Hot Spots, Patrolling Intensity, and Robberies:

Lessons from a three-year program in Uruguay

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Abstract

Can concentrating police patrols at high-crime micro-places reduce robbery without merely moving it nearby, and do the gains last? We study PADO, a large-scale hot-spots policing program in Uruguay, using geocoded robbery reports and high-frequency GPS records of realized police presence from 2015 to 2018. Ten changes in the program's target areas allow us to compare cells as they enter PADO with cells not assigned to it. Entry increased police presence by 48 percent and reduced robberies by 23 percent. The additional deployment remained sharply concentrated within targeted areas, and robberies did not increase detectably in cells immediately adjacent to them. We also examine selected exits and continued assignment. Formal exits reduced but did not eliminate police presence and did not coincide with a discrete robbery increase; because exits were selected and robbery pretrends were non-flat, this evidence is descriptive. Among cells selected to remain in PADO for at least six months, robberies remained lower through month six. The results show that large-scale hot-spots policing can produce substantial local robbery reductions without detectable displacement to immediately adjacent locations, and that measuring actual deployment is essential for assessing place-based policing in practice.

Keywords: Crime; Policing; Hot spots; Difference-in-differences; Uruguay.

JEL codes: K42, O17, J48.

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1 Introduction

How much can targeted police deployment reduce robbery? Do reductions persist, or does crime move to nearby streets? These questions matter because crime is concentrated at a small number of places (Weisburd 2015) and police resources are limited. Concentrating visible patrols at those places may produce large local gains. But a local decline can overstate the benefit if offenders move nearby, and an initially successful program may change as it expands and matures.

This paper studies the Programa de Alta Dedicación Operativa (PADO), a high-intensity hot-spots policing program introduced in April 2016. We study its Montevideo deployment, which targeted robbery (rapiña). Robbery combines property loss with violence or threats and is defined as a distinct legal category in Article 344 of Uruguay's Penal Code (República Oriental del Uruguay 1933). PADO combined geographically concentrated patrols with program-specific shifts, additional compensation, compliance monitoring, and personnel from several police units. We treat these components as the PADO deployment bundle. Targeted areas and operating schedules changed repeatedly between 2016 and 2018.

We combine geocoded robbery reports, planned PADO patrol routes, and high-frequency GPS records from the Ministry of Interior's police-radio system. We map PADO's operational street segments into 200-by-200-meter analytical cells and measure police presence from GPS records in the same grid. Successive entries into PADO provide ten short event windows. Our main comparison is between entrant cells and cells never treated during those windows.

Entry into PADO increased weekly police presence by 763 minutes per cell-week, or 47.7 percent relative to entrants' pre-treatment mean. Robberies fell by 0.0558 per cell-week, or 22.6 percent. The ratio implies a reduced-form elasticity of -0.47 for entry into the PADO bundle. The increase in police presence was smaller for the 2018 cohorts than for the 2016 and 2017 cohorts. The three annual robbery estimates are negative and are not statistically distinguishable across cohorts, although the 2017 estimate is imprecise.

To study spatial displacement, we use four clean entry transitions in 2018 and compare newly treated cells, immediately adjacent cells (the first ring), and stable controls. Police presence increased by about 727 weekly minutes in newly treated cells and by about 62 minutes in adjacent cells, showing that the additional deployment was geographically concentrated. Robberies fell in newly treated cells and did not increase detectably in the first adjacent ring. Stacking all ten revisions from 2016 to 2018 yields the same qualitative robbery pattern.

We also examine persistence beyond the initial impact. Across 2016-2018 entry cohorts, we identify cells that remained continuously in PADO for at least 183 days. Robberies remain lower through month six, with an average difference of 0.289 robberies per month. Because the authorities selected which locations remained treated, this evidence describes persistence under continued assignment rather than the causal effect of extending treatment.

A secondary analysis considers locations that leave PADO, a question that matters when authorities reallocate patrols. Police presence falls around formal exit but remains well above the level in never-treated cells. We find no discrete increase in robberies at the exit date. Because authorities selected exits and the joint robbery pretrend test rejects, this pattern is descriptive and does not identify residual deterrence or the causal effect of withdrawing patrol.

The paper contributes in three ways. First, GPS records show whether geographic assignments translated into police presence and how implementation changed across program versions. This complements work on force size, labor inputs, recurrent redeployments, and high-frequency patrol locations (Di Tella and Schargrodsky 2004; Draca et al. 2011; Cheng and Long 2018; Chalfin and McCrary 2018; Mastrobuoni 2019, 2020; Mello 2019; Weisburd 2021; Lovett and Xue 2022). Second, the paper extends the earlier evaluation of PADO by exploiting its successive revisions (Chainey et al. 2021). Third, it adds fine-scale evidence from a multi-year Latin American program on first-ring displacement, selected exits, and persistence under continued assignment, complementing experiments in Medellin and Bogota (Collazos et al. 2021; Blattman et al. 2021).

The estimates capture the PADO deployment bundle rather than the separate effect of adding an officer or assigning a particular police unit. The data do not allow us to distinguish deterrence from incapacitation or other potential mechanisms. The spatial, exit, and persistence patterns describe how the intervention operated, but none independently identifies a mechanism.

The remainder of the paper proceeds as follows. Section 2 describes PADO and its successive versions. Section 3 presents the data and empirical strategy. Section 4 reports entry effects, selected exits, changes in implementation, spatial displacement, and persistence. Section 5 discusses interpretation and limitations. Section 6 concludes.

2 Institutional Setting and PADO

Robbery was a major policing concern that led to the design of PADO. In 2015, Montevideo accounted for 81.2 percent of recorded robberies in Uruguay (Banco Interamericano de Desarrollo and Ministerio del Interior de la República Oriental del Uruguay 2018) and registered more than 17,000 incidents in our administrative data. The Ministry of Interior introduced PADO in April 2016 in Montevideo and in the neighboring departments of Canelones and San José. The Crime Analysis Unit selected areas and operating times in the three territories using the spatial and temporal concentration of reported robberies (Banco Interamericano de Desarrollo and Ministerio del Interior de la República Oriental del Uruguay 2018). Our analysis is limited to Montevideo.

At launch, groups of two or three officers patrolled each selected location (called patrol routes or segments) on foot. Segments were bundled into circuits for operational and logistical purposes. Motorbike patrols and a supervising officer in a patrol car supported each circuit. The initial deployment operated from 5:00 p.m. to 1:00 a.m., matching the hours when robberies were concentrated. Start times began to diversify in the second week and later varied across circuits, including overlapping shifts and periods of 24-hour coverage. Because the GPS records come from the Ministry's broader police monitoring system rather than a mechanism introduced by PADO, we observe police presence across the city and throughout the day instead of assuming that planned patrols were followed or that implementation intensity remained constant.

Crime analysts periodically revised the patrol segments, creating entries, continued treatment, exits, and changes in adjacency. We observe ten major geographic revisions and additional schedule subversions used to assign treatment status day by day. Appendix Figure A.1 compares PADO's geographic coverage at launch and in the final 2018 version, while Appendix Table A.1 reports the implementation calendar. Appendix A provides further details on schedules and staffing.

PADO drew personnel from multiple existing units, including the Montevideo Police Headquarters' Grupo de Reserva Táctica (GRT) and, in some circuits and periods, the Dirección Nacional de la Guardia Republicana (DNGR). These units differed in training and potentially in equipment. Participation was voluntary and involved additional compensation. Unit assignment to patrol routes was not random, and the identifiers available in archived GPS records do not provide a complete, mutually exclusive measure of unit assignment. We consequently treat targeting, additional presence, schedules, compensation, monitoring, and unit composition as a single PADO deployment bundle.

3 Data and Empirical Strategy

3.1 Data and spatial units

The analysis uses three confidential administrative sources supplied by the Ministry of Interior for 2015-2018. The first is the Sistema de Gestión de Seguridad Pública, which records reported crimes, their location, date, time, and legal category. We retain robbery because it was the primary offense targeted by PADO's Montevideo deployment. The second source is the set of planned patrol routes and circuits for the program. The third consists of high-frequency GPS records associated with police radios carried by officers or installed in vehicles.

We partition Montevideo into 200-by-200-meter cells and assign every geocoded robbery and GPS signal to a cell. Because GPS records are high frequency and multiple radios can be present in the same cell, we divide time into five-minute intervals and mark a cell as occupied when at least one police signal appears. Each occupied interval contributes five minutes of police presence, which we sum by cell-week. The measure records presence, not the number of officers.

Treatment is constructed by intersecting the analytical grid with the patrol routes assigned under each PADO version. Our main 2015-2018 weekly panel contains 3,502 complete cells with at least one reported robbery in 2015. Some areas recorded no robberies during the 2015 pre-treatment year and tend to be less populated; we exclude these cells from the main sample rather than use them as potential controls. Because this restriction could miss displacement into nearby low-baseline areas, we repeat the displacement analysis using all 13,422 complete grid cells covering Montevideo.

For displacement, a cell is adjacent when it belongs to the first contiguity ring around a treated cell under the active PADO version. The three comparisons are treated cells versus stable non-adjacent controls, treated cells versus adjacent cells, and adjacent cells versus stable non-adjacent controls. Two cells whose spatial map and operational treatment record disagree during one subversion are excluded in the main analysis and reclassified in robustness checks.

3.2 Descriptive patterns

In the 3,502-cell main sample, the average cell-week contains 0.093 reported robberies and 1,032.6 minutes of police presence. The annual mean number of robberies per cell-week fell from 0.094 in 2015 to 0.083 in 2016 and 0.079 in 2017, before rising to 0.118 in 2018. Mean police presence ranges from 999.6 to 1,079.9 minutes after PADO begins. Appendix Table B.2 reports the full distribution and cell-week counts. These are unconditional summaries that combine treated and untreated observations.

3.3 Empirical designs

In the weekly entry design, we stack ten changes in PADO. For each change, we construct an eight-week window covering four weeks before and four weeks after the change. Entrant cells are untreated throughout weeks -4 to -1 and treated throughout weeks 0 to +3. The comparison group comprises cells never treated in any of the ten study windows. We use week -4 as the reference period. Our event-study specification is

$$Y_{ist} = \alpha_i + \lambda_y + \mu_m + \sum_{k \neq -4} \beta_k \left(\text{Entrant}_{is} \times \mathbf{1}\{\tau_{st} = k\}\right) + \sum_{k \neq -4} \delta_k \mathbf{1}\{\tau_{st} = k\} + \varepsilon_{ist}. \tag{1}$$

In equation (1), i indexes original grid cells, s indexes program-change windows, t indexes weeks, and τ_{st} denotes event time. The coefficients β_k trace the entrant-control difference relative to week -4. The model includes original-cell (α_i), calendar-year (λ_y), and calendar-month (μ_m) fixed effects, with standard errors clustered by original cell. To estimate the average effect reported in Table 1, we use the corresponding pre/post specification, replacing the event-time indicators and interactions with a post indicator and an entrant-by-post interaction. Its coefficient compares the change from weeks -4 to -1 to weeks 0 to +3 among entrant cells with the same change among never-treated cells.

For the secondary exit analysis, we estimate a specification analogous to equation (1) over the same eight-week window. Leavers are treated throughout weeks -4 to -1 and untreated throughout weeks 0 to +3. We replace the entrant indicator with a leaver indicator and compare exit episodes with cells never treated during any of the ten study windows. Identification of the entry effect requires that, absent entry into PADO, outcomes in entrant and never-treated cells would have followed similar paths over the event window. We examine this assumption using the coefficients for weeks -3 to -1 and joint pretrend tests. Cell fixed effects absorb persistent differences in robbery levels across cells, but not temporary shocks that may have influenced the authorities' decision to add a location to PADO. The four-week pre-period can reveal differential movements immediately before entry, but it cannot rule out selection based on earlier shocks. Cell-specific linear trends provide an additional sensitivity check. Stacking keeps each program change and its comparison observations explicit when treatment timing and effects may differ (Goodman-Bacon 2021). The exit analysis is descriptive because exits were selected by the authorities and the joint robbery pretrend test rejects.

$$Y_{ist} = \alpha_{is} + \lambda_{st} + \sum_{k \neq -1} \beta_k^T \left(\text{NewlyTreated}_{is} \times \mathbf{1}\{\tau_{st} = k\}\right) + \sum_{k \neq -1} \beta_k^N \left(\text{Adjacent}_{is} \times \mathbf{1}\{\tau_{st} = k\}\right) + \varepsilon_{ist}. \tag{2}$$

In equation (2), s indexes the four 2018 transitions, t indexes weeks, and week -1 is omitted. Stable non-adjacent cells form the comparison group. The coefficients β_k^T and β_k^N trace, respectively, the newly treated-control and newly adjacent-control differences. For each event period, the treated-adjacent contrast is $\beta_k^T - \beta_k^N$; the stable-control path cancels from this comparison. Table 4 averages these contrasts over weeks 0 to +3, with standard errors calculated from the joint covariance matrix.

The displacement design focuses on four clean entry transitions in 2018 (April 2, May 2, June 25, and September 3). For each active patrol map, cells are classified as newly treated, immediately adjacent to any treated cell (the first ring), or stable non-adjacent controls, and the [-3,+3] weekly windows are stacked. Figure 1 illustrates the three spatial groups. Treated areas may form corridors, and a cell may border more than one treated cell; classification uses the full patrol map rather than the number of treated neighbors. The model includes cell-by-transition and calendar-week-by-transition fixed effects and clusters standard errors by original cell. We focus on 2018 because these transitions isolate control-to-treated and control-to-adjacent changes within a common operational phase. A full-period spatial regression would mix entries, exits, changes in adjacency, and persistent exposure. Appendix Table C.3 stacks all ten revisions as a robbery robustness check.

To examine persistence, we identify the first qualifying spell in which a cell remains continuously assigned to PADO for at least 183 days. This procedure yields nine monthly entry cohorts from 2016 to 2018, which we stack against never-treated cells in a [-6,+6] month window. Because most qualifying cells enter after the first day of a month, month 0 is a partial-exposure transition month, and we evaluate persistence over months +1 to +6.

$$Y_{ism} = \alpha_{is} + \lambda_{sm} + \sum_{k \neq -1} \gamma_k \left(\text{TreatedCohort}_{is} \times \mathbf{1}\{\tau_{sm} = k\}\right) + \varepsilon_{ism}. \tag{3}$$

In equation (3), m indexes calendar months and s indexes the nine entry cohorts. $\text{TreatedCohort}_{is}$ indicates cells in cohort s that remain continuously assigned to PADO for at least 183 days; the comparison group contains never-treated cells. Month -1 is omitted. The model includes cell-by-stack fixed effects (α_{is}) and calendar-month-by-stack fixed effects (λ_{sm}), with standard errors clustered by original cell.

We estimate the same specification for police presence as an operational diagnostic. Because the authorities selected which locations remained under treatment, the design describes persistence among selected locations rather than the causal effect of an additional month of treatment.

4 Results

4.1 Police presence and robberies

We first establish whether assignment to PADO changed police presence and robberies. Reporting both outcomes matters because a patrol plan need not translate into deployment, and PADO changed several operational margins at once (Blanes i Vidal and Mastrobuoni 2018; Blattman et al. 2021).

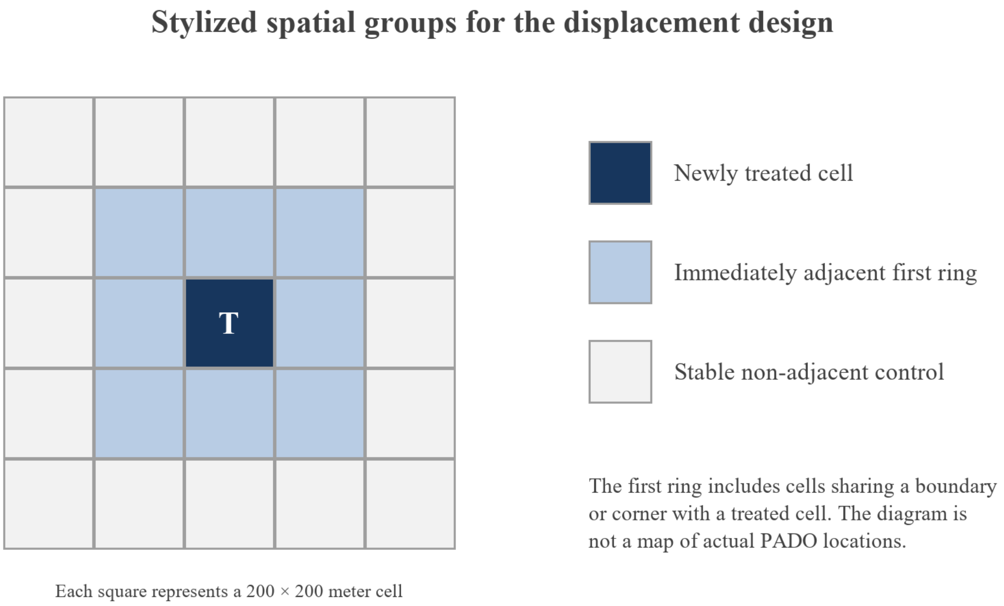

Figure 1: Spatial groups in the displacement design

Notes: Stylized, non-geographic illustration. The first ring contains cells immediately adjacent to any treated cell in the full active map. Treated areas may contain contiguous cells, and an adjacent cell may border more than one treated cell.

Figure 2 shows a sharp increase in police presence when cells enter PADO and an immediate reduction in robberies. Averaging weeks 0 to +3, presence rises by 763.26 minutes per cell-week ($p<0.001$), while robberies fall by 0.0558 per cell-week ($p<0.001$). Relative to entrant cells' pre-treatment means, these changes are +47.7 percent and -22.6 percent.

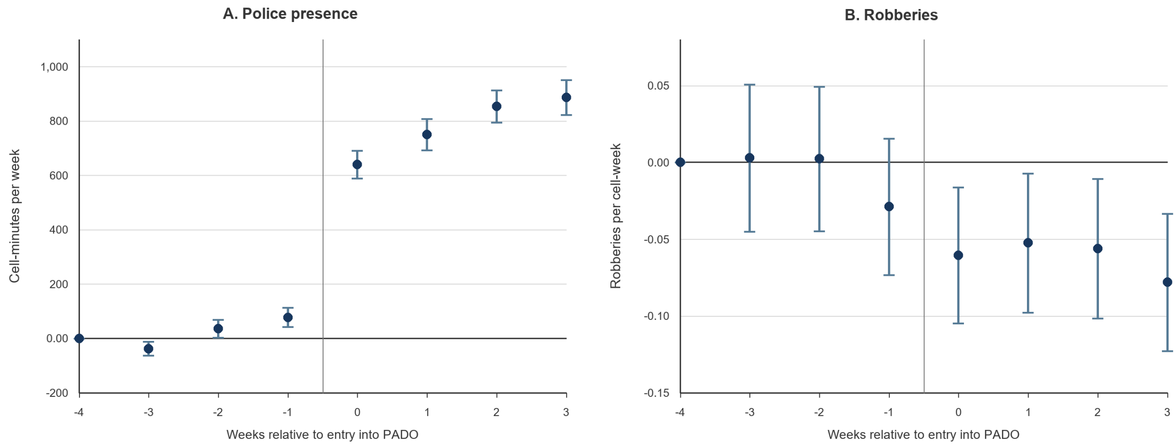

Figure 2: Entry into PADO: event-study estimates

Table 1: Average effects of entry into PADO

Outcome	Main	Cell trend	Entrant pre mean	Change (%)	Observations
Police presence	763.26*** (24.43)	703.51*** (29.75)	1,599.41	47.72	227,712
Robberies	-0.05581*** (0.01141)	-0.06216*** (0.01562)	0.24663	-22.63	227,712

Notes: The main specification compares entrant cells with 2,750 cells never treated during the ten study windows and averages event weeks 0 through 3. Entrant pre mean is the mean among entrant cell-weeks during weeks -4 through -1; Change (%) is calculated from the main estimate. Both columns include cell, year, and month fixed effects and use the main sample of complete cells with at least one robbery in 2015; Cell trend additionally includes cell-specific linear trends. Standard errors clustered by original cell in parentheses. Police presence is weekly cell-minutes with at least one police GPS signal. Three asterisks indicate a p-value below 0.01.

The pre-treatment robbery coefficients are jointly consistent with parallel trends (p=0.419). Police presence begins to move before the formal revision date in some windows, consistent with operational preparation or phased implementation. Adding cell-specific linear trends gives a robbery estimate of -0.0622 ($p<0.001$) and a presence estimate of 703.5 minutes per cell-week ($p<0.001$). The all-non-entrant comparison uses the same main sample but treats every cell-window in which a cell does not enter PADO as a comparison observation, including windows for cells that remain treated or leave. It gives -0.0570 robberies and +776.0 minutes, respectively (Appendix Table C.2).

The ratio of the proportional changes reported in Table 1 implies a reduced-form elasticity of -0.47. Joint estimation gives a delta-method standard error of 0.10 and a 95 percent confidence interval from -0.67 to -0.28, treating entrant pre-treatment means as fixed normalizations. This is an elasticity for entry into the PADO bundle, not a structural elasticity of police manpower or an independently varied patrol dose.

4.2 Exits from PADO

Authorities deciding whether to retarget a hot-spots program may be concerned that crime will rebound when a location leaves. Residual deterrence after patrol withdrawal is possible in principle, but clean evidence requires an exogenous withdrawal such as the randomized design in Barnes et al. (2020). PADO exits were selected by the authorities and did not remove ordinary police activity.

Table 2 pools all qualifying exit episodes around the ten PADO changes from 2016 to 2018. The sample contains 629 eight-week exit episodes involving 578 unique cells—some of which exit more than once—and compares them with 2,750 cells never treated in any of the ten study windows. Around formal exit, police presence falls by 559.45 minutes per cell-week ($p<0.001$). The robbery post-pre estimate is +0.0259 (p=0.059), but the pretrend test rejects (p=0.011) and the estimate falls to +0.0155 (p=0.513) with cell-specific trends.

Police presence does not return to the comparison level: exiting cells average 1,704 weekly minutes after exit, compared with 796 in never-treated cells. A local comparison of week 0 with week -1 shows no discrete robbery increase at the formal exit date (-0.0120; p=0.646). These patterns are relevant for patrol reallocation, but they do not identify residual deterrence or the causal effect of withdrawing patrol.

Table 2: Outcomes around exits from PADO

Outcome	Main	Cell trend	Leaver pre mean	Change (%)	Pretrend p-val	Observations
Police presence	-559.45*** (32.29)	-599.84*** (41.12)	2,252.22	-24.84	0.017	225,032
Robberies	0.02586 (0.01368)	0.01546 (0.02365)	0.15421	16.77	0.011	225,032

Notes: The table pools 629 exit episodes involving 578 unique cells and compares them with 2,750 cells never treated during the ten study windows. Main is the difference between weeks 0 to +3 and -4 to -1, relative to never-treated controls. Models include cell, year, and month fixed effects; Cell trend additionally includes cell-specific linear trends. Police presence is weekly minutes with at least one police GPS signal; robberies are weekly reported counts. Leaver pre mean refers to exit episodes in weeks -4 to -1. Observations are stacked cell-weeks. Standard errors clustered by original cell are in parentheses. The pretrend p-value is from the joint test of pre-exit coefficients. Three asterisks indicate a p-value below 0.01. Because exits were selected and pretrend tests reject, the estimates are descriptive and do not identify residual deterrence.

4.3 Changes in treatment intensity

The GPS records also show whether PADO produced the same increase in police presence across annual cohorts. We estimate the entry specification separately for 2016, 2017, and 2018. Because geography, schedules, and unit composition changed together, these comparisons do not isolate a single cause of the change in implementation.

Table 3 shows that entry increased weekly police presence by 923 minutes in 2016, 889 in 2017, and 585 in 2018. Equality is strongly rejected across cohorts (p<0.001); the 2018 increase is smaller than both earlier estimates (p<0.001 for each comparison). Appendix Table C.1 reports the same pattern in a separate phase model.

The three annual robbery estimates are negative: -0.0726 in 2016 (p=0.001), -0.0205 in 2017 (p=0.422), and -0.0567 in 2018 (p=0.001). A joint test does not reject equality across cohorts (p=0.267). Robbery pretrend tests also do not reject within any cohort. Joint tests reject flat presence pretrends in each cohort, consistent with operational preparation or phased implementation around formal revision dates. The supported conclusion is that the increase in police presence was lower in 2018, not that the robbery response weakened.

Table 3: Entry effects by annual cohort

Outcome	2016	2017	2018	Equality p
Police presence	923.12*** (38.19)	889.32*** (58.16)	585.40*** (33.61)	<0.001
Robberies	-0.07257*** (0.02279)	-0.02052 (0.02554)	-0.05665*** (0.01674)	0.267

Notes: Entrants are compared with cells never treated during the ten study windows. Each column estimates the main pre/post entry model within the indicated cohort. Standard errors clustered by cell in parentheses. Equality p tests equality of the three annual effects. Joint pretrend p-values for 2016, 2017, and 2018 are 0.396, 0.633, and 0.554 for robberies and below 0.001, 0.048, and 0.007 for police presence. Three asterisks indicate a p-value below 0.01.

4.4 Spatial displacement

A decline in treated cells could overstate the benefit if robbery moved to nearby streets. Prior evidence more often finds diffusion of benefits than displacement, but results vary across settings (Bowers et al. 2011; Braga et al. 2019; Maheshri and Mastrobuoni 2021; Chainey et al. 2021; Blattman et al. 2021; Collazos et al. 2021).

For each clean 2018 transition, stable non-adjacent cells form the omitted comparison group. Equation (2) estimates separate event-time effects for cells that become treated and cells that become adjacent to treated locations. Thus, β_k^T measures the newly treated-control contrast, β_k^N measures the newly adjacent-control contrast, and $\beta_k^T - \beta_k^N$ gives the treated-adjacent contrast. A negative treated-control robbery estimate accompanied by a positive adjacent-control estimate would be consistent with displacement to the first ring. The treated-adjacent contrast shows how sharply changes in police presence and robberies are concentrated within the assigned areas.

Table 4 reports police presence and robberies, while Figure 3 shows the robbery dynamics. In the main sample, weekly police presence rises by 727.3 minutes in newly treated cells relative to stable controls (p<0.001), compared with 61.8 minutes in newly adjacent cells (p=0.030). The treated-adjacent difference is 665.5 minutes (p<0.001), and the joint presence pretrend test does not reject (p=0.334). The additional deployment was therefore geographically concentrated; this pattern does not show that concentration itself caused the robbery decline.

Averaging weeks 0 to +3, robberies fall by 0.1018 in newly treated cells relative to stable controls (p=0.006). The adjacent-control estimate is -0.0098 (p=0.516), and the treated-adjacent difference is -0.0920 (p=0.022). The joint robbery pretrend test does not reject (p=0.318). We find no evidence that the treated-cell decline was offset by displacement to the first ring.

The all-cell sample gives similar contrasts for both outcomes, although its joint police-presence pretrend test rejects (p=0.020), so that presence row is descriptive. Robbery results are also stable when all ten revisions from 2016 to 2018 are stacked: the treated-control estimate is -0.0617 (p=0.003), and the adjacent-control estimate is -0.0116 (p=0.223), with a joint pretrend p-value of 0.603 (Appendix Table C.3). These designs do not measure displacement beyond the immediately adjacent ring.

Table 4: Spatial displacement: stacked 2018 entries

Outcome and sample	Treated-control	Adjacent-control	Treated-adjacent	Observations
Police presence: main sample	727.29*** (52.33)	61.79** (28.39)	665.50*** (59.34)	71,932
Police presence: all-cell sample	731.04*** (48.78)	85.00*** (21.09)	646.05*** (53.34)	342,440
Robberies: main sample	-0.10179*** (0.03724)	-0.00977 (0.01503)	-0.09202** (0.04004)	71,932
Robberies: all-cell sample	-0.08409** (0.03517)	-0.00375 (0.01063)	-0.08035** (0.03696)	342,440

Notes: Each row averages weeks 0 through 3. Police presence is weekly cell-minutes with at least one police GPS signal; robberies are weekly reported counts. The main sample contains complete cells with at least one reported robbery in 2015. Treated-adjacent is the linear contrast between the treated-control and adjacent-control estimates; its standard error is calculated from the joint covariance matrix. All models include cell-by-transition and calendar-week-by-transition fixed effects and cluster standard errors by original cell. Joint pretrend p-values for presence are 0.334 (main sample) and 0.020 (all-cell sample); the corresponding values for robberies are 0.318 and 0.375. Observations are stacked cell-weeks. Standard errors are in parentheses. Two and three asterisks indicate p-values below 0.05 and 0.01.

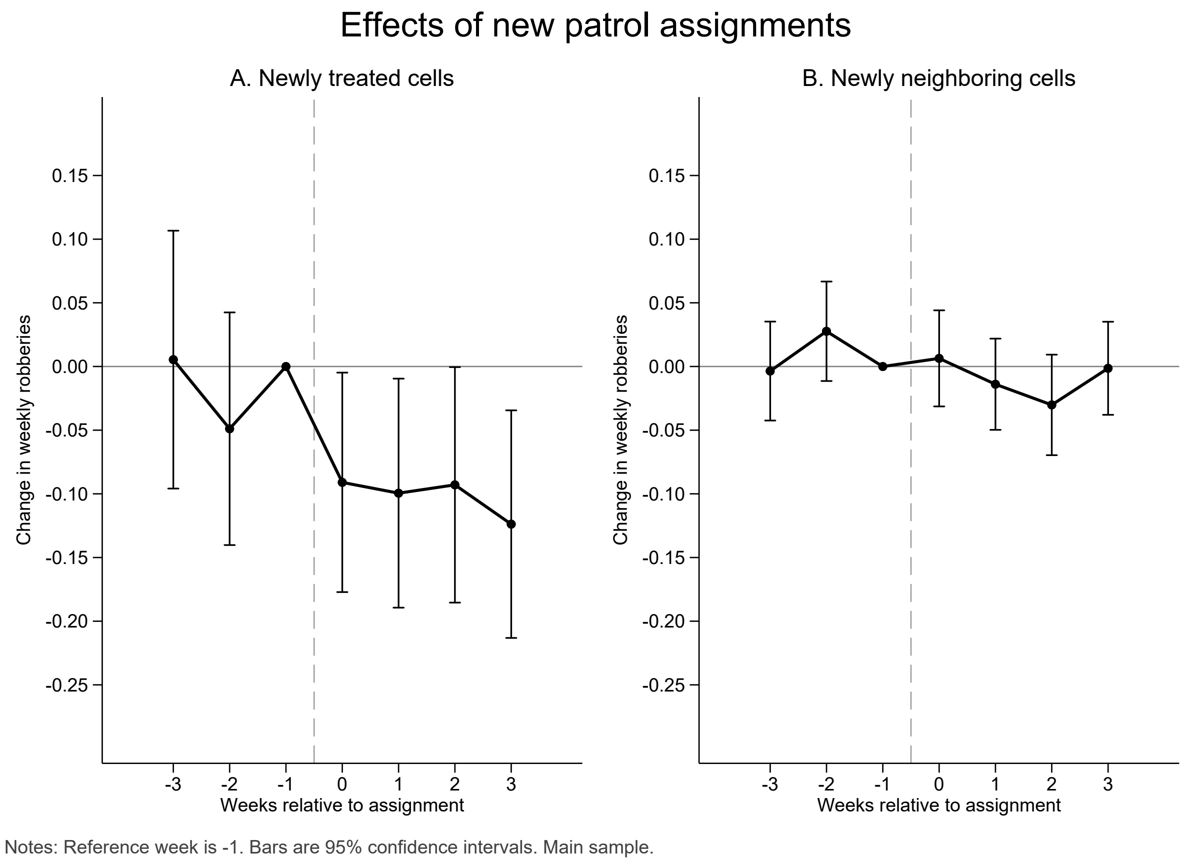

Figure 3: Spatial displacement around clean entries

4.5 Persistence

We next examine whether robberies remain lower in locations that continue to be geographically assigned to PADO. Continued assignment does not imply a fixed treatment dose: patrol schedules and realized police presence may change over time, while offenders may adapt and officers may acquire place-specific knowledge. The analysis therefore describes persistence under continued assignment to the evolving PADO bundle, rather than persistence under an unchanged patrol schedule or intensity. Experiments in Bogota and Medellin provide related six- to eight-month evidence (Blattman et al. 2021; Collazos et al. 2021).

Equation (3) stacks nine 2016-2018 cohorts of cells selected to remain in PADO for at least 183 days against never-treated controls and traces outcomes from months +1 to +6. The authorities selected which locations remained treated.

Table 5 first describes realized police presence in the main sample. From months +1 to +6, the estimated difference relative to never-treated controls averages 4,026.6 minutes per cell-month ($p<0.001$) and equals 3,613.2 minutes in month +6 ($p<0.001$). Equality of the six monthly coefficients is rejected ($p<0.001$), indicating that the difference remains substantial but declines over the period. Because the joint pretrend test for police presence also rejects ($p<0.001$), we use these estimates only as an operational diagnostic of how realized implementation evolved, not as causal effects of continued assignment.

From months +1 to +6, the estimated robbery difference averages -0.2887 per cell-month relative to never-treated controls ($p<0.001$), equivalent to 28.4 percent of the treated cohorts' weighted pre-treatment mean. The month-six estimate is -0.2869 ($p<0.001$), and equality of the six monthly coefficients is not rejected ($p=0.454$). The average estimate changes little when the sampling frame is expanded from the 3,502-cell main sample to all 13,422 complete grid cells (-0.3031), or when the only qualifying treated cell with any PADO exposure during the preceding six months is excluded from the main sample (-0.2916). The main specification's joint robbery pretrend test yields $p=0.080$, while the longer-horizon test for the largest initial cohort rejects the joint null that the pre-treatment coefficients equal zero (Appendix Table C.4). Together with the authorities' selection of locations into continued treatment, this evidence limits the interpretation to persistence among selected locations rather than the causal effect of extending treatment.

Table 5: Persistence among locations treated for at least 183 days

Outcome and sample	Average +1 to +6	Month +6	Pretrend p-val	Equality p	Observations
Police presence: main sample	4,026.61*** (163.58)	3,613.22*** (190.75)	<0.001	<0.001	328,003
Robberies: main sample	-0.28873*** (0.06558)	-0.28687*** (0.08054)	0.080	0.454	328,003
Robberies: all-cell sample	-0.30308*** (0.06118)	-0.30518*** (0.07524)	0.081	0.730	1,517,087
Robberies: clean pre-period	-0.29163*** (0.06566)	-0.28976*** (0.08067)	0.077	0.526	327,990

Notes: The stacked monthly models use nine 2016-2018 entry cohorts and include cell-by-stack and calendar-month-by-stack fixed effects and cluster standard errors by original cell. Police presence is monthly cell-minutes with at least one police GPS signal; robberies are monthly reported counts. Average +1 to +6 is the mean of the six monthly coefficients. The pretrend p-value is from the joint test of pre-entry coefficients; Equality p tests equality across the six post-entry coefficients. The police-presence row is an operational diagnostic rather than a causal estimate because its pretrend test rejects. The clean pre-period robbery row excludes the single qualifying cell with treatment during the prior six months. Observations are stacked cell-months. Standard errors are in parentheses. Three asterisks indicate a p-value below 0.01.

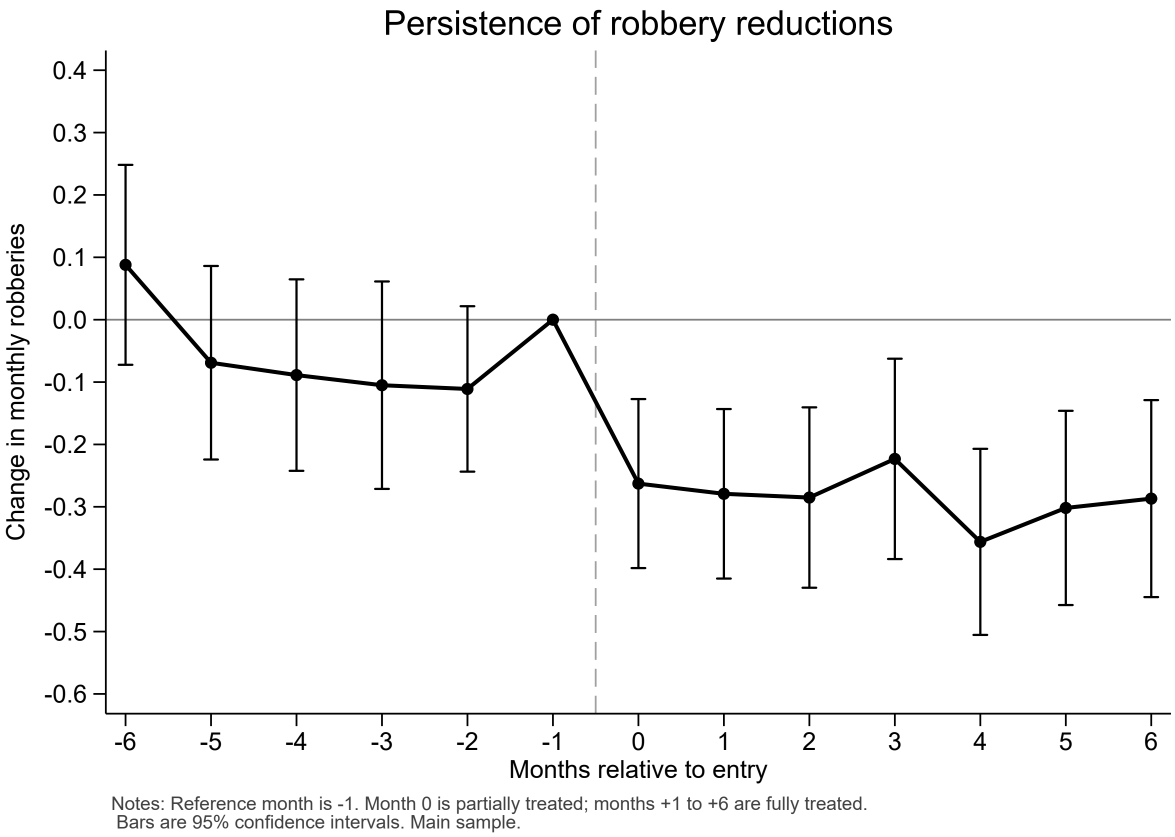

Figure 4: Persistence over six months

5 Discussion and Limitations

PADO substantially increased police presence, measured from GPS signals, and reduced robberies at targeted micro-places. Its implied elasticity of -0.47 is near the -0.52 to -0.57 robbery range in Chalfin and McCrary (2018)'s IV specifications with state-by-year effects and the -0.3 to -0.4 range in Draca et al. (2011). Weisburd (2021) finds a larger local crime response to police presence, while Lovett and Xue (2022) report a smaller estimate for violent crime. These comparisons are descriptive: outcomes, geographic units, designs, and policing margins differ. PADO's denominator is minutes of targeted police presence, not force size or officer-hours.

The rapid and geographically concentrated decline in robberies is consistent with deterrence, but our data do not identify the behavioral mechanism. Without individual-level information on police encounters, case clearances, or offender behavior, we cannot distinguish deterrence from incapacitation or other channels. The displacement, exit, and persistence estimates show how police presence and robberies evolved across space and time, but they do not resolve this distinction.

The exit results are relevant for patrol reallocation but do not identify residual deterrence. Formal exit reduced targeted police presence without eliminating police activity in those locations. Moreover, the authorities selected when locations left PADO, and the joint robbery pretrend test rejects. The absence of a discrete increase in robberies at exit may therefore reflect continued police presence, endogenous selection, or the pre-existing robbery path.

Uruguay implemented a new Code of Criminal Procedure on November 1, 2017, replacing an inquisitorial system with an adversarial system in which prosecutors direct investigations and judges oversee proceedings. The transition could affect reported crime through several channels that our data cannot separate: temporary disruption as police and prosecutors adjusted to new roles; changes in reporting or recording; and changes in the timing or use of pretrial detention, which could alter incapacitation and the perceived certainty of punishment. Cattaneo et al. (2025) estimate an immediate increase in police reports after the reform, while Chainey and Estévez-Soto (2024) study longer-run changes alongside other contemporaneous institutional and recording changes. Neither study identifies the reform as the explanation for PADO's year-specific effects. Our event-study specifications include calendar-time fixed effects, which absorb shocks at the time of the reform that are common to all cells. They do not absorb differential responses in PADO or other high-risk locations, which remain a limitation. We therefore treat the reform as a contemporaneous institutional change rather than an identified mechanism for our estimates.

The geographic scope is also limited. The main sample excludes cells with no reported robberies in 2015, and PADO deliberately targeted high-robbery locations. The reduced-form effect and implied elasticity therefore should not be extrapolated to low-crime areas.

External validity is bounded by the intervention bundle. PADO combined selected officers, additional compensation, special schedules, compliance monitoring that used the Ministry's pre-existing GPS infrastructure, and personnel from several units. The estimate need not equal the effect of adding an average officer under ordinary deployment. Unit-specific estimates would not solve this problem because unit assignment was endogenous to risk and the identifiers in the archived GPS records do not provide a complete, mutually exclusive unit classification. Related studies reach mixed conclusions about the effects of specialized police equipment (Bove and Gavrilova 2017; Lowande 2021).

6 Conclusion

Using geocoded robbery reports and high-frequency GPS records, we find that entry into PADO increased weekly police presence by 47.7 percent and reduced robberies by 22.6 percent. These estimates imply a reduced-form elasticity of -0.47 for targeted presence. The increase in police presence was smaller for the 2018 cohorts, while annual robbery estimates are not statistically distinguishable.

Deployment was concentrated within assigned micro-places. Among locations selected to remain treated, robberies stayed lower through month six. Formal exits reduced targeted police presence without eliminating police activity and did not coincide with a discrete robbery increase, although selection and pretrends make this evidence descriptive. Taken together, these findings show that a large-scale hot-spots program can substantially reduce robbery at targeted micro-places without detectable displacement to immediately adjacent areas.

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A Additional Implementation Detail

PADO began on April 11, 2016. During its first week, 28 circuits were scheduled from 5:00 p.m. to 12:59 a.m. Start times diversified from April 18, and some circuits received second shifts from May onward. Between April 2017 and early 2018, several circuits were scheduled for 24-hour coverage. During 2018, schedules from eight to 24 hours coexisted across circuits.

The operational calendar distinguishes three broad phases and finer subversions. The main event study uses ten substantial geographic changes. The displacement analysis uses four 2018 transitions for which newly treated, newly adjacent, and stable-control cells can be followed over a common short window without another deployment revision.

PADO staffing and schedules changed over time. The launch description of two or three officers on foot, supported by motorbikes and a supervisor, should not be read as a fixed staffing rule for every location and version. The GPS measure is designed precisely to capture police presence under this operational variation.

Table A.1: PADO implementation calendar

Effective date	Version	Phase	Days active	Cells entering	Cells leaving	Treated cells
11 Apr 2016	1.0	Phase 1	91	257	0	257
11 Jul 2016	1.5	Phase 1	264	43	0	300
1 Apr 2017	2.0	Phase 2	140	159	190	269
19 Aug 2017	2.1	Phase 2	110	13	0	282
7 Dec 2017	2.3	Phase 2	39	44	0	326
15 Jan 2018	2.4	Phase 2	77	57	0	383
2 Apr 2018	3.0	Phase 3	30	131	181	333
2 May 2018	3.1	Phase 3	54	97	195	235
25 Jun 2018	3.1.3	Phase 3	70	42	14	263
3 Sep 2018	3.2	Phase 3	120	217	114	366

Notes: Dates identify the ten principal geographic changes used in the entry design. Phase 1 covers April 11, 2016-March 31, 2017; Phase 2 covers April 1, 2017-April 1, 2018; and Phase 3 begins April 2, 2018. Days active are calendar days counted inclusively from the effective date through the day before the next displayed geographic change; the final version is counted through December 31, 2018. Cells entering and leaving are changes relative to the preceding displayed map (the launch is measured relative to no PADO assignment), so previous treated cells minus leavers plus entrants equals the new treated total. Finer schedule subversions are grouped with the version shown. For version 3.1.3, the two cells with conflicting spatial and operational records are classified consistently with the main analysis.

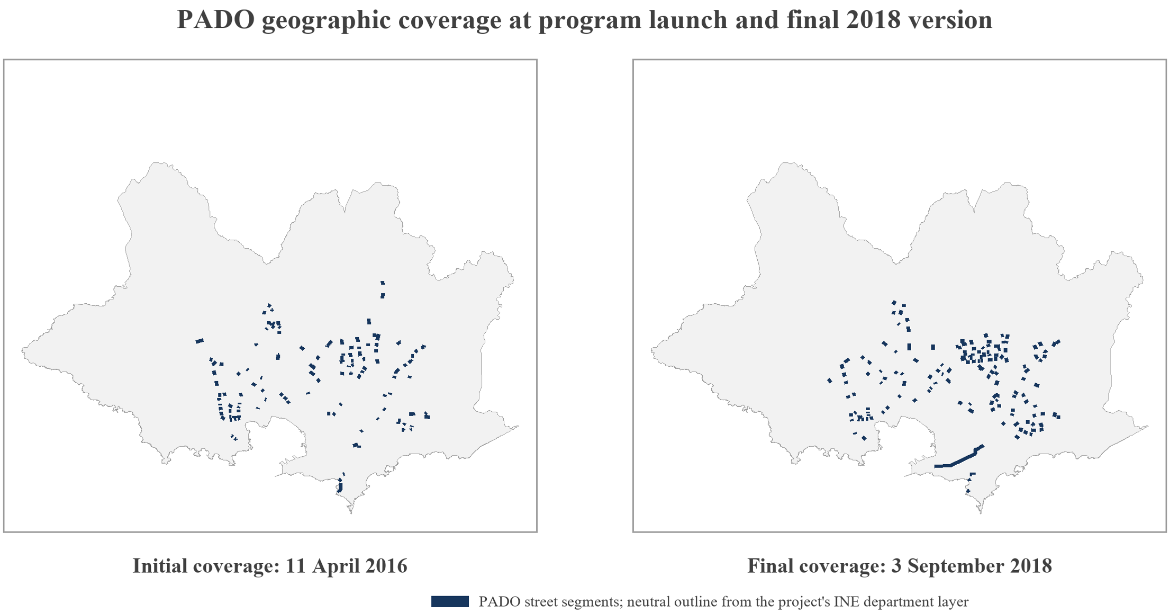

Figure A.1: PADO geographic coverage at launch and in the final 2018 version

B Analytical Samples

Table B.1: Analytical samples and pre-treatment moments

Design; frequency; window	Treatment and comparison support	Observations	Pre means: robbery; presence
Entry 10 windows; weekly [-4,+3]	964 entrant cell-windows; 2,750 never-treated cells	227,712	0.2466; 1,599.4
Exits 10 windows; weekly [-4,+3]	629 exit episodes (578 cells); 2,750 never-treated cells	225,032	0.1542; 2,252.2
Displacement 4 transitions; weekly [-3,+3]	255 treated; 711 adjacent; 9,310 stable-control cell-windows	71,932	0.1856; 1,521.4
Persistence 9 cohorts; monthly [-6,+6]	481 qualifying treated; 2,750 never-treated cells	328,003	1.015; 7,518.2

Notes: Support is counted in the natural stacked unit of each design. Pre means refer to the treated, entrant, or exiting group and report robberies first and police-presence cell-minutes second. The displacement pre means use cells treated in the spatial design.

Table B.2: Weekly descriptive moments in the main sample

Period	Variable	Mean	SD	Min	Max	Cell-weeks
All years	Robberies	0.0934	0.3324	0	14	728,416
	Police presence	1,032.6	1,230.4	0	10,080	728,416
2015	Robberies	0.0940	0.3299	0	8	182,104
	Police presence	1,008.6	1,150.9	0	10,080	182,104
2016	Robberies	0.0825	0.3097	0	7	182,104
	Police presence	999.6	1,196.8	0	10,080	182,104
2017	Robberies	0.0794	0.3031	0	6	182,104
	Police presence	1,079.9	1,282.2	0	10,080	182,104
2018	Robberies	0.1179	0.3802	0	14	182,104
	Police presence	1,042.1	1,284.7	0	10,080	182,104

Notes: The unit of observation is a cell-week. Robberies are weekly reported counts; police presence is weekly cell-minutes with at least one police GPS signal. The balanced main sample contains 3,502 complete cells observed for 208 weeks (728,416 cell-weeks); each annual block contains 52 weeks per cell (182,104 cell-weeks). These unconditional statistics combine treated and untreated observations.

C Robustness

Table 1 reports the main specification, which uses cells never treated during the ten study windows as controls, and a version that adds cell-specific linear trends. The estimated changes are +763.3 weekly cell-minutes and -0.0558 robberies in the main specification, and +703.5 and -0.0622 with cell-specific trends, respectively. Appendix Table C.2 reports the all-non-entrant comparison, which uses the same main sample but treats every cell-window in which a cell does not enter as a comparison observation. It yields +776.0 weekly cell-minutes and -0.0570 robberies. The substantive conclusion is unchanged.

For displacement, Table C.3 first reports the main four-transition 2018 design in the main and all-cell samples. It then applies the same stacked treated, adjacent, and stable-control classification to all ten principal revisions from 2016 through 2018. The all-revision results preserve the qualitative pattern: robberies fall in newly treated cells, do not increase detectably in immediately adjacent cells, and joint pretrend tests do not reject. Launch-only estimates agree with this conclusion. The broad TWFE row remains a composition diagnostic because it mixes entries, exits, changes in treatment intensity, and persistent exposure.

For persistence, the all-cell estimate over months +1 through +6 is -0.3031; excluding the single qualifying cell with prior treatment gives -0.2916. The initial April 2016 cohort remains negative through month +11, but longer pretrends are rejected. Those longer-horizon coefficients are therefore not used to claim causal persistence.

Table C.1: Police-presence effect by program phase

Phase	Treated-control	Std. error	Relative to phase 2
Phase 1	888.24***	47.22	-18.9%
Phase 2	1,095.69***	50.41	reference
Phase 3	784.61***	40.13	-28.4%

Notes: The outcome is weekly cell-minutes with police presence. Phase 1 covers April 11, 2016-March 31, 2017; Phase 2 covers April 1, 2017-April 1, 2018; and Phase 3 begins April 2, 2018. Weeks are assigned to phases by their midpoint; Table A.1 maps each PADO version to a phase. Models include cell and week fixed effects, with standard errors clustered by cell. The phase-3/phase-2 difference has $p<0.001$.

Table C.2: All non-entrant comparison

Outcome	All non-entrant	+ cell trends	Entrant pre mean	Change (%)	Observations
Police presence	776.03*** (24.90)	770.30*** (25.11)	1,599.41	48.52	280,240
Robberies	-0.05702*** (0.01143)	-0.05814*** (0.01145)	0.24663	-23.12	280,240

Notes: The all-non-entrant comparison uses the main sample and compares entrants with every cell-window in which the cell does not enter, including windows for cells that remain treated or leave treatment. Entrant pre mean is calculated over weeks -4 through -1; Change (%) is calculated from the All non-entrant estimate. Both columns include cell, year, and month fixed effects; + cell trends additionally includes cell-specific linear trends. Standard errors clustered by original cell are in parentheses. Three asterisks indicate a p-value below 0.01.

Table C.3: Displacement robustness

Specification	Treated-control	Adjacent-control	Treated-adjacent	Pretrend p-val	Observations
2018: main	-0.10179*** (0.03724)	-0.00977 (0.01503)	-0.09202** (0.04004)	0.318	71,932
2018: all-cell	-0.08409** (0.03517)	-0.00375 (0.01063)	-0.08035** (0.03696)	0.375	342,440
All rev.: main	-0.06174*** (0.02083)	-0.01156 (0.00949)	-0.05018** (0.02284)	0.603	187,369
All rev.: all-cell	-0.05518*** (0.01935)	-0.01042 (0.00668)	-0.04476** (0.02065)	0.477	865,179
Launch: main	-0.03664 (0.03329)	-0.01754 (0.01682)	-0.01910 (0.03631)	0.730	87,550
TWFE: main	-0.03877*** (0.00617)	-0.00964*** (0.00232)	-0.02913*** (0.00604)	—	728,396

Notes: The first two rows average weeks 0 through 3 in the four clean 2018 entries. The next two apply the same stacked design and [-3,+3] window to all ten principal map revisions from 2016 through 2018, excluding mixed transition weeks. The launch row averages weeks 0 through 12. Stacked models include cell-by-transition and calendar-week-by-transition fixed effects and cluster standard errors by original cell. The pretrend p-value is the joint test of treated and adjacent pre-entry coefficients. Observations are stacked cell-weeks. The TWFE row mixes entries, exits, intensity changes, and persistent exposure and has no corresponding stacked pretrend test. Two and three asterisks indicate p-values below 0.05 and 0.01, respectively.

Table C.4: Persistence robustness

Specification	Average post effect	Pretrend p-val	Observations
Main stacked	-0.28873*** (0.06558)	0.080	328,003
All-cell sample	-0.30308*** (0.06118)	0.081	1,517,087
Clean pre-period	-0.29163*** (0.06566)	0.077	327,990
Initial cohort, months +1 to +11	-0.29307*** (0.10096)	<0.001	71,832

Notes: The first three rows average months +1 to +6. The last follows the initial cohort through month +11; its longer pretrend rejects, so the estimate is descriptive. Pretrend p-values jointly test pre-entry coefficients. Clustered standard errors are in parentheses. Three asterisks indicate a p-value below 0.01.