete, row All crimes) and then varied the effect by crime type, with results detailed below this interaction. A standard discrete TD model is a benchmark against which other crime-specific estimates can be judged.

Table 2. The effects of supply drop on individual crimes

	Discrete			Annualized		
Triple difference term	IRR↓	SE	p-value	IRR	SE	p-value
All crimes	0.892	0.020	0.000	0.990	0.003	0.000
Break and enter no-dwelling	0.840	0.026	0.000	0.981	0.003	0.000
Steal from motor vehicle	0.865	0.037	0.001	0.984	0.005	0.001
Robbery without a weapon	0.867	0.048	0.009	0.985	0.006	0.008
Break and enter dwelling	0.876	0.033	0.000	0.986	0.004	0.001
Robbery with a weapon not a firearm	0.878	0.051	0.025	0.985	0.007	0.038
Receiving or handling stolen goods	0.909	0.059	0.138	0.995	0.004	0.254
Other theft	0.916	0.026	0.002	0.995	0.003	0.175
Steal from retail store	0.929	0.054	0.204	0.990	0.004	0.027
Steal from dwelling	0.979	0.027	0.442	1.002	0.002	0.341
Steal from person	0.997	0.080	0.974	0.995	0.005	0.332
Robbery with a firearm	1.095	0.077	0.198	1.004	0.007	0.532
# of postcodes	456					
# of observations	1,827,264					

Notes: The left column estimates (*High heroin use area* $\times$ $\mathbf{1}\{t \geq 2001m1\} \times$ *Instrumental crimes*), with further interaction by crime type below. The right column (*High heroin use area* $\times$ *Trend*$\{t > 2001\} \times$ *Instrumental crimes*), also detailed by crime type under.
Source: BOCSAR offence data (2022a): 1995m1 – 2011m12.

The Discrete specification uses a single indicator for the treatment period post-shortage instead of per-month dummies, representing the average effect from 2000m1 to 2012m12. However, we saw that the treatment effects exhibit a strong dynamic component, violating the 'no dynamic effect assumption' as described by Chaisemartin and D'Haultfœuille (2023), which suggests the conventional discrete TD model is misspecified.

To accurately capture the effect by crime type, we introduce a trend function, assigning 1 to 2001, 2 to 2002, and so on, with pre-2001 values set to zero. This allows the coefficients to be interpreted as the average annual change, enhancing precision and simplifying the calculation of the total effect over the study period. In the table shown in Table 2, the parameter for all crimes combined in the Annualized column, All crimes row, is 1%. Multiplying this by the 19 years of treatment gives us a 19% total crime reduction, with an uncertainty of ±5%, which aligns with the dynamic TD model's total effect of 20.87% in 2019h2 as reported in Figure 12. Calculations for individual crime types are detailed in the rows below.

Robbery with a firearm shows no significant response to the heroin shortage, providing a valuable falsification test for our study. This aligns with theoretical expectations, as such expressive crimes are typically driven by factors beyond drug-seeking behavior. In contrast, instrumental crimes show substantial reductions, particularly break-and-enter offenses, and vehicle theft. These crimes, being more opportunistic and suited for sustaining drug habits, demonstrate the strongest response to the supply shock.

Table 3. The estimated monetary benefits of the shortage, millions AUD

	(1) Total Effect by 2019	(2) Total cost in 2000	(3) Reduction in 2000 prices	(4) Reduction in 2020 prices
Break and enter non-dwelling	36.89%	$ 786.00	$ 289.92	$ 469.68
Steal from motor vehicle	29.60%	$ 530.00	$ 156.88	$ 254.14
Robbery with a weapon not a firearm	29.06%	$ 598.00	$ 173.77	$ 281.50
Robbery without a weapon	28.81%	$ 598.00	$ 172.31	$ 279.15
Break and enter dwelling	25.87%	$ 1,648.00	$ 426.40	$ 690.77
Steal from retail store	18.11%	$ 810.00	$ 146.67	$ 237.60
Total				$ 2,212.84

Notes: This figure shows the estimates by crime. The costs of these crimes before the shortage and an accumulated total reduction in crime costs.
Source: Crime costs are taken from Mayhew and Adkins (2003).

The relationship between Discrete and Annualized estimates reveals non-linear treatment effects. When an instrumental crime's annualized coefficient exceeds its discrete effect, it suggests a convex pattern of reduction — sharper initial decreases followed by gradual tapering. This pattern varies across crime types, with property offenses showing more pronounced early responses compared to other categories.

With crime-type estimates in hand, we quantify the monetary benefits of the heroin shortage. Using dose-response estimates, we calculated the cumulative crime reduction over the study period, shown in Column (1) of Table 3. We obtained pre-shortage crime costs from the Australian Institute of Criminology (Mayhew and Adkins 2003), listed in Column (2). These reductions were then monetized, with inflation adjustments to reflect 2020 values in Columns (3) and (4). The total monetary benefit from the shortage amounts to approximately 2.2 billion AUD annually.

6. Discussion

Using a TD design on the complete dataset of crime incidents, this study offers, to the best of our knowledge, the most extensive empirical evidence on the effects of supply-side drug policies on crime. It also provides the most complete empirical characterization of the Australian heroin shortage, a rare case where prevention-oriented policies appear feasible and effective.

Our findings reveal an 8.42% initial increase in crime during the heroin shortage, followed by a substantial 23% reduction over time. This pattern highlights that supply-side policies often take years to show their full effects, underscoring the importance of long-term commitment rather than short-sighted evaluations tied to electoral timelines. These results validate Becker and Murphy's (1988) economic theory of addiction, which posits that users respond to permanent price changes while temporary measures are ineffective or counterproductive. The heroin shortage exemplifies this, demonstrating that sustained supply reductions can lead to significant social and economic benefits.

Australia's unique context further underscores the feasibility of effective prevention strategies. Unlike the US methamphetamine shortage, where benefits faded within 18 months due to easy production and porous borders (Dobkin and Nicosia 2009), the Australian heroin shortage demonstrates that sustained supply-side enforcement is achievable under specific conditions. This is supported by our calculations, which credit Australian police with an annual monetary benefit of 2.21 billion AUD from crimes not committed as the result of the shortage — an amount equivalent to more than 10% of the combined police and corrective services annual budget of 19 billion AUD.

This success has critical implications for drug policy in Australia. If supply-side enforcement can credibly and sustainably reduce drug availability, it should be prioritized over harm reduction approaches. The demonstrated

success of the heroin shortage suggests that prevention could be a realistic and effective strategy in Australia's unique setting, where geographic and systemic factors provide a distinct advantage. This perspective challenges the widespread advocacy for policies like safe injection sites, which are often justified by evidence from other countries (Liang and Alexeev 2023). While harm reduction remains vital in many contexts, Australia's experience highlights that prevention-oriented approaches may, in some cases, provide a viable and preferable alternative.

That said, strictly enforced prohibition may not always be the optimal approach to minimizing drug-related harm. The effectiveness of such policies depends on the specific drug and the broader societal costs of enforcement, including its potential iatrogenic harms. For some substances, legalizing and regulating drug markets might provide policymakers with more flexible tools to balance public health and safety. However, in the case of heroin, the Australian context suggests that this approach is unlikely to garner widespread public or political support (Weatherburn, Alexeev, and Livingston 2021). Instead, prevention-oriented policies, when executed effectively and supported over time, can achieve meaningful and sustained reductions in harm.

As a final note, a noticed avenue for future research is the potential effect of the heroin shortage on the labor market. Individuals who recovered from heroin addiction and ceased committing instrumental crimes would ultimately need to re-enter the workforce. Past instances of comparable reductions in drug supply have shown increases in labor supply, raising the question of whether similar effects occurred in Australia during this period (Beheshti 2022; Deiana and Giua 2018; Park and Powell 2021). Exploring this link could offer valuable insights into the broader societal impacts of supply-side drug policies.

Finally, while the data used in MS may not be ideal for studying the effect of the shortage on crime incidence, it is well-suited for investigating its impact on reoffending. This remains an unanswered empirical question. Theoretically, the heroin shortage may have discouraged new criminals but increased the likelihood of reoffending among existing offenders. If reducing drug supply has such conflicting effects — deterring new crime while exacerbating recidivism — it could lead to unintended outcomes, such as a net increase in total crime if the prison population is large enough. These considerations emphasize the importance of nuanced, context-specific research to fully understand the complexities of supply-side interventions.

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Dedication. This work is dedicated to the memory of those who lost their lives to heroin addiction and to the resilience of individuals, families, and communities affected by the opioid crisis. We especially honor the frontline workers — the paramedics, social workers, nurses, and community outreach staff — who witness firsthand the raw dramas and profound tragedies of lives shattered by addiction.

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