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Productivity in teams: double crewing for police

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Abstract
Whether working in a team or alone results in higher productivity has been extensively studied in many settings, often being a controversial issue. This is none more so than for the police. Whether single or double crewing enhances or diminishes police productivity remains a perennial, contentious debate, yet credible empirical evidence is scarce. This paper provides new, quasi-experimental evidence on the causal impact of crew size on officer performance. Rich administrative data show that a policy shift (known as the 'Banded Shift Pattern') increased double crewing by altering vehicle-to-officer allocation in response teams. Double crewing significantly enhances police performance through two primary mechanisms: it improves officer productivity and reduces officer injury risks by enhancing situational safety. A cost-benefit analysis demonstrates that the performance gains of double crewing outweigh its increased operational expenses, proving it can be an effective strategy for modern policing.

Keywords: Police; double crewing; productivity; safety
JEL codes: J45; K42

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1. Introduction

Collaboration and teamwork are foundational to modern production and service environments (Arrow, 1974; Simon, 1979; Lazear and Shaw, 2007). While collaborative complementarities boost productivity through information sharing and coordinated decision-making (Hayek, 1945; Smith, 1965; Becker and Murphy, 1992), they can also be detrimental to performance due to development costs and moral hazard (Holmstrom, 1982; Garicano and Rayo, 2016). Consequently, understanding how crew or team size affects operational efficiency relative to independent work is a critical area of study for organisational performance.

Prior literature has examined the relationship between teamwork and productivity across diverse environments, exploring workplace peer effects (Mas and Moretti, 2009; Cornelissen et al., 2017), healthcare delivery teams (Bartel et al., 2014), and broader personnel economics (for recent reviews, see Bonhomme, 2026; Hoffman and Stanton, 2025). The optimal organisation of personnel - specifically whether individuals perform more efficiently alone or in groups - remains a controversial issue. This debate is particularly acute in law enforcement and policing, where the operational efficacy of single versus double crewing has been a perennial source of contention. Despite its operational significance, credible empirical evidence on the subject remains scarce, as establishing a causal link within existing policing studies has proven methodologically challenging.

This paper provides new, unique quasi-experimental evidence on the causal impact of crew size on police productivity. Police officer deployment offers a uniquely high-stakes setting in which to evaluate public-sector team production, characterised by multidimensional outputs, costly operational errors, and crew configuration as a central institutional choice. To isolate this effect, the paper leverages a major policy shift, i.e., the 'Banded Shift Pattern' (BSP), implemented by West Midlands Police (WMP), the second largest of 43 police forces in England and Wales. The BSP altered the allocation of officers to vehicles within emergency response teams, significantly increasing double crewing relative to single crew deployments during day shifts. This institutional variation provides an ideal empirical setting to analyse performance differentials between officers operating in pairs versus those responding to emergency calls alone.

Implemented in May 2018, the BSP initiative restructured how WMP allocated response officers to vehicles during emergency calls. The reorganisation aimed to reinforce, or "band", the force's three core daily shift patterns, effectively increasing double crewing capacity during peak daytime windows.[1] In practice, this shift boosted double crew deployments across two specific blocks: the Early Banded Pattern (09:00 to 18:00) and the Late Banded Pattern (12:30 to 22:00).

[1] The actual shift times over the week are: 7:00 to 16:00, 15:00 to 00:00, 22:00 to 7:00 on Monday to Thursday; 7:00 to 18:00, 16:00 to 03:00, 22:00 to 7:00 on Friday and Saturday; 7:00 to 16:00, 15:00 to 23:00, 22:00 to 7:00 on Sunday.

Crucially, this policy applied exclusively to response teams during daytime hours; it was not extended to other specialised WMP units, nor to response teams operating the overnight shift (22:00 to 07:00).

For the empirical strategy, it is important that this increase in double crewing did not stem from a resource diversion or headcount reduction in other units. Instead, the capacity was generated by optimising existing, underutilised officer availability toward the end of the night shift, when emergency demand naturally declines. This operational feature is vital for the research design: because the policy change was isolated to daytime response units, it allows overnight response teams and non-response divisions (such as neighbourhood, firearms, and public protection teams) to serve as valid, unexposed control groups to identify the causal impact of double crewing on police productivity.

The empirical analysis focuses on emergency calls dispatched to either a single crew or a double crew vehicle. By viewing these distinct configurations of labour (police officers) and capital (vehicles) as inputs within a formalised police production function, it is possible to establish a framework to isolate the performance returns to crew size. The implementation of the BSP serves as an exogenous policy shock that shifted the labour input mix between single and double crewing. Measuring the operational outcomes before and after this shift allows us to causally identify the impact of double versus single crewing on police performance.

Owing to the multidimensional nature of police performance, four measures of officer productivity are considered. The first is crime detection, which serves as the immediate objective of emergency response and the baseline for subsequent criminal investigations. The second is a measure of crime clearance from WMP operational codes. This metric registers a positive outcome if one or more offenders are charged, summonsed, cautioned, arrested, or formally identified as suspects. Because UK policing guidelines restrict arrests to cases of legal necessity, this comprehensive measure captures suspect identification both with and without physical arrest. Third and fourth, this clearance metric is disaggregated to evaluate the policy's distinct impacts on violent versus non-violent crime clearance. Finally, the possibility of a safety dividend is also assessed through officer safety, i.e., a critical institutional outcome, by measuring the probability of an officer being assaulted during an arrest or detection event. Throughout the focus is on these multiple margins of police output and comparing the resulting benefits with the additional labour cost of assigning two officers rather than one.

The likelihood of double crewing emergency responses increased significantly during day shifts following the May 2018 policy implementation of the BSP. Conversely, double crewing incidence remained unchanged among non-response units and overnight response teams, validating their use as unexposed control groups. Baseline descriptive analysis indicates that double crewed

vehicles were systematically more likely to attend crime-related calls, detect offences, and clear both violent and non-violent crimes.

Moving to a difference-in-differences (DiD) research design that uses variations in double crewing due to the BSP introduction to isolate a causal impact shows that the rise in double crewing increased police officer performance. Double crewing generates net improvements in crime detection and crime clearance rates. The likelihood that one or more crimes are detected increases by approximately 39.6%, and the likelihood of crime clearance (i.e., an offender is either charged, summonsed, cautioned, arrested or identified by the police for a crime) increases by 108.4%. When a focus is placed on incidents involving violent crime, the double crewing productivity benefits are larger. The likelihood that one or more violent crimes are cleared increases by 124.5%, while the likelihood of crime clearance for non-violent crimes remains seemingly unaffected. The fact that violent crime clearance drives these performance gains mitigates the concern that the policy may have led officers to focus on less serious offences.

While one may be concerned about a potential deterrence-productivity trade-off, the BSP did not affect the number of fleets on the streets. Additional analysis also reveals a null impact of double crewing on the average productivity of officers in adjacent emergency calls, indicating no evidence of externalities of the additional double crewing induced by the BSP. Moreover, suggestive evidence from records of assaults against officers is also presented that the rise in double crewing reduced the risk of injury during an assault and improved officer safety in dangerous situations.

The key result of net productivity improvement is robust to a large set of checks, including specifying a set of difference-in-discontinuity specifications, replicating the analysis at the officer level with officer fixed effects, restricting the analysis to officers hired prior to May 2018 and restricting the analysis to a matched sample of calls. The officer-level analysis also reveals that junior and male officers benefited disproportionately from the BSP, while benefits were equally distributed between officers with differential prior experience in double crewing and prior productivity.

Weighing up the performance and safety gains against a deliberately broad set of explicit implementation costs and implicit opportunity costs demonstrates that the double crewing policy represents a highly efficient deployment of public resources. A conservative cost-benefit appraisal - monetising the societal value of violent crime clearance alongside estimated reductions in officer injury, compared to the marginal expense of the BSP programme - indicates that the reform generated welfare gains above its operational costs. The resulting benefit-cost ratio is approximately 1.97 over the first 12 months of the programme, and all the explicit and implicit costs were fully recovered after approximately 6.09 months. This finding implies that double crewing can raise net public-sector productivity even when the additional worker cost is fully accounted for.

The findings carry broader implications for the economics of policing and law enforcement and offer two distinct contributions to those literatures. First, the study supplements established research on the crime-reducing efficacy of police resources (e.g., Levitt, 1997, 2002; Di Tella and Schargrodsky, 2004; Draca et al., 2011) by demonstrating that crew composition can operate as a critical efficiency multiplier for existing personnel and fleet deployments. Recent work has begun to show that officer identity, training, supervision, and pair interactions affect multidimensional police outputs (Ba et al., 2021b; Rivera, 2025; Adger et al., 2026; Gudgeon et al., 2026; Kwok, 2026). The present setting isolates a distinct institutional margin: an exogenous, policy-induced increase in the number of officers teamed up in a response vehicle.

Second, the paper advances the burgeoning literature on public sector productivity and state capacity. While recent evidence highlights that managerial talent, worker quality, and organisational design drive substantial disparities in public sector performance (Fenizia, 2022; Best et al., 2023), this study introduces a vital, yet to date overlooked margin: the structural assignment of frontline personnel to independent or collaborative team structures. While this operational margin is central to policing and adjacent high-stakes emergency services, rigorous causal evidence of its dual impact on productivity and occupational safety has previously remained elusive.

The paper therefore speaks to a broader organisational question, namely, when adding a co-worker raises output enough to offset the loss of independent deployment capacity. The findings indicate that the economic return to teamwork is task-dependent and team production is most valuable when communication, specialisation, and mutual protection are inputs into output, not merely features of the work environment. Policing provides a sharp test of this idea because incidents vary in complexity and risk, and most notably the largest gains from double crewing are for the investigation of violent crimes, precisely where information, speed, and safety are most complementary.

The remainder of this paper is structured as follows. Section 2 contextualises the study within the large literature on teamwork and organisational productivity, outlining the theoretical trade-offs between single and double crewing. Section 3 delineates the empirical setting, data sources, and the difference-in-differences research design used to isolate the causal impact of crew size. Section 4 delivers the primary empirical estimates, alongside a series of robustness checks evaluating the validity of the key findings. Section 5 explores the underlying operational mechanisms and presents a comprehensive cost-benefit analysis of the BSP policy. Finally, Section 6 offers concluding remarks and policy implications.

2. Double Crewing and the Productivity of Policing

2.1 Double Versus Single Crewing

The issue of double versus single crewing for police has long been discussed. Debate surrounding optimal police crew configuration features prominently in administrative and academic discussions, reflecting enduring tensions over organisational efficiency and individual officer welfare. Advocates and detractors alike highlight distinct operational trade-offs inherent to both single and double crewing. While part of this discourse is embedded strictly within the institutional context of law enforcement, it intersects broadly with the foundational organisational question of how firms and public agencies should structure teams to balance efficiency, output quality, and worker welfare.

The personnel and organisational economics literature emphasises that collaborative production can generate significant task specialisation, information economies, and operational complementarities to elevate performance. By operating in teams, individuals aggregate and synthesise fragmented information more effectively than isolated agents (Garicano, 2000). This informational advantage is highly salient for law enforcement, where rapid information collection directly determines crime clearance success during emergency responses. Conversely, team-based production can obscure individual contributions within a joint output signal, potentially inducing moral hazard, free-riding, and a subsequent decay in operational efficacy (Holmstrom, 1982; Galashin and Popov, 2016).

In law enforcement, co-dispatching officers within the same vehicle enables immediate, face-to-face collaboration, introducing a complex set of operational trade-offs long debated across economics and criminology. Applying the framework of Becker and Murphy (1992) to a policing context, the optimal crew configuration hinges on a delicate balance between the returns to team production and its coordination costs. On one hand, pairing officers generates substantial complementarities, such as heightened situational safety and enhanced capacity to aggregate critical scene intelligence. On the other hand, these benefits may be offset by team frictions, including heightened interpersonal conflict, mutual distraction, or diluted individual accountability due to free-riding.

A first advantage from double crewing where it can enhance operational efficiency is by facilitating immediate, multi-modal communication, i.e., verbal, visual, and in-person, allowing officers to rapidly exchange critical information and coordinate actions in real-time (Battiston et al., 2021). Conversely, transitioning to single-officer configurations can severely degrade performance by inflating the communication and cognitive workloads of both field units and central dispatchers. As Green and Kolesar (1984) demonstrate, response times and operational delays are heavily

contingent on a dispatcher's capacity to manage communication streams. A change from two officers to one officer in a police squad car has scope to compound this system-wide complexity, increasing task friction and bottlenecking information flows during critical incidents.

Second, double crewing can enhance officer safety through both increased tactical capability and structural deterrence. Beyond upgrading immediate tactical resilience against physical violence, the visible deployment of multi-officer units serves as an ex-ante deterrent that can prevent situational escalation. Empirically, the relationship between crew configuration and officer safety remains a subject of ongoing debate. Early foundational work by Day (1956) asserts that two-officer configurations are fundamentally safer and more effective than single-officer units. This is supported by Wilson, Brunk, and Meyer (1990), who demonstrate that single crewed officers incur significantly higher injury rates when assaulted. Similarly, qualitative evidence from the UK context indicates that solo officers perceive themselves as vulnerable targets, leading to a documented reluctance to engage with potential threats during high-risk overnight shifts (Prissell, 2009).

Conversely, several empirical studies find that double crewing does not yield superior safety outcomes. In a foundational field experiment, Boydstun, Sherry, and Moelter (1977) compared crew configurations in San Diego, concluding that single-officer patrols are as effective as, and generally safer than, two-officer units outside of specialised operational contexts. Supporting this finding, subsequent evaluations in both the US and Australia detect no statistically significant difference in safety outcomes across staffing modes, showing that assault rates remain invariant to crew size (Wilson and Brewer, 1992; del Carmen and Guevara, 2003). However, this consensus is challenged by more recent meta-analytic evidence; Fridell et al. (2009) review the literature on workplace violence and identify a robust counter-pattern, noting that the highest volume of law enforcement assaults in the US systematically involves solo officers.

Third, emergency response operates within a high-intensity, cognitively demanding environment where officers must rapidly interpret highly ambiguous situational cues. In this context, face-to-face dialogue serves as a critical mitigation mechanism against cognitive biases, such as confirmation bias and premature closure. By forcing a real-time deliberative process, double crewing reduces the probability of impulsive, sub-optimal decision-making. As Dube, MacArthur, and Shah (2025) demonstrate, mitigating these cognitive errors directly minimises the risk of adverse operational outcomes, including the escalation to excessive force, unwarranted arrests, and officer injuries. Related evidence from domestic-abuse risk assessments also shows that officer predictions can be distorted by representativeness, overreaction, categorisation, and selective attention, further reflecting how cognitively demanding police responses can be (Grogger et al., 2026).

Fourth, double crewing can enhance information gathering and subsequent crime clearance through parallel task processing and strategic demographic matching. Operationally, two-officer units can execute multiple time-sensitive investigative tasks concurrently, such as interviewing disparate witnesses simultaneously. Beyond pure operational capacity, crew diversity can mitigate social and informational divides, fostering greater trust and cooperation among victims and witnesses from varied demographic backgrounds. This alignment mirrors broader evidence that team composition determines productivity when tasks require coordination across social friction lines (Hjort, 2014). Consequently, this mechanism intersects with an established economic literature evaluating the causal links between officer identity, i.e., specifically race and gender, and law enforcement quality. For instance, Miller and Segal (2019) demonstrate that expanding female officer representation improves reporting rates and reduces domestic violence recidivism. Conversely, the literature on racial diversity yields heterogeneous results. While Lott (2000) contends that minority and female officers are, on average, less effective at crime reduction than white male officers, Donohue and Levitt (2001) uncover a distinct cross-racial enforcement pattern: an influx of minority officers significantly increases arrests of white suspects without altering non-white arrest rates, whereas an increase in white officers systematically drives up non-white arrests. More recent evidence shows that officer race and gender predict materially different stop, arrest, and force patterns in otherwise comparable circumstances, and that academy peer composition alters officers' later enforcement choices (Ba et al., 2021b; Rivera, 2025). Recent evidence finds little systematic difference between Democratic and Republican officers after adjusting for multiple comparisons, while confirming differences in enforcement by officer race and ethnicity (Ba et al., 2025).

Fifth, double crewing can introduce a peer-monitoring mechanism that increases institutional accountability and reduces the risk of officer misconduct. Operating alongside a colleague creates an immediate, internal witness, thereby raising the expected costs of misbehaviour and dampening the incentive to violate operational protocols. This structural oversight is supported by early empirical evidence from Boydstun, Sherry, and Moelter (1977); their attitudinal survey of the San Diego Police Department revealed that officers systematically perceive single crewed units as more susceptible to using excessive force relative to their double crewed counterparts. More recent evidence cautions that peer influence need not improve conduct in a single direction. An on-duty injury to an academy peer temporarily increases officers' subsequent use of force and complaints (Holz et al., 2023), while field trainers exert persistent effects on recruits' later force use (Adger et al., 2026).

On the other hand, double crewing may yield diminishing returns or negative externalities for net officer productivity. First, for a fixed total number of officers, prioritising a single crewed fleet maximises spatial coverage and visible presence relative to fewer, consolidated double crewed units.

As demonstrated by Kaplan (1979) and Mastrobuoni (2019), this dispersed configuration optimises the system-wide deterrence effect while minimising queuing times for unassigned units available to respond to incoming incidents. Second, intra-cabin, face-to-face collaboration introduces potential operational inefficiencies, as the presence of a second officer can cause peer-induced cognitive distraction and degrade driving performance during high-speed transits (Chelst, 1981; James, 2015).

Third, the presence of a colleague may act to catalyse discriminatory practices, use of force, or other institutional deviations. This mechanism aligns with recent economic evidence documenting systemic racial disparities in police use of force and demonstrating how officer assignment parameters directly shape civilian outcomes during emergency responses (Fryer, 2019; Hoekstra and Sloan, 2022). Recent work also shows that police-selected encounter data can materially understate racial disparities in force, and correcting for selection approximately doubles the estimated disparity in Chicago and Seattle (Gonçalves et al., 2025). Theoretically, these adverse outcomes are driven by institutional subcultures and a moral hazard problem, wherein the guaranteed proximity of immediate backup induces officer overconfidence. Such a behavioural shift can trigger heightened civilian resistance, leading to a higher volume of citizen complaints and injuries in double crewed units (Decker and Wagner, 1982; Johnson, 2002). Corroborating this channel, empirical evidence from Hastings (2007) confirms that use-of-force incidents occur with significantly greater frequency among double crewed teams than among solo-operating officers.

Fourth, double crewing can act to aggregate individual performance into a joint signal, introducing a team production problem that can induce shirking and a sub-optimal allocation of effort. Because individual contributions are unobservable within a shared unit, the high-powered incentives of individual accountability are diluted. Conversely, decoupling these teams can enhance performance through competitive sorting. For instance, field evidence from Boydstun, Sherry, and Moelter (1977) in San Diego and Kessler (1985) in Kansas demonstrates that deploying officers across two single crewed units, rather than a consolidated double crewed unit, introduces relative performance incentives that spark a competitive drive to minimise response latencies to the incident scene. Recent evidence on officer pairs finds meaningful interaction effects in arrests and use of force and shows that alternative pairing rules can materially alter aggregate force (Kwok, 2026).

Fifth, double crewing may diminish the perceived approachability of officers, undermining principles of procedural justice and altering the dynamics of community interactions. Because multi-officer units project a high-coercive capacity, citizens may perceive them as less accessible and more adversarial. Empirically, Decker and Wagner (1982) demonstrate that double crewed units are associated with fewer charges for resisting arrest, a pattern indicating that their collective presence deters overt challenges to police authority. However, these same units record a higher volume of

assault charges, suggesting a greater propensity to utilise physical force once a confrontation is initiated. Consistent with this, they note that civilian complaints levied against double crewed officers are disproportionately filed by individuals who sustained physical injuries during the encounter, contrasting sharply with the lower-severity complaints associated with solo officers.

Consequently, due to these offsetting theoretical mechanisms in both directions, the question of how double versus single crewing impacts police performance is ultimately an empirical question that also may differ across operational tasks. For instance, Blake and Coupe (2001) demonstrate that double crewed units achieve no incremental efficacy over solo officers when apprehending burglars red-handed. Given the constraints of the empirical setting, the individual structural parameters of each mediating channel cannot be fully disentangled. However, the primary objective of this study is to evaluate the overall net effect of these competing forces. By analysing a significant policy change on officer deployment with rich administrative incident-level data, the aim is to determine how performance varies when officers operate in teams of two instead of alone.

This discussion yields three empirically testable implications. First, if double crewing improves performance by relaxing communication and information-processing constraints, its benefits should be largest in incidents where evidence gathering, witness interaction, and rapid judgement are central. Second, if two-officer units improve officer safety, safety should be viewed not only as an outcome of interest but also as a productive input that may allow officers to engage more effectively at the scene. Third, if double crewing mainly reduces spatial coverage, any productivity gains at treated incidents may be offset by worse outcomes on adjacent calls. The empirical analysis below is organised around these trade-offs.

2.2 Related Empirical Literature

This study evaluates team size, i.e., specifically, double versus single crewing configurations, as a fundamental labour input determining public sector productivity. Crew size is a pervasive organisational feature, and the economics literature has long recognised its impact on firm performance and worker behaviour across multiple subfields. Within personnel economics, an established body of research evaluates the direct causal impacts of team structure and scale on micro-level productivity (Bonhomme, 2026; Hoffman and Stanton, 2025). Another prominent example is from collective bargaining models in labour economics which incorporate crew size - conceptualised as the labour-capital or worker-per-machine ratio - to analyse how operational staffing levels intersect with wage and employment negotiations (McDonald and Solow, 1981; Farber, 1986; Clark, 1990).

However, and despite its theoretical relevance, empirical evidence directly linking crew configuration to law enforcement performance is scarce. There is some research of relevance on crime

and policing and on police productivity that can be considered, and which speaks in part to the main questions of interest of this paper.

The sizeable literature on police staffing, deployment, and causal crime reduction is one relevant body of work. Initiated by Levitt (1997), several studies use sources of plausibly exogenous variation to isolate the causal, crime-reducing impact of aggregate police staffing levels (Levitt, 2002; Evans and Owens, 2007; Lin, 2009; Chalfin and McCrary, 2018; Mello, 2019; Weisburst, 2019; Chalfin et al., 2022).[2] Recent work extends this margin from police numbers to the allocation of officer experience across neighbourhoods (Ba et al., 2021a). Complementing these, natural experiment studies have quantified the localised returns to tactical deployment strategies, establishing clear empirical evidence that targeted police presence significantly deters criminal activity across diverse jurisdictions (Cohen and Ludwig, 2003; Di Tella and Schargrodsky, 2004; Klick and Tabarrok, 2005; Draca et al., 2011; MacDonald et al., 2016).[3] And a sizeable criminological literature documents the efficacy of specific operational frameworks, including hot-spots policing, directed patrols, and focused deterrence models, in curbing crime and improving citizen satisfaction (Telep and Weisburd, 2016; Weisburd et al., 2017). Evidence from Baltimore also shows that a large-scale focused-deterrence strategy reduced shootings and homicides while redirecting, rather than expanding, enforcement, with estimated social benefits far exceeding first-year programme costs (Kapustin et al., 2026).

However, direct economic evidence regarding how team size alters the underlying productivity and safety of these units, i.e., independent of aggregate deployment volume, remains virtually non-existent. Kwok (2026) estimates officer-pair interaction effects in arrests, stops, and use of force; by contrast, the present design isolates a policy-driven change from single to double crewing and studies crime clearance, response time, and officer safety. Closely related evidence also shows that faster police response raises crime clearance and reduces civilian injury during violent encounters (Blanes i Vidal and Kirchmaier, 2018; DeAngelo et al., 2023). This paper therefore identifies crew size as a distinct operational lever affecting response-related performance and officer safety, and it directly complements the existing findings by demonstrating that crew size acts as a key operational lever that can optimise response-related performance while simultaneously bolstering officer safety.

On determinants of law enforcement performance, and despite evidence of socio-economic consequences that policing practices impose on offenders and marginalised communities (Ang, 2021), the microeconomic determinants of police productivity have historically received limited

[2] Chalfin and McCrary (2017) provide a review of this literature.
[3] A different conclusion appears in Mastrobuoni (2019), who finds that criminals are not responsive to large regular shift changes among the different police forces in Milan.

empirical attention. This scarcity is particularly acute when evaluating multi-dimensional aspects of police output, which include crime rates, clearance metrics, conviction rates, use-of-force incidents, and institutional misconduct. A notable exception is Mas (2006) who leverages a final-offer arbitration framework to study the link between pay, compensation expectations and public sector effort. He demonstrates that officer performance degrades sharply when New Jersey police departments lose arbitration rulings and receive lower wage increases than anticipated, highlighting the role of reference-dependent incentives in public safety. More recent studies show that officers' private costs near the end of a shift affect arrest quantity and quality, that frontline supervisors alter teams' allocation of effort and dispatch performance, and that officer discretion need not maximise public safety (Chalfin and Gonçalves, 2026; Gudgeon et al., 2026; Gonçalves and Mello, forthcoming). Officer-level estimates also reveal substantial heterogeneity across enforcement, use of force, misconduct, and crime-control outcomes, underscoring the limits of treating arrests or stops alone as measures of socially productive policing (Rivera, 2026).

A different, and larger strand of literature focuses on technological capital inputs. Garicano and Heaton (2010) investigate the relationship between information technology (IT) investments and police efficiency. They find that IT capital accumulation fails to generate productivity gains unless accompanied by complementary organisational structures and management practices.[4] Exploiting the introduction of the Compstat system (a precursor of modern 'predictive policing') in US police forces, they show that combining IT infrastructure with intensive output monitoring, geographic accountability, and novel problem-solving tactics yielded significant returns, reconciling earlier scepticism regarding Compstat's efficacy (Levitt, 2004; Rosenfeld et al., 2005).[5] Similarly, Mohler et al. (2011, 2015) and Mastrobuoni (2020) document robust productivity gains from predictive policing systems in Los Angeles, Kent, and Milan, with the latter showing a marked expansion in robbery clearance rates driven by optimised patrol allocations. Recent body-worn-camera research likewise shows that technology's effects depend on activation rules, baseline institutional conditions, and officers' ability to avoid optional monitoring (Kim, 2025; Jordan et al., 2026).

Finally, a growing body of policy-relevant literature examines metrics beyond traditional clearance rates, focusing heavily on police use of force and misconduct. Because police unions are frequently hypothesised to act as institutional barriers against internal accountability and criminal prosecution (Fisk and Richardson, 2017), Goncalves (2018) and Dharmapala et al. (2022) evaluate the causal links between collective bargaining rights and officer behaviour.

[4] A number of studies in the criminology literature also conclude that investments in IT per se may not bring operational benefits (Manning, 2001; and Ratcliffe, 2002).

[5] Since the time the NYPD first adopted Compstat, similar systems have been rapidly introduced also across other US police forces (Weisburd et al., 2003).

Goncalves (2018) focuses on the intensive margin of unionisation within Florida, comparing departments that all possess collective bargaining rights. His findings suggest that while unionisation yields positive premiums for officer earnings, it exerts no long-run structural impact on agency size or the systematic prevalence of officer misconduct. Conversely, also utilising data from Florida, Dharmapala et al. (2022) exploit the 2003 legalisation of collective bargaining rights for deputy sheriffs, finding that unionisation triggered a 45% increase in violent misconduct incidents alongside a simultaneous decline in the racial and ethnic diversity of new hires relative to a control group of already-unionised departments. Recent work shifts attention from collective bargaining alone to officer heterogeneity and oversight design. Misconduct risk is partly predictable; stronger complaint investigation or public disclosure can reduce subsequent complaints or low-quality arrests; and oversight-induced behavioural changes do not uniformly increase crime (Stoddard et al., 2024; Jordan and Kim, 2025; Rivera and Ba, 2026; Ba et al., 2026).

3. Data, Descriptive Analysis and Research Design

3.1 Study Setting

The empirical study setting is the West Midlands Police (WMP) in England. The West Midlands is a metropolitan county in England served by WMP, the second largest police force in the country, covering roughly 350 square miles and serving a population of over 2.8 million. Figure 1 shows the eight Local Policing Units (LPUs) of the WMP. Each LPU is further subdivided into police beats, with the entire region covered by WMP being divided into roughly 1,200 beats. Birmingham, Coventry and Wolverhampton constitute the three major urban centres of the region, while the districts of Sandwell, Walsall, Solihull and Dudley are less densely populated. WMP is a large and complex public sector organisation that, during the study period, employed more than 6,600 police officers, more than 3,600 police staff, more than 150 special constables and nearly 440 police community support officers (PCSOs). On average, WMP receives more than 2,000 emergency calls per day and it responds to incidents 24 hours a day and seven days a week.

Emergency calls attended by one fleet with either one or two officers between July 2017 and September 2019 form the focus of this study.[6] These emergency calls constitute the main unit of analysis to study police productivity.[7] Since calls attended by multiple fleets are omitted from the

[6] Microdata from before July 2017 are not used because at the end of 2016 WMP implemented the "Transformation Programme", whereby the police force radically modified its policing strategies in many respects, including the redrawing of LPU boundaries, the adoption of different coding systems for emergency calls and policing resources, the modified allocation of tasks across WMP teams and the adoption of new technology, such as handheld devices.

[7] An alternative approach to identify the impact of crewing size on the productivity of policing may be to average out crewing size across the fleet dispatched to the same incident at different times. However, this is potentially problematic because the count and composition of follow-up fleet dispatched after the first fleet may be the endogenous result of the productivity of the first fleet.

analysis, the unit of analysis coincides with the single- or double crewing fleet attending the call. False alarms or hoaxes, as well as calls attended by foot patrol officers, are also excluded from the analysis. There are 270,607 emergency calls attended by 2,687 police officers studied in the analysis.

The production process for calls is as follows. Each incoming call is answered by a contact officer, who collects the initial set of details, grades the call by urgency and describes the incident in the internal computer system. The contact officer generates an opening code distinguishing crimes from other incidents. Calls are graded P1 to P9, with P1 and P2 calls requiring immediate response, respectively within 15 minutes (for P1 calls) and within the hour (for P2 calls), as there is a threat to life or an imminent threat of use of violence or serious injury to a person.

Subsequently, a dispatcher reads the description and allocates a fleet (callsign) depending on incident characteristics and officer availability. Dispatchers operate in a fast-paced environment and have the critical task of managing police resources on the ground and deciding which fleets are dispatched to which call. They decide the number of fleets to dispatch, and they have direct contact with the officers that are dispatched. Police officers in Britain are typically unarmed, but each Police Force also has dedicated Armed Response Vehicles (ARVs). These ARVs are not used as standard response vehicles and are therefore excluded from this analysis. Maps are available to dispatchers displaying where all WMP resources are at any one time, and their end goal is to get the fleet to the incident as quickly as possible.

The focus is on fleets featuring a team of workers which includes either one or two police officers. The fleet features a substantial degree of heterogeneity in officers' experience, gender and level of seniority. Although over 62% of calls received by WMP from 2010-19 were attended by either one or two police officers, a fleet can include more than two police officers and calls can be attended by more than one fleet, but these are excluded from this analysis.[8] The team composition – double or single crewing – is decided independently in each WMP LPU at 7:00 am, i.e., at the beginning of the working day, and is not modified during the day. Thus, the composition and size of the fleet is predetermined and does not vary in response to an emergency call. On the other hand, as the composition of the fleet changes every day, it is impossible for a dispatcher to learn the intricacies of each fleet, hence the identities and capabilities of the officer(s) associated with each fleet.

Officers dispatched to the emergency call can be either from response policing teams or from other WMP teams. Other WMP teams include teams with diverse skills and areas of expertise doing varied policing work, and include neighbourhood teams, force firearms teams, public order teams, supervision teams, dog teams, traffic and motorway teams, forensic scene investigators, events teams,

[8] This applies, for instance, to policing of football matches or political demonstrations. However, these are not the subject of study of this paper.

investigation teams, support and operational support unit teams, national police air service and others. With regard to crew size, WMP does not have an official policy.[9] The dispatcher decides which fleet to dispatch based on the location of each, the circumstances of the incident and the set of details collected by the contact officer: typically, the closest available fleet is dispatched to the scene of an emergency call, regardless of the team.[10]

The objectives of WMP are to prevent and to reduce crime and to ensure the police service is effective and efficient.[11] In the UK, the identification of a named suspect for a crime does not necessarily lead to an arrest. Arrests are in fact avoided whenever possible and they often do not constitute the goal of officers attending an emergency call, while the detection of a crime, police charges and the identification of a named suspect are the necessary initial steps for an investigation to be made and the criminal justice system to get started.

3.2 Data and Descriptive Analysis

For each emergency call, the data contain an array of information on the nature of the incident, the exact time and location of the incident, the exact time (i.e., measured in seconds) taken to dispatch a team and for the team to reach the incident scene. Information is available on the count and characteristics (e.g., gender, age, years of service and seniority in WMP) of police officers in each fleet and on the outcome of the police response. As not all emergency calls result in a criminal offence, the data allow us to distinguish between crimes and non-crime incidents. For crimes, the offence characteristics and the count and characteristics of both offenders and victims are also available.

Figure 2 shows the average share of emergency calls attended by a double crewing fleet over time without sampling restrictions. The likelihood of double crewing in WMP was 65% in July 2017, i.e., at the start of the study period. It increased by a modest 2 percentage points in the period from July 2017 to April 2018, by nearly 5 percentage points from March-May 2018, by a further 3 percentage points in the Autumn of 2018, and by a further 2 percentage points from January 2019 to September 2019, when the rate of double crewing reached a new level at over 75%.

3.3 The Banded Shift Pattern

The main objective of the empirical analysis is to quantify the causal impact of double crewing on the productivity of policing. To retrieve a causally interpretable parameter of interest, three

[9] As one can see from a recent Freedom of Information Request to WMP, *"there is no specific policy in relation to single crewing. There is no default position within Force Response with respect to single/double crewing. The allocation of officers to response call signs is based on availability of assets, assessment of risk and demand which is reviewed continually throughout the tour of duty."* (see Incidents and single crewing (1222A/22) - Freedom of Information - West Midlands Police (west-midlands.police.uk)).

[10] In principle, even off-duty police officers may intervene if they were to witness an incident that requires immediate action.

[11] As an example, the West Midlands Police and Crime Plan 2021-2025 is online and publicly available here: https://www.westmidlands-pcc.gov.uk/wp-content/uploads/2021/10/The-West-Midlands-Police-and-Crime-Plan-2021-25.pdf?x23694#:~:text=My%20objectives%20are%20to%20prevent,trust%20and%20confidence%20in%20policing.

identification problems need to be tackled. The first is that individuals and teams may self-select into treatment, a crucial concern for the identification of workers' performance effects in general, and team incentives in particular (see Prendergast 1999; Hamilton, Nickerson, and Owan 2003; Bandiera, Barankay, and Rasul 2009 and 2013; Friebel et al., 2017). Double crewing vehicles are typically dispatched to more urgent, difficult and risky situations, and thus a naïve comparison of the means is likely to retrieve a downward-biased estimate of the productivity gains generated by double crewing. Second, across firms as well as policing teams, technology and profitability differ (see Prendergast 1999), and these differences matter for decisions related to team organisation and compensation (see Boning, Ichniowski, and Shaw 2007). The final source of difficulty is potential measurement error, which may bias naïve mean comparisons towards zero and which can be addressed using instrumental variables and detailed microdata.

The plan is to tackle these challenges by exploiting the empirically observed introduction of the Banded Shift Pattern (BSP), whereby response teams in WMP experienced a sizeable deployment boost during certain times of the day when demand for policing is typically highest. In the words of Sir Dave Thompson, former chief constable of WMP, King's Police Medal and deputy lieutenant:

"Before May 2018, response officers were on constant duty through the working day, being over-resourced off-peak and stretched at peak times. The new shifts in the Banded Pattern moved resources to when they were needed most, featuring more officers and double crewing at times of the day with higher demand."

When the BSP was introduced in May 2018, police resources in WMP response teams were reorganised in order to boost deployment in the day shifts, i.e., the Early Banded Pattern was introduced from 9:00 to 18:00 and the Late Banded Pattern from 12:30 to 22:00. Prior to May 2018, each day had three operating shifts running from 7am to 3-4pm, from 2-3pm to 11pm-midnight and from 10pm to 7am, while two shifts were on rest day. In total, at any point in time there were five shifts, three of which busy working and two on rest. This basic organisation remained unchanged after May 2018. As shown in Figure 3, until the BSP was introduced, the same number of officers and fleet was on duty in each operating shift and thus at all hours. Therefore, if each shift had n officers, n officers were on duty at all times.

Figure 4 and Table 1 focus on the six months surrounding the introduction of the BSP in May 2018, i.e., from February to July 2018, to study descriptively whether in fact the BSP was effective at relocating officers in response teams to busier shifts during the day. To this end, a balanced panel dataset was defined from the administrative WMP data on the count of emergency calls attended by

all the 5,683 officers on duty in WMP during that period. The unconditional descriptive comparison in Figure 4 shows that, after the introduction of the BSP, officers in response teams during the day experienced a differential increase in the count of emergency calls attended on average, while a much smaller change occurred in other teams during the day and little to no change occurred after May 2018 during the night both in response teams and other teams.

The descriptive estimates in Table 1 represent the regression analogue with fixed effects to Figure 4. They indicate that, while before the BSP officers in response teams during the day shifts typically attended 2.19 emergency calls on average, officers on duty in response teams during the day after the introduction of the BSP increased their average daily count of emergency calls by 9.3%-14.5% (depending on specification). This holds true also when officer fixed effects are included in the estimated equation in columns (3)-(8), therefore suggesting that response officers who were switched to the day-time shifts as a result of the BSP started to respond to more emergency calls on average. Columns (2), (4), (6) and (8) also show that these estimates do not reflect a differential underlying trend in the count of emergency calls attended by response teams during the day, as no differential pre-trend appears in the two weeks prior to May 2018 between response teams during the day and all other officers. The descriptive results in Figures 3 and 4 and Table 1 support the notion that response officers were on constant duty through the working day prior to the BSP, and what this policy change did was address pre-existing inefficiencies to allocate officers more efficiently and according to demand, thus resulting in more emergency calls being attended at peak times.

Figure 5 focuses on the emergency calls for the entire period of the analysis separately for response teams and other teams and it shows the evolution of double crewing. In particular, it shows the average share of double crewing vehicles attending an emergency call during the day and at night before and after the introduction of the BSP. The steep increase in the likelihood of double crewing in response teams in day shifts after May 2018 appears evident. Figure 5 also shows that the likelihood of double crewing in response teams in night shifts and in other teams increased ever so slightly after May 2018. Prior to May 2018, double crewing was already the norm at night for response teams. Since May 2018, arguably as a result of the Banded Pattern, response teams started to face a marked increase by approximately 8 percentage points in the share of double crewing teams during day calls, resulting in a much more uniform distribution of double crewing throughout the day. In contrast in other teams, where the BSP was not adopted and no other organisational change occurred during the study period, there was no significant change since May 2018 in the likelihood of double crewing both during the day and at night.[12]

[12] Appendix Figure A.1 also shows descriptively that after May 2018 idle time reduced for response officers during the night and it increased during the day, which is consistent with the notion that the BSP "switched response officers to

Since, prior to the BSP, the same number of officers was on duty in each shift, WMP response officers were *de facto* underutilised late at night and early in the morning, in particular from 3am to 7am, while WMP struggled to attend all emergency calls and sometimes ran out of officers in the late afternoon/early night. In May 2018, the shift pattern was amended to address this and make more officers available during this time. The introduction of the BSP implies that, for each of the five shifts mentioned above, one third of police officers started to follow the banded pattern (from 9am to 6pm; and from 12:30 to 10pm), thus increasing (decreasing) the number of available police officers during (outside) these busy times. In particular, since May 2018 each shift in WMP response teams is split into 3 so that, if a given shift has n officers, $n/3$ officers are in each group: at any one time, this shift has two thirds on the 'core' or normal pattern and one third on the 'banded' pattern. This then rotates so that all groups take their turn on the banding. The intention of the BSP was to give more officers during the really busy bit at 7pm, splitting the nightshift so that only half would be on duty from 10pm to 7am, while the other band back and start at 7pm (to help out the late shift).

The BSP was introduced in response teams and not in other WMP teams. Moreover, during the study period no change occurred in the definition of emergency calls nor in the allocation of fleet across teams or hours of the day. While response teams in WMP experienced a boost in officers' deployment during day shifts, this boost did not originate from a reduction in police deployment in other WMP teams. It originated from a reallocation of police officers across time but drawing on pre-existing excess supply of officers late at night within response teams, implying that response teams in night shifts and other teams can be used as comparison group.

Figure 6 shows differences in average double crewing in WMP on any one date and police shift in response to emergency calls separately by treatment status, i.e., separately for response teams in day shifts (T = 1) and other teams or response teams in the night shift (T = 0). The Figure shows that, while the likelihood of double crewing in treated teams and other teams in response to emergency calls featured different average levels with a 5 percentage points difference from July 2017 to April 2018, these averages evolved in parallel over time from July 2017 to April 2018. During this pre-policy period, approximately 81% of vehicles in response teams in day shifts and 76-77% of other vehicles were double crewed. However, the May 2018 introduction of the BSP caused a discontinuous increase of double crewing in response teams in day shifts by nearly 10 percentage points, while leaving other teams' crew size unaffected by the end of the study period. While double crewing increased discontinuously in May 2018 in response teams in day shifts reaching almost 90%, the pre-

demand", it reduced prior inefficiencies and under-utilisation of officers during the night and it made response officers less stretched during day shifts.

existing trend in other teams since before May 2018 remained substantially unchanged with the likelihood of double crewing fluctuating at around 75-80% by September 2019.

Finally, Appendix Table A.1 focuses on the 2,687 police officers who responded to emergency calls in WMP during the study period. It shows individual level determinants of being a response officer in day shifts, i.e., the treatment status, prior to the introduction of the BSP. The unit of observation is the police officer responding to an emergency call. The analysis is conducted on all the emergency calls received by WMP before May 2018, i.e. pre-BSP. Results show that no selection by gender, nor by years of service in WMP or age, appears in treated teams prior to the introduction of the BSP. Senior police officers, defined as Chief Constables, Deputy Chief Constables, Superintendents, Inspectors and Sergeants, are as likely to be in treated teams as junior police officers, defined as Constables, Special Constables, Temporary Sergeants, Special Sergeants and Police Community Support Officers (PCSOs).[13] The conclusion that WMP officers in treated teams and other teams prior to the BSP are observably similar is not altered by the addition (column (8)) of fixed effects for date, incident hour and P1 vs P2 call, which indicates call urgency in the opening code.

3.4 Framework and Research Designs

The analysis uses WMP administrative microdata from July 2017 to September 2019 to study whether and how team size and the presence of one co-worker influence the outcome of police responses to emergency calls and the behaviour and safety of police officers. The unit of observation is the WMP fleet attending an emergency call and the analysis starts in July 2017. As stated previously, earlier data cannot be used because the "Transformation Programme" implemented by WMP in December 2016 radically changed over the subsequent months the policing strategies of WMP in many respects. In contrast, the July 2017 to September 2019 period was relatively stable in WMP and the introduction of the BSP was the only notable change in the police force, and thus empirical study of emergency calls received by WMP during this period allows retrieval of generalisable, externally valid estimates of the impact of double crewing on police performance.

The empirical focus is restricted to emergency calls in either a single crew or a double crew vehicle. Formally, a general structural police production function for a given emergency incident i can be defined as $Y_i = F(K_i, L_i)$ where Y represents operational output, K the capital input (number of vehicles), and L represents the labour input (number of officers). This production function can be rewritten as a function of total capital and the labour-capital ratio L/K, yielding $Y_i = G(K_i, L_i/K_i)$. Limiting to a single dispatched asset ($K_i = 1$) holds capital constant, meaning that variation in output is driven solely by crew size ($L_i/1$). This parameterisation isolates two operational scenarios

[13] In England, special constables are volunteers who have the same powers as police officers, while PCSOs work with police officers and share some, but not all of their powers.

characterised by asymmetric labour costs, which are dependent on how many officers in a vehicle are dispatched to an incident. Recognising that $K_i = 1$ and L_i is defined in integer space {1, 2} for single and double crewing gives empirical measures for a given dispatched vehicle as:

i) S_1 - one single crewed dispatched fleet: K = 1; L =1 → L/K = 1;

ii) S_2 - one double crewed dispatched fleet: K = 1; L = 2 → L/K = 2.

The principal objective of this paper is to assess the performance effects of working in a team of two dispatched officers versus a single officer dispatched to an incident alone. Scenario S_2 is the treatment of interest, a single double crewed vehicle with a labour-capital ratio of 2, that can be compared to scenario S_1.[14] The impact on police performance for S_2 versus S_1 is evaluated and an assessment of whether the benefit-cost ratio is higher or lower for double crewing versus single crewing operations is undertaken.

The research design specification used to isolate the causal impact of transitioning an incident from S_1 to S_2 exploits the exogenous variation in crew configurations generated by the BSP policy change. These scenarios can be mapped into a generalised difference-in-differences (DiD) framework estimated at the incident level as:

$$Y_{ict} = \alpha + \beta(\text{Double Crew}_{ict}) + X'_{ict}\delta + \theta_c + D_t + \varepsilon_{ict} \quad (1)$$

where Y_{ict} is the operational outcome of incident i handled by unit type c at time t. $(\text{Double Crew}_{ict})$ is a binary variable equal to 1 if the incident is handled under Scenario 2 (S_2, double crewed) and 0 if handled under Scenario 1 (S_1, single crewed). The X_{ict} vector captures incident-level controls, while θ_c and D_t represent unit and day fixed effects, respectively. In (1), the coefficient β is an ordinary least squares estimate of the net marginal return to public productivity when transitioning from a single-officer (S_1) to a double-officer (S_2) operational configuration.

Because the BSP policy dictates the availability of crew structures rather than deterministically assigning every single incident, the actual crew configuration observed in the field remains an endogenous operational choice which can introduce bias in β. To recover a causal impact of transitioning from S_1 to S_2, an Instrumental Variables (IV) approach is adopted, using the BSP policy shift as a difference-in-differences instrument. In this framework, the BSP policy acts as an instrumental shifter in the probability of an incident being assigned to the S_2 state during daytime

[14] One may also be interested in a scenario S3 - two single crewed dispatched fleets, K = 2; L = 2; L/K = 1 and its comparison to scenario S2. In this case, the focus would be on emergency calls attended by two officers in either one or two dispatched fleets. Since the goal of the paper is to assess the productivity gains from double vs single crewing in policing, this analysis is not presented in the paper. However, results are available upon request. When this scenario is included in the analysis, the takeaway that double crewing generates productivity gains in policing remains unchanged.

shifts for response teams, while leaving overnight and non-response units unexposed. The system is jointly estimated at the incident level via the following specifications:

$$\begin{aligned}
&\text{First stage} && (\text{Double Crew})_{ict} = \beta_1(\text{Response}_c \text{ x Day Shift}_i \text{ x Post}_t) + X'_{ict}\delta_1 + \theta_c + D_t + \varepsilon_{1ict} \\
&\text{Reduced form} && Y_{ict} = \beta_2(\text{Response}_c \text{ x Day Shift}_i \text{ x Post}_t) + X'_{ict}\delta_2 + \theta_c + D_t + \varepsilon_{2ict} \qquad (2) \\
&\text{Second stage} && Y_{ict} = \beta_3(\widehat{\text{Double Crew}})_{ict} + X'_{ict}\delta_3 + \theta_c + D_t + \varepsilon_{3ict}
\end{aligned}$$

In the first stage, $(\text{Double Crew})_{ict}$ - the endogenous indicator for an incident being handled under Scenario 2 versus Scenario 1 - is instrumented by the three-way interaction across unit type (Response_c), day shift (Day Shift_i) and the post-BSP introduction time period (Post_t) that maps the policy's structural boundaries. This instrument is equal to 1 only for incidents handled by daytime response teams during the post-implementation era. The first-stage coefficient on the instrument, β_1, captures the policy's compliance rate by measuring the localised increase in double crewing. The reduced form coefficient on the instrument, β_2, shows policy induced shifts in crime outcomes. When put together, entering the predicted probability of double crewing generated from the first stage into the crime equation produces, under the standard IV exclusion restriction, an estimate where the instrument affects police performance solely through its disruption of the labour-capital configuration. Under the identifying assumptions, the second stage coefficient β_3 (equal to the ratio of the reduced form and first stage coefficients β_2/β_1) identifies a local average treatment effect (LATE) of shifting from a single-officer deployment (S_1) to a double-officer deployment (S_2) for policy-compliant responses (de Chaisemartin and D'Haultfœuille, 2018).

Additionally, the immediate nature of the discrete jump in double crewing on BSP introduction, shown very clearly in Figures 2 and 6, offers an opportunity to estimate difference-in-discontinuity specifications, or more precisely interrupted time series estimates since the days variable defines the policy. When time itself acts as the running variable, the design transforms into a Regression Discontinuity in Time (RDiT) framework. Applying a Difference-in-Discontinuities (DiDC) logic to this temporal setup essentially evaluates an Interrupted Time Series (ITS) (or an event study with a control group). These specifications again can use the BSP introduction as an instrumental variable, with estimations augmenting the full sample specifications above with days as a running variable and focusing on narrower time windows around BSP introduction. The additional value-added this offers is to give an assessment of whether the one-off change that permanently shifts DC incidence impacts police performance. The system is jointly estimated at the incident level via the following specifications:

$$\text{First stage} \quad (\text{Double Crew})_{ict} = \beta_4(\text{Response}_c \text{x Day Shift}_i \text{x Post}_t) + (\text{Post}_t) + (\text{Response}_c \text{x Day Shift}_i) + Date_{ict}((\text{Response}_c \text{x Day Shift}_i \text{x Post}_t) + (\text{Post}_t) + (\text{Response}_c \text{x Day Shift}_i)) + X'_{ict}\Gamma + \theta_c + \varepsilon_{4ict}$$

$$\text{Reduced Form} \quad Y_{ict} = \beta_5(\text{Response}_c \text{x Day Shift}_i \text{x Post}_t) + (\text{Post}_t) + (\text{Response}_c \text{x Day Shift}_i) + Date_{ict}((\text{Response}_c \text{x Day Shift}_i \text{x Post}_t) + (\text{Post}_t) + (\text{Response}_c \text{x Day Shift}_i)) + X'_{ict}\Gamma + \theta_c + \varepsilon_{5ict} \quad (3)$$

$$\text{Second stage} \quad Y_{ict} = \beta_6(\widehat{\text{Double Crew}})_{ict} + (\text{Post}_t) + (\text{Response}_c \text{x Day Shift}_i) + Date_{ict}((\text{Response}_c \text{x Day Shift}_i \text{x Post}_t) + (\text{Post}_t) + (\text{Response}_c \text{x Day Shift}_i)) + X'_{ict}\Gamma + \theta_c + \varepsilon_{6ict}$$

This design compares the discontinuity at the BSP cutoff for treated observations with the corresponding discontinuity for untreated observations, while allowing the relationship between outcomes and the running variable to differ by treatment status and by pre- versus post-policy period. The excluded instrument in the first stage is $(\text{Response}_c \text{x Day Shift}_i \text{x Post}_t)$, which captures the differential jump in double crewing for daytime response-team incidents at the cutoff. The remaining interactions with $Date_{ict}$, a continuous variable indicating the date of the emergency call that is used as the running variable, flexibly control for smooth trends in the running variable on either side of the 1st May 2018 threshold, i.e., the date the BSP was introduced. The second stage replaces actual double crewing with its predicted value from the first stage. Under the exclusion restriction that the differential discontinuity at the BSP threshold affects outcomes only through induced changes in crew configuration, β_6 identifies a cutoff-specific LATE of double crewing for incidents whose crew status was shifted by the BSP.

4. Results

4.1 Unconditional Results

Table 2 shows a set of naïve comparisons of the likelihood of double crewing and the productivity outcomes of interest before and after the introduction of the Banded Shift Pattern (BSP) between response teams in day shifts, i.e., the Treatment (T) teams, and other teams in West Midlands Police (WMP). Unconditional comparisons are presented for all emergency calls from July 2017 to September 2019.[15] Prior to May 2018, treated teams were more likely to operate in double crewing

[15] Appendix Table A.2 reports naïve mean comparisons of proxies for officer selection and productivity for double and single crewed fleet before and after BSP introduction, separately for treated response teams on day shifts (treated teams) and other WMP teams. Panel A shows that double crewed fleet were more likely than single crewed fleet to be dispatched to emergency calls initially coded as crimes: 35.5% versus 26.7%, an 8.8 percentage-point gap. After the BSP, in double crewed cars the differential dispatch rate rose by 5.9 percentage points. Panel B shows a similar pattern for crime detection. Double crewed fleet detected a criminal offence in 30.3% of emergency calls, compared with 22.1% for single crewed fleet. Post-BSP introduction, the differential detection rate rose by 6.5 percentage points. Panel C shows that double crewed fleet also cleared more crimes, i.e., 25.6% versus 13.1% for single crewed fleet, and their clearance rate

fleet, to be dispatched to calls labelled as crimes in the opening code by the dispatcher, to detect a criminal offence and to clear both violent and non-violent crimes (i.e., to charge, summons, caution, arrest or identify by name an offender for a crime). These discrepancies are consistent with response teams being the first public face-to-face contact for victims of crime in need of immediate help.

The Table also shows that the likelihood of double crewing in treated teams increased by 8.1 percentage points after May 2018 while it remained stable in other teams, resulting in an 8.2-percentage-point difference-in-differences unconditional estimate (corresponding to 10.1% of the pre-BSP average in treated teams). The fact the likelihood of double crewing remains substantially stable in control teams is unsurprising because treated teams and other teams did not exchange fleet, thus not affecting the likelihood of double crewing in the other teams, as a result of the BSP.

Columns (4)-(6) show that the likelihood of treated teams to be dispatched to calls labelled as crimes in the opening code by the dispatcher decreased by approximately 3.3% and Columns (7)-(9) show that after May 2018 the likelihood of treated teams to detect a crime increased by an insignificant 1.2% in comparison with other teams. Subsequent columns focus on crime clearance, i.e., the likelihood to charge, summons, caution, arrest or identify an offender, and they show that crime clearance rates increased among treated teams by a significant 5% for all crimes, by 7.5% for violent crimes and decreased by an insignificant 4.8% for non-violent crimes.

4.2 Conditional Results

Table 3 subjects these descriptive findings to a more rigorous econometric analysis. In the Table, column (1) shows the first-stage, while subsequent columns show reduced form and IV estimates of the system of equations (2). All columns control for a set of fixed effects for the date of the incident, for treatment status, for team, P1 vs P2 call (which indicates the urgency of the call), and hour of the incident interacted with pre and post indicators (i.e., dummy variables respectively taking value 1 before or after May 2018 and 0 otherwise). The unit of observation is the emergency call attended by one fleet and standard errors were two-way clustered by date and the "WMP team * hour of the incident" interaction in all estimates, resulting in 331 clusters. Reported % effects were calculated as the estimated coefficient divided by the mean of the dependent variable in the treatment group prior to May 2018.

In the Table, column (1) shows a strong and positive first-stage estimate of the impact of the BSP on the likelihood of double crewing. In particular, estimates in column (1) suggest that the

differential increased by 4.9 percentage points after May 2018. Panels D and E separate violent and non-violent crime clearance. Double crewed fleet cleared violent crimes in 20% of emergency calls and non-violent crimes in 5.7%, both roughly twice the corresponding rates for single crewed fleet. After May 2018, in double crewed fleet the differential violent crime clearance rate rose by 4.7 percentage points, while non-violent clearance was unchanged. All the patterns hold for treated and non-treated fleet, indicating that these productivity trends are not specific to BSP treatment status.

likelihood of double crewing increased by 10.6% due to the BSP. In columns (2) and (3), Panel A additionally indicates that the BSP did not affect the likelihood of treatment teams to attend emergency calls classified as crimes in the opening code. IV estimates show that double crewing does not exert a causal impact on the likelihood to attend emergency calls classified as crimes in the opening code. This result appears plausible considering the production process for calls described in Section 3 and the fact that dispatchers operate in a fast-paced environment and their duty is to allocate a fleet as soon as possible to the incident depending on incident characteristics and officer availability.

Subsequent columns show the reduced form and IV estimates of the impact of double crewing on the key metrics of police productivity, namely crime detection in the closing code of the call (columns (4)-(5)), crime clearance (columns (6)-(7)), proxied by whether any offender was either charged, summonsed, cautioned, arrested or identified by the police, violent crime clearance (columns (8)-(9)) and non-violent crime clearance (columns (10)-(11)).

Reduced form and IV estimates in columns (4)-(7) show that BSP introduction increased the likelihood of treated teams to detect a crime and to clear a crime in response to an emergency call. Reduced form estimates indicate that the BSP increased the crime detection rate by 3.4% and the crime clearance rate by roughly 9.2% among treated teams, and IV estimates indicate that double crewing increases the crime detection rate by 39.6% and the crime clearance rate by roughly 108%. Estimates in column (8) indicate that the BSP increased the clearance rate for violent crime by roughly 10.5% among treated teams, and IV estimates in column (9) show that double crewing increases the violent crime clearance rate by roughly 124.5%, while columns (10)-(11) show a set of positive but statistically insignificant estimates for non-violent crime clearance.[16] This, in turn, indicates that the crime clearance gains from double crewing are driven by the improved ability of officers to clear violent crimes, while the ability to clear other, non-violent crimes does not show a statistically detectable change in the baseline specification.

The causal interpretation of the findings in Panel A relies on the absence of differential trends between treated teams and other teams in the outcome variables of interest. Panel B presents first-stage, reduced form and IV estimates adding tests for the presence of differential pre-trends between treatment and control observations. Figure 7 also presents event study reduced form estimates that test this for all the outcomes of interest. In all cases, event study estimates use the full set of controls as in Panel A of Table 3. For each outcome, Figure 7 displays point estimates and 95% confidence

[16] The IV magnitudes are reassuring when compared with the unconditional double-minus-single differences in Appendix Table A.2. For detection and non-violent clearance, the IV estimates (12.7 and 3.4 percentage points) closely match the unconditional differences (12.1 and 3.0 percentage points). For overall and violent-crime clearance, the IV estimates (28.3 and 24.9 percentage points) are approximately twice the unconditional differences (15.5 and 12.5 percentage points). These magnitudes are economically plausible, because unconditional comparisons may understate the benefits of double crewing if double-crewed vehicles disproportionately attend incidents that would be harder for a single officer to resolve.

intervals for each 90-day period before and after May 2018. Results in Panel B of Table 3 and Figure 7 show that the interactions between the treatment status and the 90-day pre-periods are numerically small and statistically insignificant for the likelihood of dispatch to a crime call, crime detection, crime clearance and violent crime clearance. Therefore, as a whole results in Table 3 can be interpreted as causal and showing that, although treated teams and other teams were dispatched to similar emergency calls after May 2018, the BSP enabled treated teams to detect and clear more crimes, especially violent crimes, while leaving clearance of other crimes unaffected. The concentration of gains in violent crime clearance is consistent with a task-complexity interpretation. Violent incidents are precisely those in which uncertainty, safety risk, victim and witness interaction, and rapid evidence collection are most salient. These are the conditions under which the complementarities from teamwork should be largest.

4.3 Difference-In-Discontinuity Estimates

The results from difference-in-differences specifications in Table 3 indicate that double crewing generates sizeable benefits to police productivity especially in violent circumstances compared with single crewing. Yet, one may worry that some unobserved idiosyncratic change may have occurred in treated teams at some point during the study period. If, for instance, treated teams experienced a technological shock, e.g., if they started to use better vehicles at some point, in turn that may have directly affected the productivity and safety outcomes of policing that are studied here and the exclusion restriction of the IV analysis would therefore be violated. This seems unlikely and we are not aware of any such change over time that was specific to treated teams.

However, to mitigate this concern and to complement the difference-in-differences estimates in Table 3, the system of difference-in-discontinuity specifications (3) was also estimated. As illustrated in equations (3), the date of the emergency call was used as the running variable and the discontinuous change for treated teams (vs other teams) in the likelihood of double crewing and police productivity in May 2018 was estimated. This specification has the advantage that effects are estimated at the discontinuity, i.e., in May 2018, and therefore they cannot be driven by any unobserved idiosyncratic change that may have occurred in treated teams away from May 2018.

The results of difference-in-discontinuity (interrupted time series since time is the running variable) analysis are presented for all outcomes of interest in Table 4. Results are presented using one year of data post-May 2018 in Panel A and using six months of data either side of the introduction of the BSP in May 2018, i.e., from November 2017 to October 2018, in Panel B. All specifications control for the treatment status, the Post indicator (i.e., Post-May 2018) and the continuous trend for date of the emergency call together with its interactions with treatment status, with Post (i.e., post-May 2018) and with the "Post x Treatment" interaction.

The results in Table 4 are fully coherent with those in Table 3, and the event studies in Figure 7 which show a productivity kick up in the first year, followed by a plateauing out thereafter. In particular, column (1) in both panels shows a strong and positive first-stage estimate of the introduction of the BSP on the likelihood of double crewing in May 2018. Columns (2)-(3) also show that in May 2018 there was no discontinuous increase for treatment teams in their likelihood to be dispatched to crime calls. Subsequent columns show that in May 2018 the likelihood of treatment teams to detect a crime discontinuously increased by approximately 5%, the likelihood to clear a crime increased by 11%-12%, the likelihood to clear a violent crime increased by approximately 13% and in this case also the likelihood to clear a non-violent crime appears to increase by 3%-6.4%. Columns (5), (7), (9) and (11) indicate that, depending on the time window used around May 2018, double crewing increases the likelihood of crime detection in response to an emergency call by 44.9%-62%, the likelihood of crime clearance by 106.5%-137%, the likelihood of violent crime clearance by 121%-164% and the likelihood of non-violent crime clearance by 47.6%-58.1%. The results remain nearly unchanged when a richer set of fixed effects is included in the estimated equation and the full dataset is used.[17]

Figure 8 provides graphical evidence for the difference-in-discontinuities IV estimates reported in Panel A of Table 4. Each panel plots the outcome against days to or from the introduction of the BSP. The Figure compares response teams during daytime with other teams before and after the policy change. The causal effect is identified by the change in the discontinuity at the cutoff for response teams, net of the corresponding change for other teams. The fitted lines use the same estimation samples and specifications as the reported regressions, while the binned points are included to summarise the underlying data visually. In Figure 8, the plotted discontinuities correspond to the IV estimates of the effect of double crewing. The Figure confirms there was little change in the propensity of response teams to be dispatched to crime calls, whereas there was a discontinuous increase in the likelihood of crime detection, crime clearance and violent crime clearance. No other discontinuous jump appears in the data away from the discontinuity for treated teams nor for other teams.[18] Therefore, results in Table 4 and Figure 8 provide support for the conclusions of the main

[17] The set of difference-in-discontinuity estimates of the impact of double crewing on selection into crime calls and productivity using the full period of data from July 2017 to September 2019 is presented in Appendix Table A.3. Appendix Table A.4 also shows results for the three time windows used for this analysis when controlling for response team fixed effects; hour of the emergency call fixed effects and its interaction with the Post indicator; and P1 vs P2 call fixed effects.
[18] Appendix Figure A.2 shows difference-in-discontinuity estimates also from July 2017 to April 2019 (One Year Post BSP) but with the Full Set of Fixed Effects, i.e., response team fixed effects; hour of the emergency call fixed effects and its interaction with the Post indicator; and P1 vs P2 call fixed effects. Appendix Figures A.3 and A.4 do likewise for the period from November 2017 to October 2018 (Six Months either side of BSP), while Appendix Figures A.5 and A.6 do likewise for the entire period of the analysis from July 2017 to September 2019. Regardless of the time window used in the analysis, estimates appear very coherent and no discontinuous jumps appear away from the 1st May 2018 cutoff.

difference-in-differences analysis and mitigate the concern that some unobserved idiosyncratic change in treated teams at some point during the study period may act to confound the results.

4.4 Matched Estimates

One natural question to ask is also whether the emergency calls attended by the treated teams (i.e., response teams during the day) and those attended by response teams at night and other teams are truly comparable. One may worry that there might be systematic differences either in the types of emergency calls these two groups attend or in the differential conditions in which officers might operate. For example, one may worry that officers at night may be more tired, and therefore that the findings might reflect greater tiredness in the control group, rather than the genuine impact of double crewing on the police productivity metrics.

To mitigate this concern, Appendix Table A.5 replicates the main analysis on a matched sample of fleet. Each treated fleet was matched with a counterfactual fleet using 1:1 nearest-neighbour propensity score matching. The propensity score was estimated by predicting the treatment status using a probit model that includes as covariates the precise location (i.e., police beat), date, hour and opening code of the emergency call. *De facto*, this implies that only daytime calls that look observably very similar to the emergency calls attended by the treated teams are included in the control group. When the analysis is conducted on the matched sample, the same set of controls and fixed effects as in the main analysis are added to the estimated equation and standard errors are still two-way clustered at the date and "team x hour" level.

Appendix Table A.5 is organised in the same way as Table 3. The reduced form and IV estimates on the matched sample suggest that any potential systematic difference in the types of calls attended by treated teams and others is not driving the conclusions. In particular, the estimates in columns (2)-(3) confirm that the BSP did not make response teams more likely to attend "crime" calls. The estimated reduced form and IV effects are negative and either statistically insignificant or weakly significant.

Columns (4)-(7) confirm that the BSP increased the likelihood of treated teams to detect and clear a crime in response to an emergency call. In particular, columns (4)-(5) suggest that treated teams became 2.8% more likely to detect a crime after May 2018 and that double crewing vehicles are 40.2% more likely to detect a crime. As estimates are not always significant in columns (4)-(5) of Appendix Table A.5, a word of caution is in order. In contrast, columns (6)-(7) show that treated teams clearly became 9.2% more likely to clear a crime after May 2018 and that double crewing vehicles are 142.1% more likely to clear a crime. This effect too appears driven by violent crime clearance, as the reduced form and IV estimates on the matched sample displayed in columns (8)-(9) also confirm the results in the main analysis. The BSP increased the likelihood of treated teams to

clear a violent crime by 10%-12% and double crewing vehicles appear 161.5% more likely to clear a violent crime. In contrast, estimates in columns (10)-(11) for non-violent crime clearance appear positive but statistically insignificant as in the main analysis. Reassuringly, no evidence of differential pre-trends appears in Panel B for any of the metrics of police productivity. In sum, estimates on the matched sample of emergency calls suggest that any potential systematic difference in the types of calls attended by treated teams and others is not driving the conclusions.

4.5 Estimates for Incumbent Pre-BSP Officers

Finally, one may wonder whether compositional changes over time in the police workforce may contaminate the difference-in-differences results. If, for example, the introduction of the BSP coincided with disproportionate hiring of new officers in response teams, then the exclusion restriction may be violated for the IV estimates. Based on our discussions with WMP officers, the introduction of the BSP did not coincide with any new wave of hiring in WMP. However, to address this potential concern, results were re-estimated restricting the analysis to police officers employed in WMP since prior to May 2018, thus holding the quality of officers, i.e., L, constant over time and mitigating the potential concern that changes in the composition of the police workforce might contaminate the results.

Appendix Table A.6 shows the results of this exercise. The Table is organised as Table 3 and the results look like a replication of those in Table 3. In particular, and regardless of the sampling restrictions, IV estimates in Appendix Table A.6 show that double crewing does not affect the likelihood of pre-existing officers to be dispatched to "crime calls", but it makes them more likely to clear a crime, especially a violent crime, while it leaves non-violent crime clearance unaffected. The results for crime detection appear positive but statistically insignificant, suggesting that this result should be treated with caution. However, for crime clearance, especially for violent crimes, these results suggest that any potential compositional change that may have occurred over time in the police workforce is not driving the conclusions.

4.6 Deterrence and Externalities

Did the greater likelihood of double crewing in treatment teams induced by the BSP coincide with a lower number of police fleet dispatched on the streets? If this was the case, then the BSP may have come at the cost of a reduced deterrence effect of police fleet in the street, and estimates in Table 3 may be picking up both the productivity-enhancing effect of double crewing and the negative deterrence effect of the BSP due to the lower number of dispatched fleet (see Mastrobuoni, 2019).

As discussed above, there was no re-allocation of patrol fleet across the various functions of WMP. The BSP can be thought of as a more efficient allocation of labour across times of the day. It reorganised the deployment of police officers across times of the day by exploiting the spare capacity

of officers in the night shift and by boosting deployment in the day shifts when not enough officers were being deployed, but the fleet remained constant both across teams and across times of the day. To our knowledge, confirmed by interviews with the WMP, there was no re-allocation of fleet across the various functions of WMP. The fleet for both response teams and other teams is fixed but naturally fluctuates slightly as the WMP car park gets continuously refreshed. This is illustrated in Table 2, where the likelihood of double crewing appears nearly unchanged in other teams after May 2018.

Appendix Table A.7 shows an additional set of empirical tests of whether the BSP generated negative externalities. The Table presents a set of falsification tests where the impact of double crewing on the productivity outcomes of teams in adjacent emergency calls is quantified. To be precise, the impact of double crewing in emergency call *i* is estimated on the productivity of policing in emergency call *i-1*, i.e., the previous emergency call, and *i+1*, i.e., the next emergency call. If the BSP generated negative externalities by reducing the count of fleet in the street, then negative externalities on adjacent calls should appear and regressions should generate negative coefficients.

Column (1) shows IV results for the previous call, i.e., call *i-1*, and column (2) shows IV results for the next call, i.e., call *i+1*. In all cases, estimated IV coefficients appear statistically insignificant, providing no empirical support to the concern that the BSP may have generated negative externalities on adjacent calls by reducing the number of WMP fleet in the street. Thus, while the possibility that the number and quality of the fleet may have fluctuated slightly over time and across teams cannot be ruled out *ex ante*, no evidence appears that the BSP generated negative externalities by reducing the count of fleet in the street and the subsequent deterrence effect. As a whole, the results suggest that the introduction of the BSP did not imply a trade-off between the productivity and deterrence effects of double crewing.[19] Since these tests address the main operational objection to double crewing, namely that concentrating officers into fewer units may reduce spatial coverage, the absence of detectable negative spillovers on adjacent calls suggests that, in this setting, the gains from within-unit collaboration were not offset by measurable losses in operational coverage.

In contrast, Figure 9 presents suggestive evidence that the increased double crewing in response teams may have generated a desirable externality in terms of increased officer safety. Panel A of the Figure provides graphical evidence for the difference-in-discontinuities IV estimates of the impact of double crewing on the likelihood that an officer gets assaulted, which can be used as a measure for officer safety in the execution of their duties to keep the community safe. Panels B and

[19] Appendix Table A.8 also tests whether the BSP may have led treated teams to disproportionately target some categories of civilians. In particular, the Table displays IV estimates of the impact of double crewing on the characteristics of offenders: results indicate that teams that double crewed because of the BSP were equally likely to clear crimes with offenders above or below 40 years of age, male or female offenders and white British offenders as well as offenders from other ethnic backgrounds. Therefore, results in Appendix Table A.8 provide no empirical support to the hypothesis that the BSP may have induced a compositional change in the offender population.

C complement Panel A by showing results from the difference-in-discontinuities IV estimates of the impact of double crewing on the likelihood of violent crime clearance without any assaults against officers (Panel B) and with at least one assault against officers (Panel C). In all Panels of Figure 9, the exact same diff-in-disc specification as in Panel A of Table 4 and Figure 8 was re-estimated.

Since officer assaults are rare events, the diff-in-disc IV estimate in Panel A of Figure 9 is imprecise and statistically indistinguishable from zero.[20] However, the officer-assault panel points in the direction of a potential safety benefit: after the introduction of the programme, the fitted discontinuity for response teams during daytime shifts downward relative to other teams, providing at least suggestive visual evidence of a possible ancillary safety benefit. Moreover, Panels B and C clearly indicate that the productivity gains in violent crime clearance documented in the main analysis originate from incidents where officers did not become victims of assaults. Thus, while Figure 9 does not provide conclusive evidence of a causal reduction in assaults against officers, the IV estimates and the visual discontinuities in the Figure both have the sign one would expect if the programme improved officer safety, thus offering evidence of a safety dividend. Finally, it is important to point out that officer safety is also a productive input. A safer deployment environment may allow officers to intervene more confidently, remain engaged at the scene, and gather evidence more effectively. The officer-safety results should therefore be interpreted as suggestive evidence of a safety channel that may reinforce, rather than merely accompany, the productivity gains.

4.7 Analysis at the Officer Level and Potential Officer Self-Selection into Treatment

A natural question to ask is also whether the introduction of the BSP may have led officers to endogenously self-select in and out of double crewing fleet. As stated above, the composition of callsigns is decided independently in each WMP LPU every morning at 7:00 am, i.e., at the beginning of the working-day, and it is not modified during the day. The composition of double crewing fleet after May 2018 may have been organised in order to either select the highest performers into the BSP or to combine complementary officers who work well together (e.g., assigning one junior officer and one senior officer to the same fleet) and to separate officers who may seem redundant and work less well together in the same team (e.g., two senior officers in the same fleet).

One way to test whether the BSP may have led the best-performing officers to select into double crewing teams and to test whether this, rather than a genuine productivity gain, may generate the results in Table 3, is to replicate the main analysis at the officer level controlling for officer fixed effects. This is not presented as the main analysis because the outcomes of interest are measured at

[20] Because the outcome is a rare binary event, the residualised binned values in the Figure can lie slightly below zero. These points should not be interpreted as negative event probabilities. They are regression-adjusted visual summaries from a linear probability specification and may fall outside the 0-1 range after residualisation and fixed-effect adjustment. The relevant formal estimate is the IV coefficient, which is close to zero and statistically indistinguishable from zero.

the incident level, i.e., separately for each unit of observation in the main analysis. However, conducting the analysis at the officer level has the obvious advantage that officer-specific heterogeneity, e.g., officer-specific productivity, can be controlled for via officer fixed effects.

Appendix Tables A.9 and A.10 and Appendix Figure A.7 replicate the main analysis at the officer level controlling for officer fixed effects. While Appendix Table A.9 and Appendix Figure A.7 replicate the difference-in-differences analysis in Table 3 and the event-study estimates in Figure 7 at the officer level controlling for officer fixed effects, Appendix Table A.10 does likewise for Appendix Table A.6, i.e., it conducts the analysis at the officer level controlling for officer fixed effects focusing on officers who were present in WMP prior to May 2018. In all cases, the same sets of control variables and fixed effects were included in the estimated equation.

Results in Appendix Tables A.9 and A.10 and Appendix Figure A.7 look very coherent with those from the main analysis: even when officer fixed effects are controlled for, double crewing does not appear to exert a significant impact on the likelihood to be dispatched to crime calls. However, double crewing officers appear significantly more likely to detect a crime, to clear a crime and to clear in particular violent crimes, while no detectable productivity gain appears for other, non-violent crimes. These conclusions appear in both Appendix Tables A.9 and A.10. The lack of differential pre-trends in these tables and in Appendix Figure A.7 for all outcomes of interest indicates that, also in this case, the causal interpretation of these results is warranted.

4.8 Analysis at Officer Level and Heterogeneous Productivity Gains

The robustness of the conclusions to the inclusion of officer fixed effects in the analysis should mitigate the concern that officer self-selection into the BSP may lie behind its apparent productivity gains. Yet, different officers may have benefited very differently from the increased rate of double crewing and teamwork brought about by the BSP in WMP response teams. Appendix Figures A.8 and A.9 plot officer-specific estimates and they display substantial heterogeneity across officers in the impact of the BSP. In particular, Appendix Figure A.8 shows officer-specific estimates of the impact of the BSP on double crewing and on the productivity measures of interest, while Appendix Figure A.9 shows officer-specific estimates of the impact of the BSP on the likelihood of crime detection vs crime clearance (Panels A-C) and on the likelihood of violent crime clearance vs non-violent crime clearance (Panel D). All the estimates were derived controlling for officer fixed effects and focusing on officers employed in WMP since before May 2018. In both Figures, each dot represents a treated officer (i.e., a response officer during daytime) employed in WMP since prior to May 2018: this is because only for these officers could an individual-specific estimate of the impact of the BSP be retrieved. Both Figures also show a linear fit and its slope, reflecting whether a statistically significant relationship appears between one set of officer-specific effects and another.

Appendix Figure A.8 shows that, while on average the BSP caused an increase in the rate of double crewing, there was substantial heterogeneity in the actual take up of the BSP. Similarly, while on average the BSP generated improved crime detection and crime clearance rates, these effects were not uniformly distributed across different officers. The positively sloped linear fits in Appendix Figure A.8 indicate that officers who were induced to a greater extent into double crewing by the BSP also experienced greater productivity gains. The steep and positively sloped linear fits in Appendix Figure A.9 further indicate that the same officers who experienced greater productivity gains for crime detection also experienced greater productivity gains for crime clearance. Panel D in Appendix Figure A.9 shows that officers who experienced greater productivity gains for violent crime clearance on average experienced lower productivity gains for non-violent crime clearance, further reflecting that the BSP did not exert a clear effect on non-violent crime clearance rates.

Which officers benefited the most from the BSP then? This question is relevant for research as well as for policy, as, e.g., a budget-constrained police force may need to prioritise some officers against others in the implementation of a similar initiative. Figure 10 investigates how officer characteristics are distributed across the percentiles of officer-specific effects of the BSP shown in Appendix Figures A.8 and A.9. In Figure 10, each panel focuses on a different proxy for police productivity, i.e., the same proxies examined in the main analysis. Estimates in Figure 10 were derived again controlling for officer fixed effects and focusing on officers employed in WMP since before May 2018. The gender, age and seniority of officers are the characteristics considered here. Senior officers were defined as Chief Constables, Deputy Chief Constables, Superintendents, Inspectors and Sergeants, and junior officers as Constables, Special Constables, Temporary Sergeants, Special Sergeants and Police Community Support Officers (PCSOs).

Figure 10 shows that far fewer officers are junior in the 1st percentile of the officer-specific effects distribution, whereas roughly 60% of officers are junior in the 90th-99th percentiles of the distribution of officer-specific effects for crime detection, crime clearance and violent crime clearance. A similar distribution, albeit not as steep, appears for males, who are underrepresented in the 1st percentile of the officer-specific effects distribution and are disproportionately represented in the 90th-99th percentiles of the distribution of officer-specific effects for crime detection, crime clearance and violent crime clearance. No clear gradient appears for age and for non-violent crime clearance. As a whole, Figure 10 indicates that male and junior officers benefited the most from the BSP. This holds true whether crime detection, crime clearance or violent crime clearance is used to measure police productivity, i.e., across the main outcomes of interest, while it does not apply to non-violent crime clearance.

Appendix Figure A.10 additionally explores whether other acquired characteristics at the officer level, such as the pre-BSP rate of double crewing, the pre-BSP crime detection rate or the pre-BSP crime clearance rate, might predict the distribution of estimated officer-specific productivity gains. The Figure is organised in a similar way to Figure 10. Each panel focuses on a different proxy for police productivity, i.e., the same proxies examined in the main analysis, and estimates were derived again controlling for officer fixed effects and focusing on officers employed in WMP since before May 2018.

In Appendix Figure A.10, no clear gradient appears across the different panels, suggesting that benefits from the BSP were not concentrated among officers who did more or less double crewing, or more crime detection or crime clearance, prior to the policy change. This, in turn, should further mitigate the potential concern that officers self-selected endogenously into the treatment when the BSP was introduced. While it could be that some strategic considerations may have been made in the formation of some teams in WMP, the evidence in Appendix Figure A.10 is reassuring in that it indicates benefits were equally distributed among officers with different prior experience in double crewing and different prior rates of crime detection and crime clearance.

5. Mechanisms and Cost-Benefit Analysis

5.1 Mechanisms

So why does double crewing seem to generate productivity gains for policing? Section 2 highlighted several channels through which double crewing may affect police productivity: real-time communication, officer safety, task allocation at the scene, psychological support and possible losses from reduced spatial coverage. This section tests these mechanisms empirically. In particular, Figure 11 investigates two potential mechanisms behind the productivity gains documented so far. First, it studies both the time, measured in seconds, taken to reach the incident scene by the fleet since the moment it was dispatched by the dispatcher and the likelihood of reaching the incident scene within 15 minutes: these can be seen as measures of a timely response. Second, it studies the time spent at the crime scene as a measure of the amount of effort actually devoted to collecting evidence and assisting the victim at the crime scene. This exercise is conducted at the incident level and the exact same difference-in-discontinuity specification as in Panel A of Table 4 and Figures 8 and 9 is estimated.

The response-time outcomes speak directly to the communication channel discussed in Section 2. If face-to-face interaction allows officers to exchange information, coordinate navigation, and allocate tasks while travelling to the incident, then double crewed units should reach and process incidents more efficiently. Panels A and B of Figure 11 focus respectively on the seconds taken to

reach the incident scene since the fleet was dispatched (Panel A) and on the likelihood that the fleet dispatched to an incident reaches the scene within 15 minutes (Panel B). Panel C focuses on the amount of time (measured again in seconds) spent on the incident scene. Results in Panels A and B indicate that double crewing markedly reduces response time and it improves by nearly 23 percentage points the likelihood that officers reach the scene within 15 minutes. Results in Panel C additionally show that double crewing increases the time spent at the crime scene by roughly 40%.[21]

The ability to reach the incident scene more rapidly documented in Panels A and B plausibly results from the two-way, oral, visual and in-person form of communication between officers in the same fleet after they have been dispatched, which eases the rapid exchange of questions and answers between the interlocutors (see Battiston et al., 2021). This mechanism is consistent with evidence that response time matters for crime clearance and injury outcomes (Blanes i Vidal and Kirchmaier, 2018; DeAngelo, Toger and Weisburd, 2023). The greater time spent at the crime scene documented in Panel C appears as a direct consequence of the fact that treated officers are more likely to detect and clear crimes, which implies paperwork, talking to victims and witnesses, or charging, summonsing, cautioning or arresting an offender. However, this finding is also consistent with the hypothesis that, by forcing a real-time deliberative process, double crewing may reduce the probability of impulsive, sub-optimal decision-making, prompting officers to "think twice" before making a decision and thus resulting in longer time spent on the incident scene (Dube, MacArthur, and Shah, 2025).

As a whole, the results in Figure 11 provide evidence consistent with two channels through which double crewing raises police productivity. Double crewing appears to be associated with faster arrival and more time spent at the crime scene. These patterns are consistent with improved coordination between officers before and during the response, but they should be interpreted as evidence of mechanisms rather than a full decomposition of the treatment effect. Taken together, the results suggest that the productivity gains from double crewing arise in settings where information, speed and safety are complementary inputs into police output.

5.2 Cost-Benefit Calculation

Recent welfare analyses of policing stress that crime-control gains should be valued jointly with the social costs of force and misconduct (Rivera, 2026; Holz et al., 2026). Table 5 reports a 12-month cost-benefit calculation of the improved productivity and safety of police officers deriving from the BSP.[22] Since the BSP re-organised officers who were already employed and did not require

[21] Appendix Figure A.11 shows difference-in-discontinuity estimates also from July 2017 to April 2019 (One Year Post BSP) but with the Full Set of Fixed Effects, i.e., response team fixed effects; hour of the emergency call fixed effects and its interaction with the Post indicator; and P1 vs P2 call fixed effects. Appendix Figures A.12 and A.13 do likewise for the entire period of the analysis from July 2017 to September 2019. Regardless of the time window used in the analysis, estimates appear very coherent and no discontinuous jumps appear away from the 1st May 2018 cutoff.

[22] Appendix B provides more detailed breakdowns of the calculations of Table 5.

additional recruitment, existing salaries were payable under both the BSP and no-BSP counterfactuals. The marginal structural-budget labour cost of redeploying these officers was therefore zero. The calculation in Table 5 nevertheless values resources used to conceive, organise and implement the programme, including senior oversight, demand analysis, Police Federation consultation, roster and Excel-workbook construction, training, frontline adaptation, grievance handling, and duty-management-system reconfiguration. This treatment follows the opportunity-cost principle that already-paid public resources have value in their next-best use (HM Treasury, 2022).

The benefit calculation in Table 5 places all flows on a 12-month basis. The productivity gain was estimated as the economic benefit from violent crime clearance using the costs of violence against the person (without injury, to derive a conservative estimate of the economic benefit) in Table E1 of Heeks et al. (2018), a UK-based and more recent version of the frequently-cited work by Cohen and Piquero (2009) and Miller et al. (1996) that reports cost of crime estimates for different crime categories. The 22,193 violent-crime clearances recorded during the ten-month pre-period for the BSP group in the full population of BSP-eligible incidents, before restricting the estimation sample to one vehicle with one or two officers, are annualised to 26,631.6 and multiplied by the 10.5% reduced-form BSP effect, producing 2,796.3 additional violent-crime clearances.[23] The £1,570 net unit value in 2015/16 prices, i.e., £3,750 of gross benefit equivalent to the consequence cost minus £120 of anticipation cost and £2,060 of response cost, is converted to £1,666.19 in 2018/19 prices using the HM Treasury GDP deflator (Heeks et al., 2018; HM Treasury, 2019).[24] This yields a clearance benefit of £4,659,195. Greater officer safety is also included in the calculation of benefits: annualising the 19 pre-BSP officer-assault observations and applying a 65.3% descriptive reduction that emerges from the raw WMP data implies 14.9 avoided assaults, valued conservatively at the same unit amount, or £24,807. The overall estimated first-year benefit is therefore £4,684,001.

To make the cost test appropriately demanding, costs are attributed to the BSP that could be publicly documented and plausibly be attributed to the BSP. This is done in three steps. First, it uses a high-friction internal opportunity cost of £709,433: an upper-bound scenario's £585,000 for 16,100 hours of strategic design, local management, frontline transition and IT work (Resource and Operations Analysis Unit, 2023), plus a £124,433 allowance for clearance-related output forgone

[23] Restricting this count to the sample with one vehicle with one or two officers used in the econometric analysis would result in approximately 13,000 incidents involving a cleared violent crime, it would generate £2.729 million of annual benefits and a benefit–cost ratio of 1.15. The conclusion that benefits exceeded costs therefore does not depend on the chosen baseline.

[24] While the consequence cost of cleared violent crimes may not be avoided thanks to the increased violent crime clearance, the analysis assigns a gross economic benefit to crime clearance that is equivalent to the consequence cost of a crime; moreover, since the anticipation and response costs are realised due to the increased violent crime clearance and decreased assaults against officers, the difference between the economic benefit equivalent to the consequence cost and the (realised) anticipation and response costs is interpreted as the unit benefit of the BSP.

during 9,000 frontline transition hours. Second, two Accenture payments explicitly coded "Smarter Responding", i.e., £25,709.83 in September 2017 and £20,586.94 in October 2017, are charged in full to the BSP, in total amounting to £46,296.77 (WMP, 2019). Third, 60% of the published 2018/19 capital envelopes for Smarter Responding (£900,000) and New Ways of Responding (£720,000) to the BSP (West Midlands Police and Crime Commissioner, 2017a, 2017b, 2018a, 2019) are costed in. This attribution is intentionally conservative: WMP's public papers show that the BSP was only one component of Smarter Responding and New Ways of Responding, alongside mobile devices, digital statements, Mobile PNC, Mobile ID and other projects (West Midlands Police and Crime Commissioner, 2018a, 2018b).

The total of explicit and implicit costs is £2,375,729.8. Against £4,684,001 of estimated 12-month benefit, net benefit is £2,308,271.2 and the benefit-cost ratio is 1.97. Thus, for every £1 invested in the BSP, the WMP experienced a net return of roughly £0.97 (i.e., £1.97 of benefits per £1 of cost). If benefits accrued approximately uniformly from launch and all costs are treated as incurred at month 0, the cumulative benefit equals the full cost after 6.09 months. Thus, within this framework, estimated benefits exceed costs within the first year even when most of the complete capital envelopes of two much broader change programmes are assigned to the BSP. The estimates are reliant on some specific assumptions on the cost side, but these have been validated in interviews with members of the West Midlands police involved in the policy change and from their policy documents which we were given access to. They strongly show that the BSP generated a net economic benefit. Of course, as the empirical analysis shows these gains from crime clearance also persisted after the first year (see the plateauing in the Figure 7 event studies) with no fade out. And most (likely all) of the cost of the programmes would not be recurrent expenditure. Thus, as the accrued benefits persist after the costs have been fully met, double crewing continues to be beneficial beyond the first year, further raising the economic return to the policy.

6. Conclusion

This paper offers a new angle on the net productivity gains that can derive from in-person team collaboration in the workplace. It shows that the ability to collaborate in person generates a productivity benefit that exceeds the additional costs that inherently derive from the utilisation of one additional worker. For police productivity, greater safety of workers when double crewed, as well as faster response time and greater coordination on the scene, appear as key mechanisms behind the main findings.

These emerge from study of rich administrative data and a unique natural experiment offered by changes in crew size among police officers responding to emergency calls in fleet in England in

an initiative by which West Midlands Police boosted deployment in response teams in day shifts in 2018. The 'Banded Shift Pattern', introduced in the West Midlands Police in May 2018, increased the likelihood of responding to emergency calls in teams for a large number of exogenously chosen workers. The combined research design featuring an organisational shock shows that crime clearance increases when police officers respond to an emergency call in teams of two rather than one. When exogenously chosen police officers attend emergency calls in teams of two, the likelihood that one or more violent crimes are cleared increases by over 100% - indicating a net productivity gain for the officers involved.

Reflecting on the general applicability of these findings, two considerations appear evident. First, the Police Service – here the West Midlands Police, the second largest force in the country – is a type of organisation in which workers may at times face particularly stressful and dangerous situations. The same is true of workers in other critical sectors of society who are confronted with stressful and difficult situations on a regular basis. For all these workers, the empirical evidence presented here is likely relevant. The results provide field evidence for a central prediction of organisational economics: teamwork is most valuable when the gains from communication, specialisation, and mutual protection exceed the coordination costs and the opportunity cost of deploying workers separately. In policing, this condition appears to hold most strongly in complex and high-risk incidents, especially violent crimes, where information, speed, and safety are complementary inputs into output.

Second, the conclusion that faster response may generate productivity gains is likely to have validity for most production activities, embracing different sectors of society and the production process. More generally, these results provide empirical support to the insight in Smith (1965) and Becker and Murphy (1992) that the specialisation of labour and produced differences among workers generate productivity gains. The issue of policy effectiveness is an important one for the police, especially on the question of double crewing which has been a key issue on the policy agenda in the face of significant cuts to police funding that took place in the UK over the austerity years in the early to mid-2010s, and to police forces facing budget cuts more generally across the world. These findings carry broader implications beyond the police setting for research on teamwork, crew size and performance, for comparisons of working alone or jointly with another co-worker, and especially in settings where resources were not being used effectively prior to a policy change.

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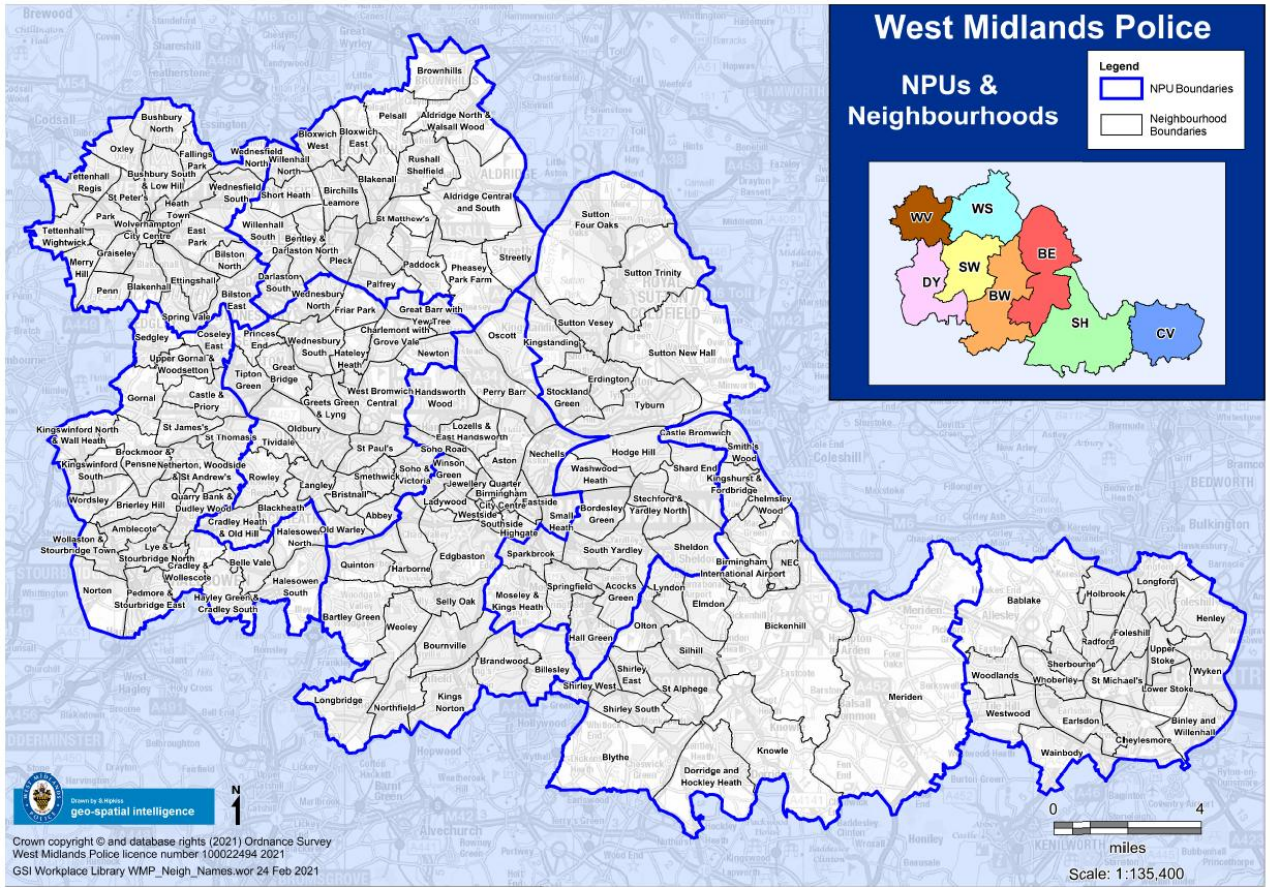
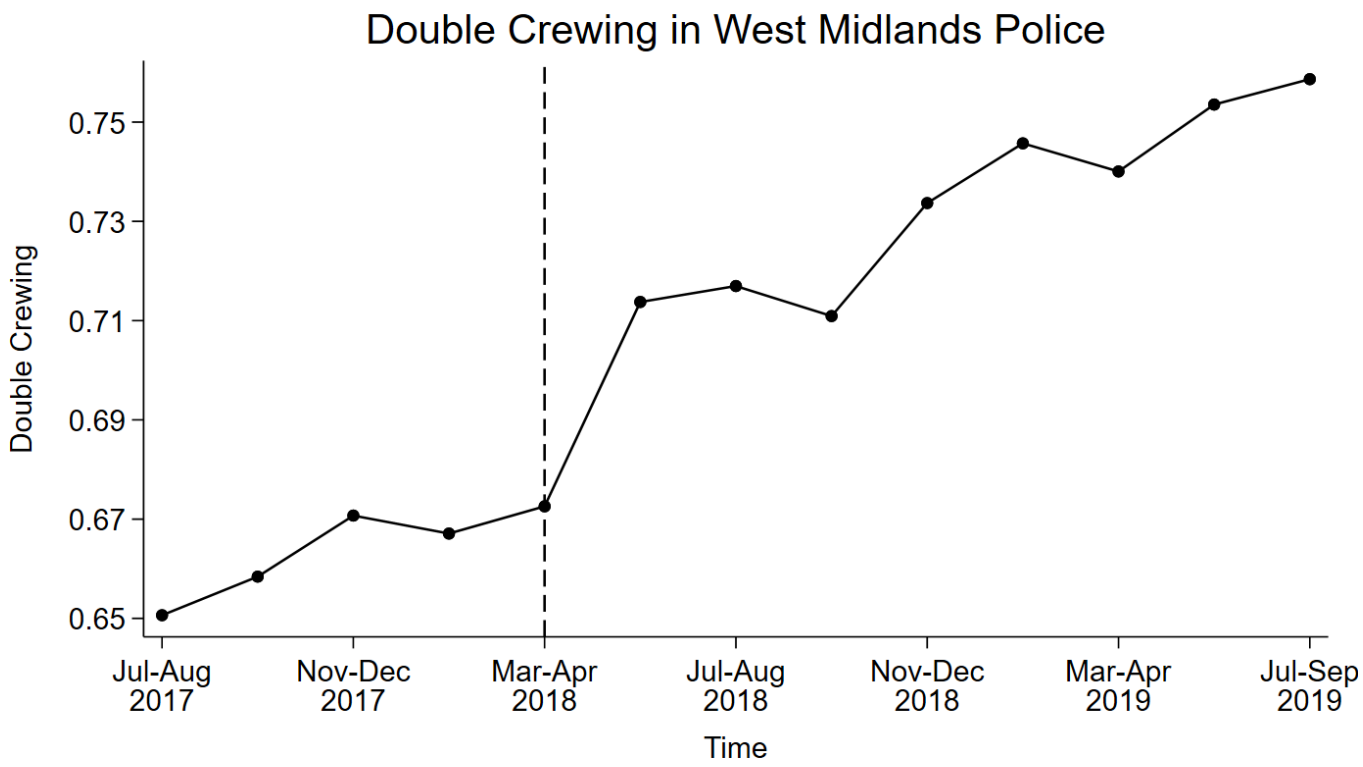
Figure 1. West Midlands Police (WMP) Area and Local Policing Units



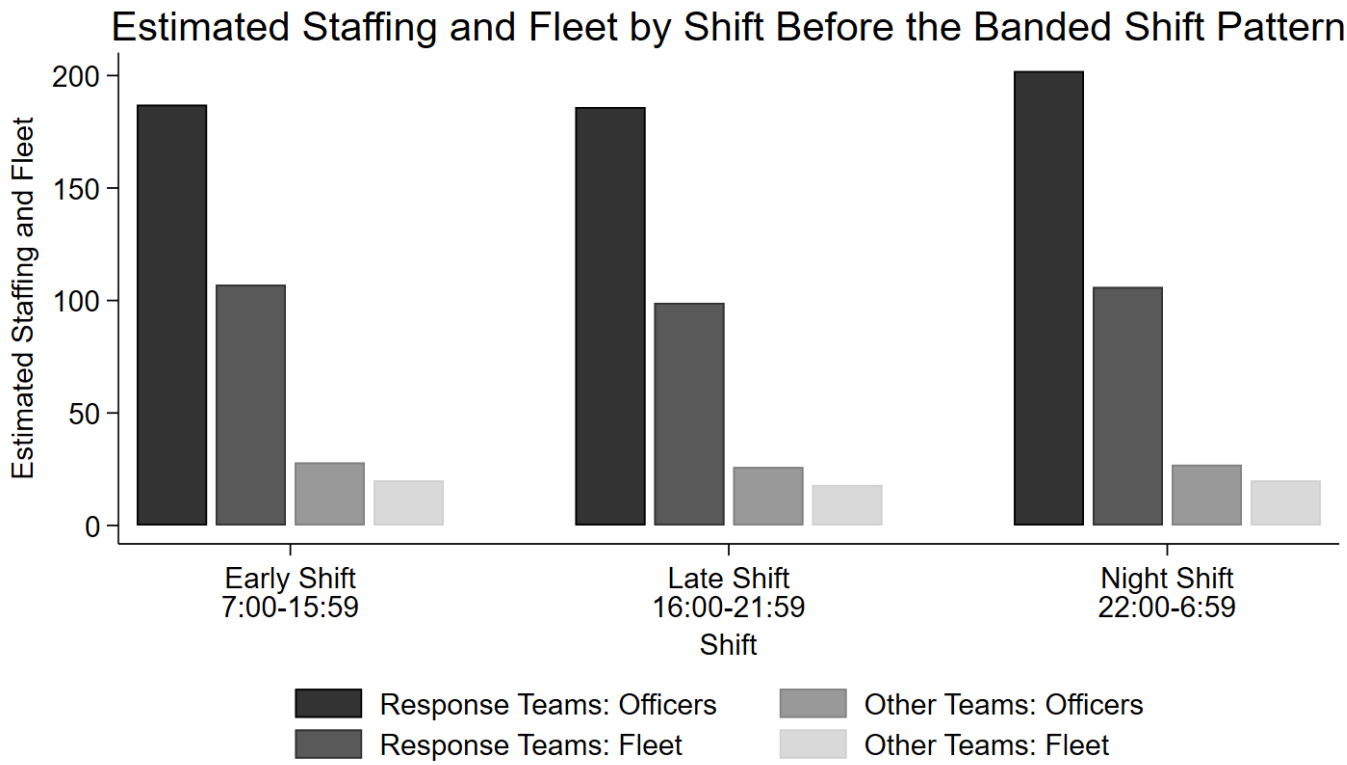
Source: West Midlands Police website.

Figure 2. Double Crewing in West Midlands Police (WMP)



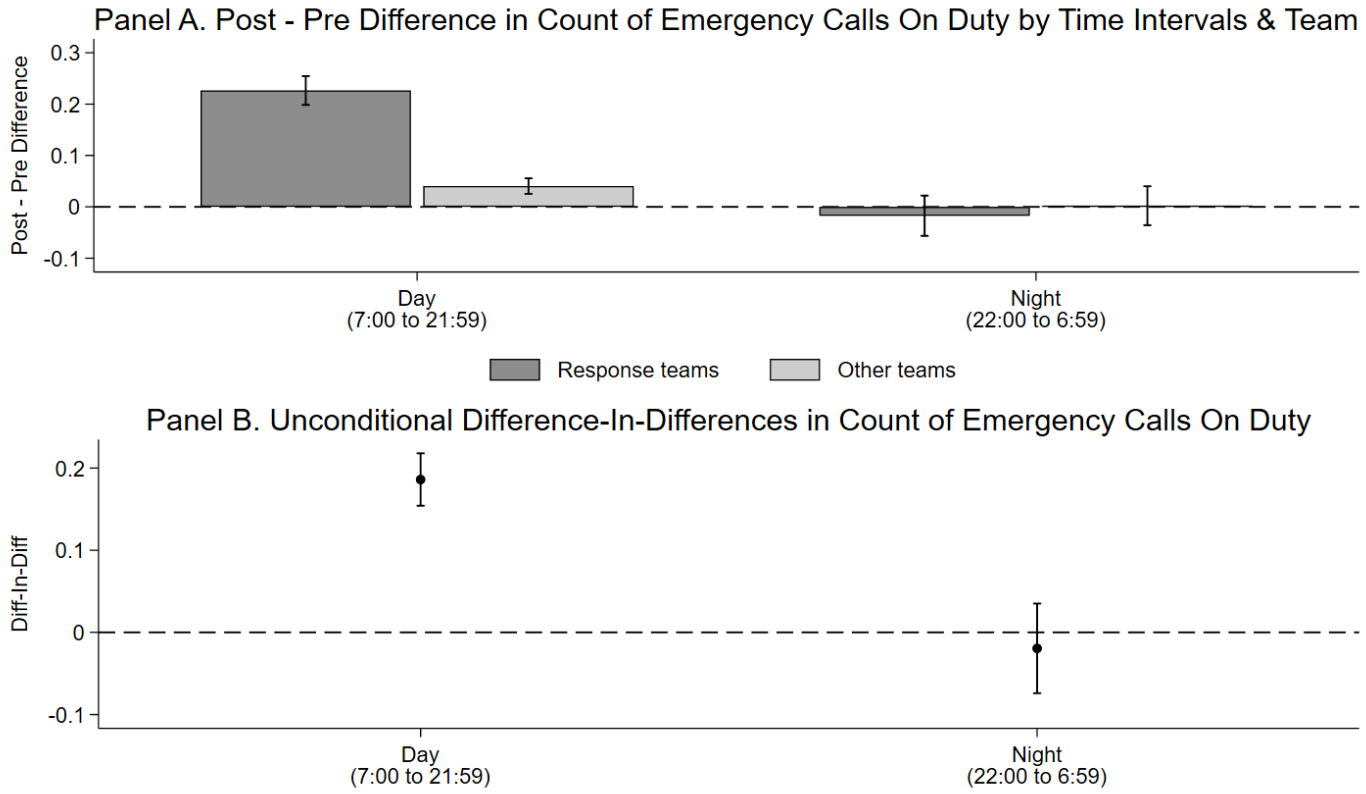
Notes: The figure shows average fractions of double crewing teams dispatched to emergency calls in West Midlands Police (WMP). The average fractions of double crewing teams were calculated on all the emergency calls received by WMP from July 2017 to September 2019.

Figure 3. Average Staffing and Fleet by Shift in West Midlands Police (WMP) Before the BSP



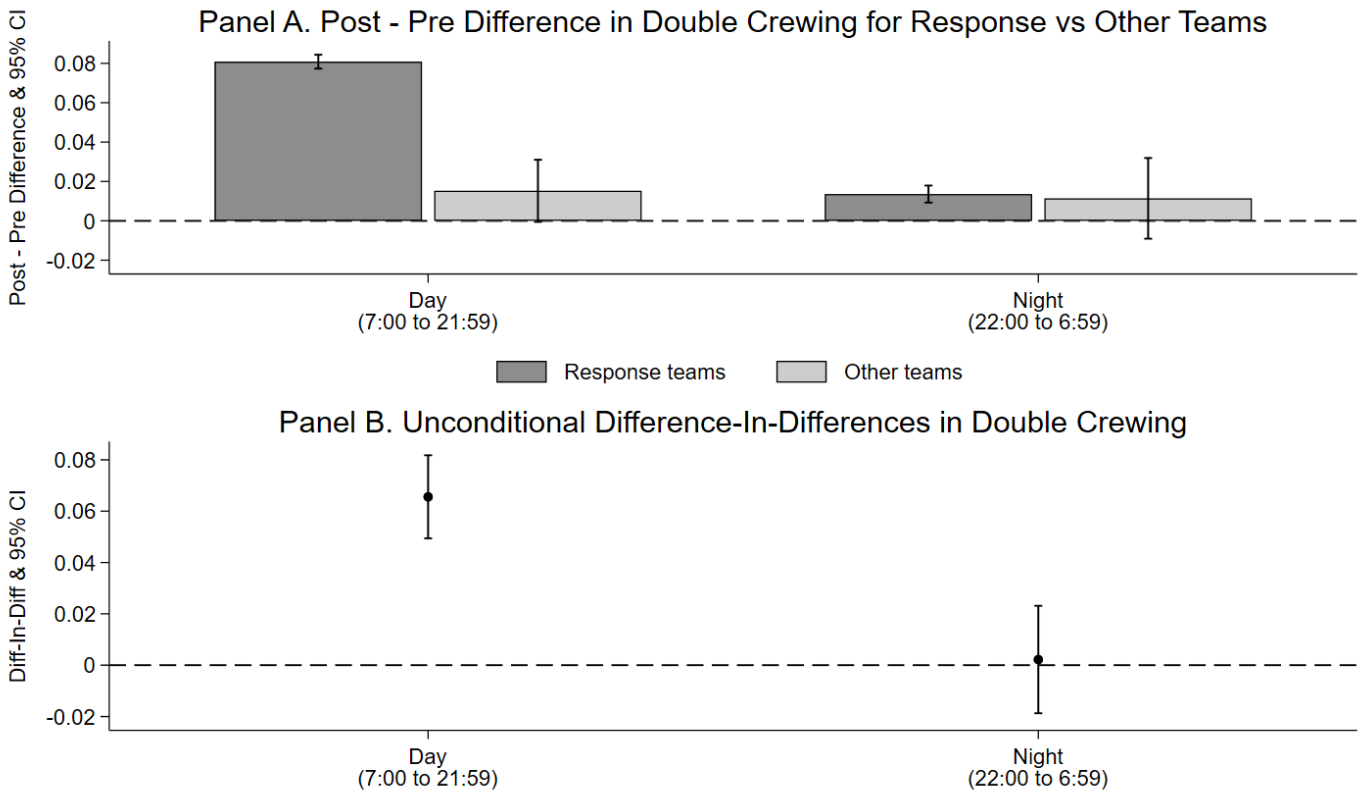
Notes: The figure shows average staffing and fleet dispatched to emergency calls in West Midlands Police (WMP) prior to the introduction of the Banded Shift Pattern (BSP) in May 2018. Results are presented separately for Response Teams and Other Teams and for the Early Shift (7:00-15:59), Late Shift (16:00-21:59) and Night Shift (22:00-6:59). The estimated staffing and fleet were calculated on the entire sample of officers used in the empirical analysis.

Figure 4. Count of Emergency Calls On Duty in West Midlands Police (WMP) for Response vs Other Teams Around the BSP



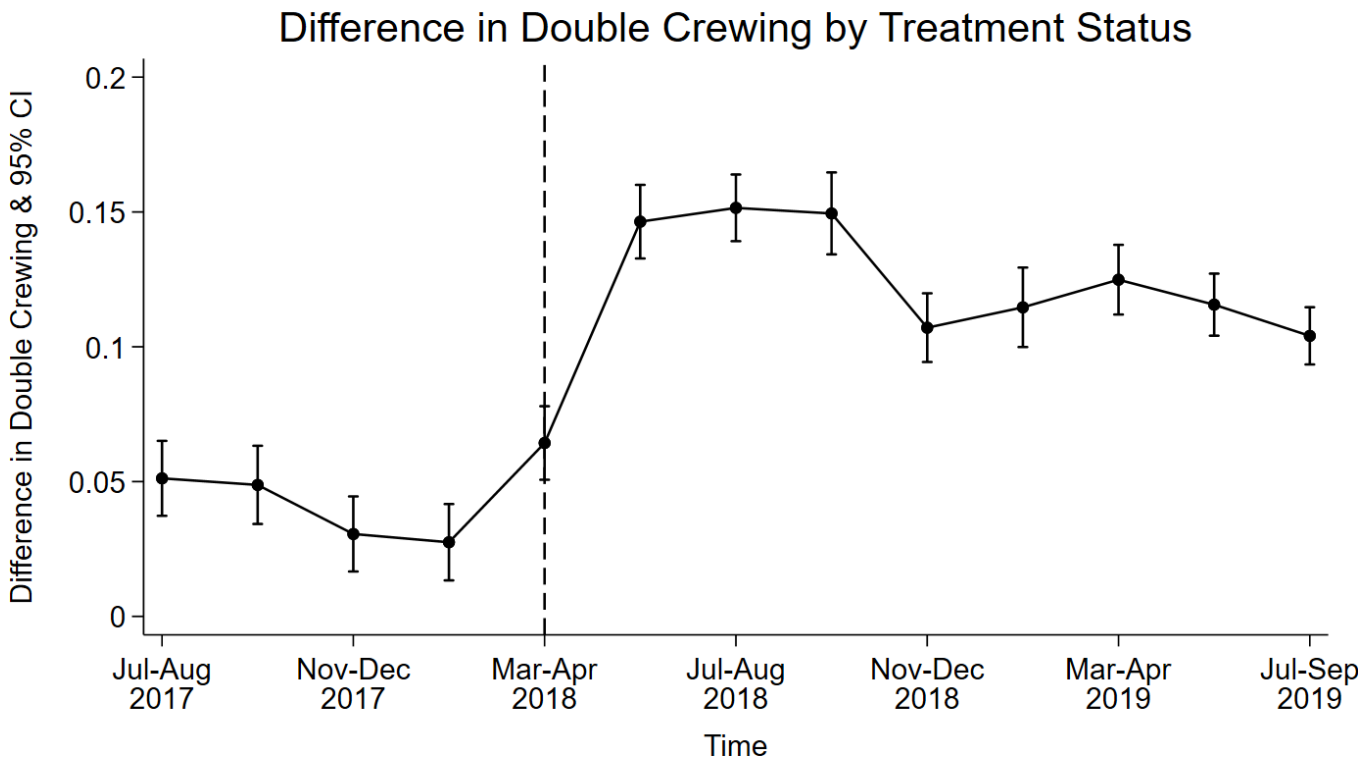
Notes: Figure shows the unconditional Post – Pre Difference in the Count of Emergency Calls on Duty around the introduction of the Banded Shift Pattern (BSP) in May 2018 in response teams of West Midlands Police (WMP). Results are displayed separately for the Day shifts (7:00 to 21:59) and the Night shift (22:00 to 6:59). Separately for response teams vs other teams and for the day shifts and the night shift, Panel A shows the difference between the count of emergency calls on duty after the introduction of the BSP and before the introduction of the BSP. Separately for the day shifts and the night shift, Panel B shows the unconditional difference-in-differences (DiD) estimate in the count of emergency calls on duty between response teams vs other teams. Underlying analysis conducted on a balanced panel of officers with half-day frequency, i.e., daytime and nighttime for each date. Focus is on all emergency calls from the 1st February 2018 to the 31st July 2018, i.e., the six months surrounding the 1st May 2018, the date of adoption of the BSP in WMP. The Count of Emergency Calls on Duty is defined as the count of emergency calls an officer was dispatched to on a given half-day while on duty, i.e., at daytime or nighttime for each date. Standard errors are clustered by officer in all estimates.

Figure 5. Double Crewing in West Midlands Police for Response vs Other Teams Around the BSP



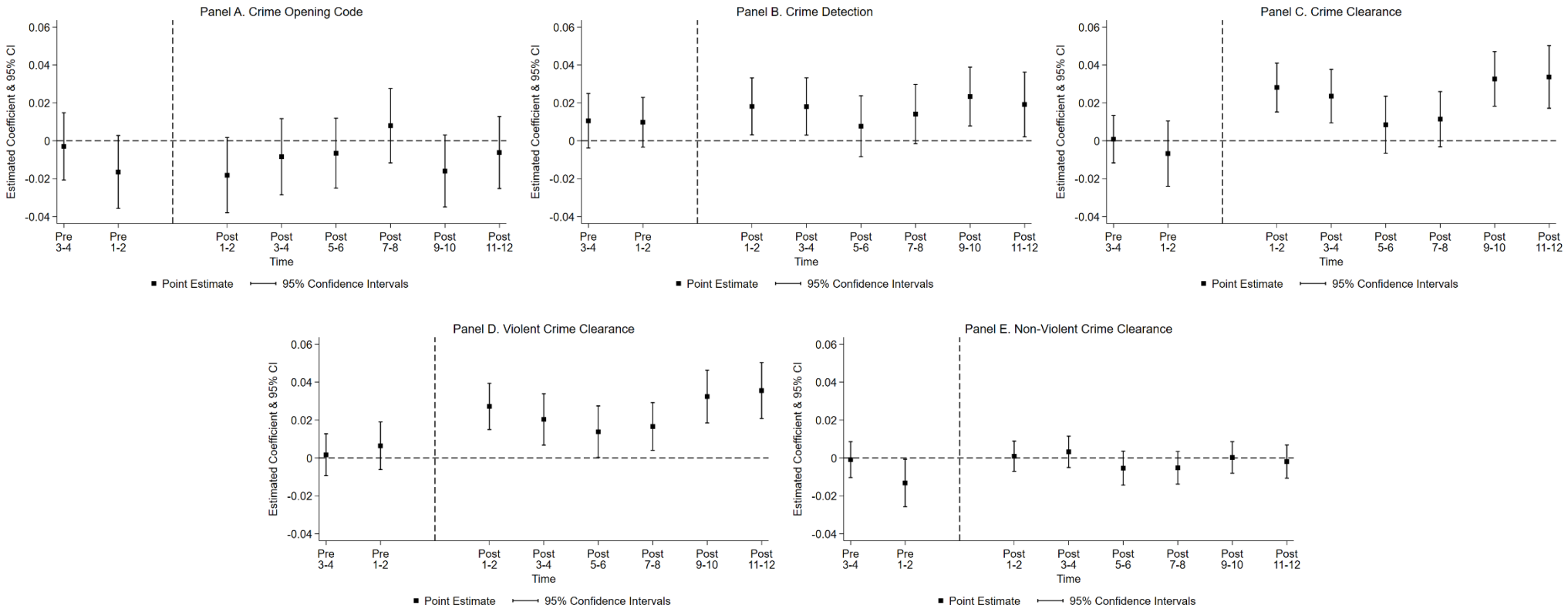
Notes: Figure shows the unconditional Post – Pre Difference in fractions of emergency calls attended by double crewing teams around the introduction of the Banded Shift Pattern (BSP) in May 2018 in response teams of West Midlands Police (WMP). Results are displayed separately for the Day shifts (7:00 to 21:59) and the Night shift (22:00 to 6:59). Separately for response teams vs other teams and for the day shifts and the night shift, Panel A shows the difference between the average fraction of emergency calls attended by double crewing teams after the introduction of the BSP and before the introduction of the BSP. Separately for the day shifts and the night shift, Panel B shows the unconditional difference-in-differences (DiD) estimate in double crewing between response teams vs other teams.

Figure 6. Difference in Double Crewing in West Midlands Police by Treatment Status



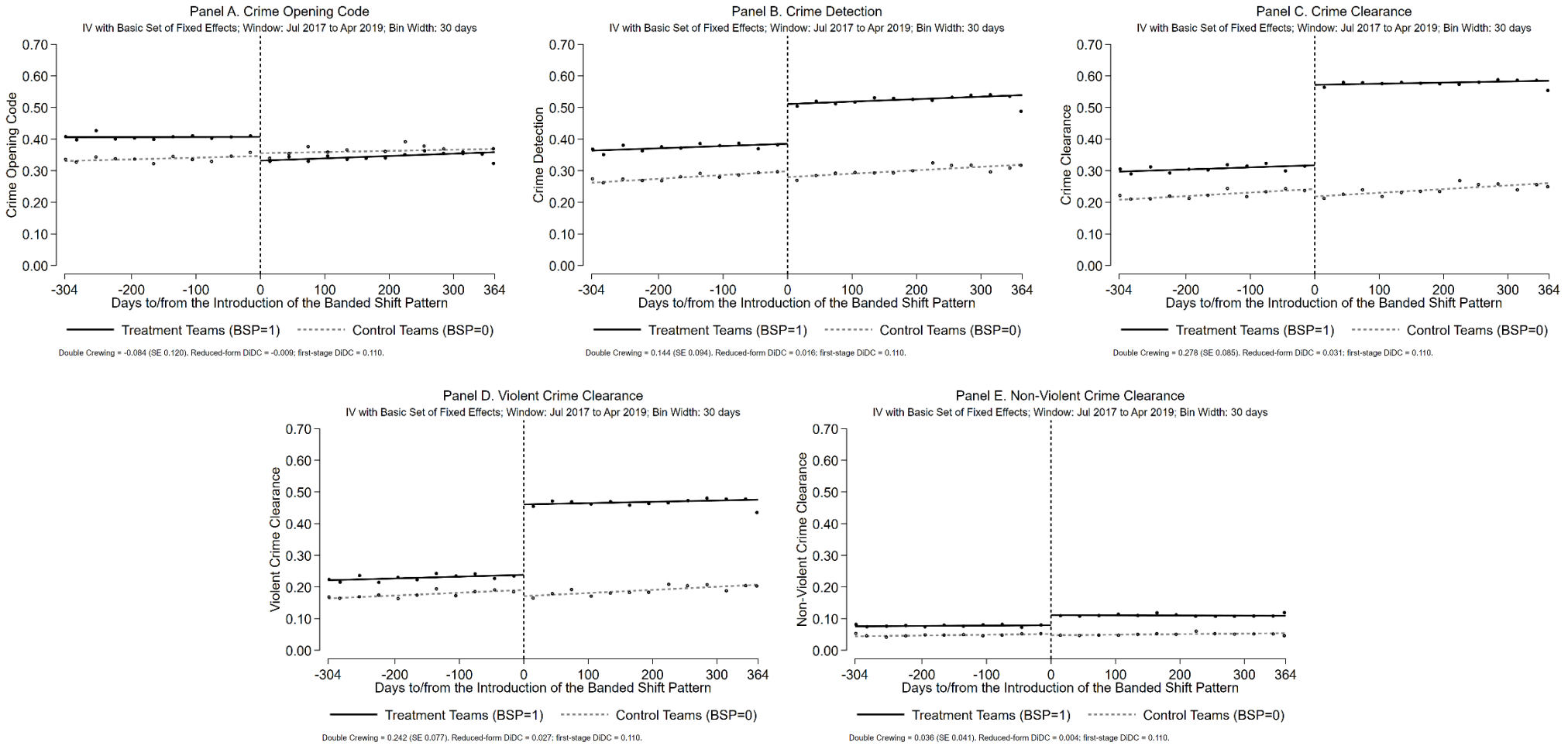
Notes: The figure shows unconditional differences in average fractions of emergency calls attended by double crewing teams in West Midlands Police (WMP) separately for Treatment Group teams (T = 1) and Control teams (T = 0). Treatment Group teams (T = 1) defined as teams in response teams in day shifts, and Control Group teams (T = 0) defined as teams in response teams in night shift and all other teams. The vertical axis displays average difference in fractions of emergency calls attended by double crewing teams.

Figure 7. Event Study Estimates of the Impact of the Banded Pattern on Selection into Crime Calls and Productivity



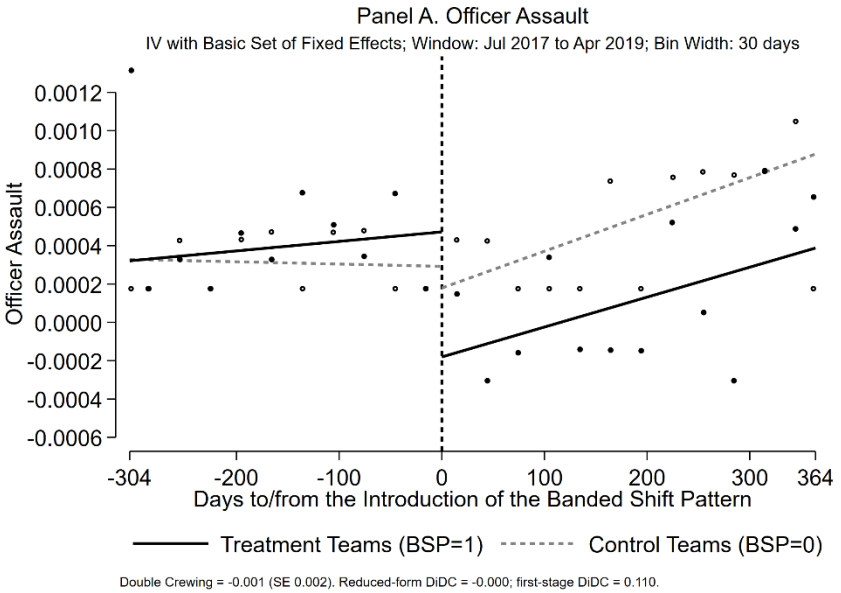
Notes: Post-period defined as starting from 1st May 2018, the date of adoption of the Banded Shift Pattern (BSP) in West Midlands Police (WMP). Treatment Group includes response teams during day shifts, i.e., the Early Shift and the Late Shift. Control Group includes all other teams. "Crime Opening Code" takes value 1 for calls classified by the dispatcher in the opening code as criminal offences or domestic violence incidents (value 0 otherwise). "Crime Detection" takes value 1 for calls where one or more criminal offences were detected in the closing code (value 0 otherwise). "Crime Clearance" takes value 1 for calls where one or more offenders were charged, summonsed, cautioned, arrested or identified by name by the police (value 0 otherwise). "Violent Crime Clearance" takes value 1 for calls where one or more offenders were charged, summonsed, cautioned, arrested or identified by name by the police for a violent offence (value 0 otherwise). "Non-Violent Crime Clearance" takes value 1 for calls where one or more offenders were charged, summonsed, cautioned, arrested or identified by name by the police for a non-violent offence (value 0 otherwise). The unit of observation is the emergency call. Figure displays estimated coefficients in the event-study analogue to the reduced-form specifications in columns (2), (4), (6), (8) and (10) of Table 3 where 90-day time periods are interacted with BSP Status and the full Set of Fixed Effects (FEs) is included in the equation. These include, namely, Date FEs; BSP Status FEs; Response Team FEs; Incident Hour FEs interacted with Pre 1, Pre 2 and Post; P1 vs P2 Call FEs. Standard errors are two-way clustered by Date and Team x Hour in all estimates, resulting in 820 date clusters and 331 team-by-hour clusters.

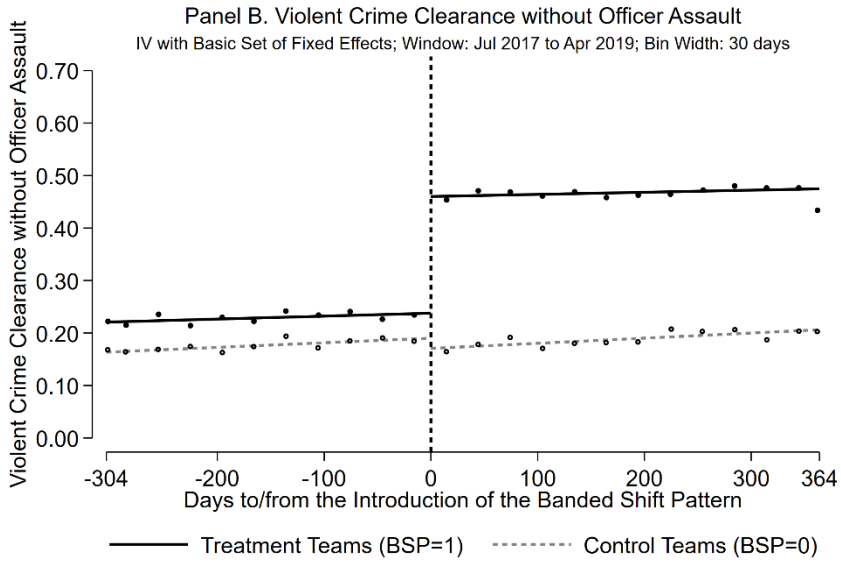
Figure 8. Difference-in-Discontinuity IV Estimates of the Impact of Double Crewing on Selection into Crime Calls and Productivity from July 2017 to April 2019 with BSP Fixed Effects

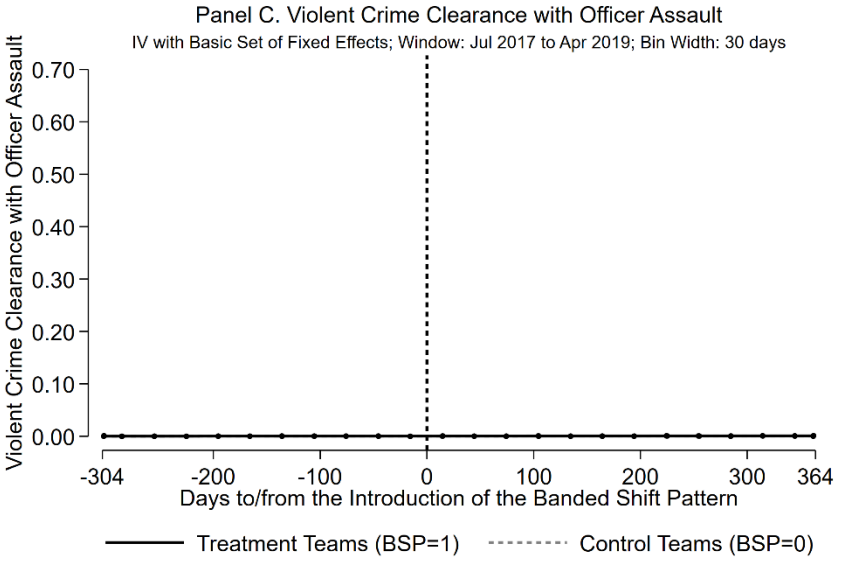


Notes: Post-period defined as starting from 1st May 2018, the date of adoption of the Banded Shift Pattern (BSP) in West Midlands Police (WMP). Treatment Group includes response teams during day shifts, i.e., the Early Shift and the Late Shift. Control Group includes all other teams. "Crime Opening Code" takes value 1 for calls classified by the dispatcher in the opening code as criminal offences or domestic violence incidents (value 0 otherwise). "Crime Detection" takes value 1 for calls where one or more criminal offences were detected in the closing code (value 0 otherwise). "Crime Clearance" takes value 1 for calls where one or more offenders were charged, summonsed, cautioned, arrested or identified by name by the police (value 0 otherwise). "Violent Crime Clearance" takes value 1 for calls where one or more offenders were charged, summonsed, cautioned, arrested or identified by name by the police for a violent offence (value 0 otherwise). "Non-Violent Crime Clearance" takes value 1 for calls where one or more offenders were charged, summonsed, cautioned, arrested or identified by name by the police for a non-violent offence (value 0 otherwise). The unit of observation is the emergency call. Standard errors are two-way clustered by Date and Team x Hour in all estimates, resulting in 667 date clusters and 325 team-by-hour clusters.

Figure 9. Difference-in-Discontinuity IV Estimates of the Impact of Double Crewing on Assaults Against Officers and Violent Crime Clearance from July 2017 to April 2019

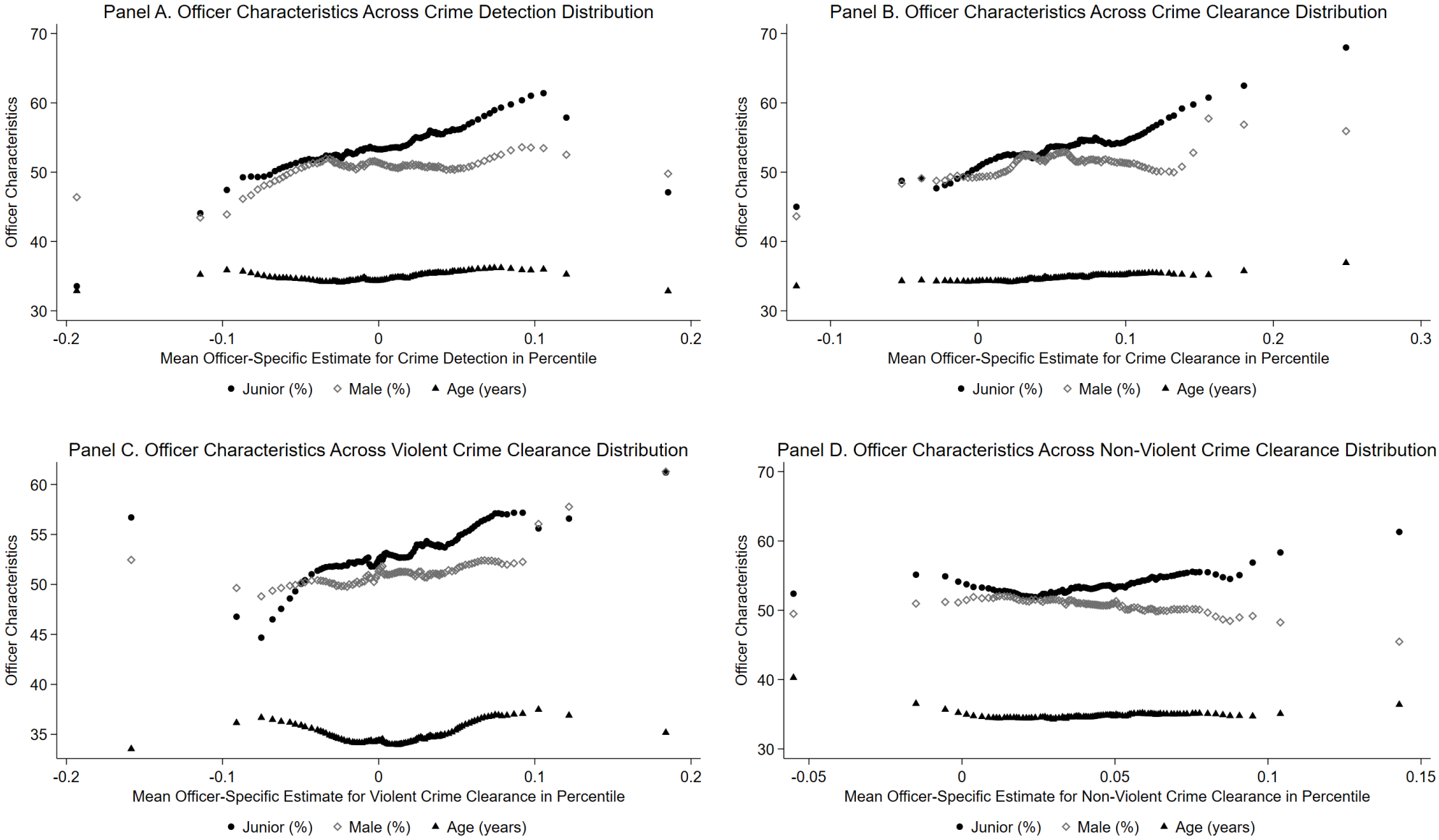






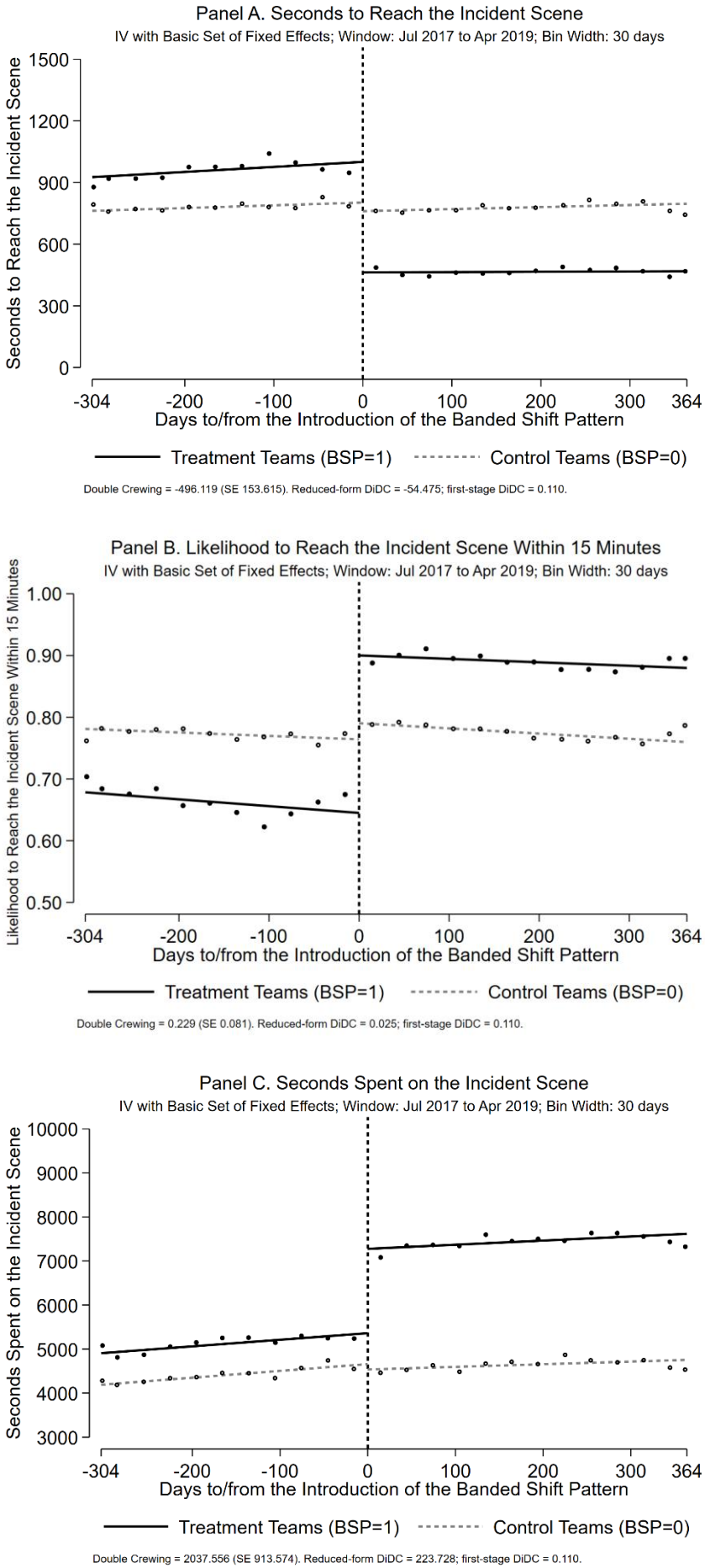
Notes: Post-period defined as starting from 1st May 2018, the date of adoption of the Banded Shift Pattern (BSP) in West Midlands Police (WMP). Treatment Group includes response teams during day shifts, i.e., the Early Shift and the Late Shift. Control Group includes all other teams. "Assault against an Officer" takes value 1 for calls where one or more officers were assaulted with or without injuries as per the closing code (value 0 otherwise). "Violent Crime Clearance without Officer Assault" takes value 1 for calls where one or more offenders were charged, summonsed, cautioned, arrested or identified by name by the police for a violent offence and no officers were assaulted (value 0 otherwise). "Violent Crime Clearance with Officer Assault" takes value 1 for calls where one or more offenders were charged, summonsed, cautioned, arrested or identified by name by the police for a violent offence and one or more officers were assaulted (value 0 otherwise). The unit of observation is the emergency call. Standard errors are two-way clustered by Date and Team x Hour in all estimates, resulting in 667 date clusters and 325 team-by-hour clusters.

Figure 10. Distribution of Officer Characteristics across Percentiles of Officer-Specific Estimates of the Impact of the Banded Pattern on Officer Productivity



Notes: The chart shows the average % share of junior officers, male officers and average age of officers prior to the Banded Shift Pattern (BSP) in each percentile of the distribution of the officer-specific estimates of the impact of the BSP on various metrics of officer productivity. "Crime Detection" takes value 1 for calls where one or more criminal offences were detected in the closing code (value 0 otherwise). "Crime Clearance" takes value 1 for calls where one or more offenders were charged, summonsed, cautioned, arrested or identified by name by the police (value 0 otherwise). "Violent Crime Clearance" takes value 1 for calls where one or more offenders were charged, summonsed, cautioned, arrested or identified by name by the police for a violent offence (value 0 otherwise). "Non-Violent Crime Clearance" takes value 1 for calls where one or more offenders were charged, summonsed, cautioned, arrested or identified by name by the police for a non-violent offence (value 0 otherwise). The unit of observation is the percentile of the officer-specific estimates of the impact of the BSP. The full Set of Fixed Effects (FEs) in the equation where officer-specific effects of the BSP were estimated includes, namely, Officer FEs; Date FEs; BSP Status FEs; Response Team FEs; Incident Hour FEs interacted with Pre 1, Pre 2 and Post; P1 vs P2 Call FEs. Standard errors are two-way clustered by Date and Team x Hour in all estimates, resulting in 820 date clusters and 331 team-by-hour clusters.

Figure 11. Difference-in-Discontinuity IV Estimates of the Impact of Double Crewing on Response Time and Time Spent on the Incident Scene from July 2017 to April 2019



Notes: Post-period defined as starting from 1st May 2018, the date of adoption of the Banded Shift Pattern (BSP) in West Midlands Police (WMP). Treatment Group includes response teams during day shifts, i.e., the Early Shift and the Late Shift. Control Group includes all other teams. "Seconds to Reach the Incident Scene" is a continuous variable that measures (in seconds) the length of time from the moment officers were dispatched by the dispatcher to the time they reached the incident scene. "Likelihood to Reach the Incident Scene Within 15 Minutes" takes value 1 for calls where officers reached the incident scene within 15 minutes from the time of dispatch (value 0 otherwise). "Seconds Spent on the Incident Scene" is a continuous variable that measures (in seconds) the length of time from the moment officers reached the incident scene to the moment they left. The unit of observation is the emergency call. Standard errors are two-way clustered by Date and Team x Hour in all estimates, resulting in 667 date clusters and 325 team-by-hour clusters.

Table 1. Count of Emergency Calls on Duty and the Introduction of the Banded Shift Pattern

	Count of Emergency Calls on Duty							
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Response x Day Shift x Post	0.205	0.203	0.242	0.247	0.236	0.241	0.306	0.319
	(0.037)	(0.039)	(0.034)	(0.035)	(0.034)	(0.035)	(0.034)	(0.036)
Response x Day Shift x Pre -1		0.024		0.058		0.054		0.102
		(0.087)		(0.078)		(0.078)		(0.080)
Response x Day Shift x Pre -2		-0.062		0.005		0.003		0.039
		(0.088)		(0.081)		(0.081)		(0.083)
Percent Relative to Pre-Mean	9.4	9.3	11.0	11.3	10.8	11.0	13.9	14.5
Number of Officers	5683	5683	5683	5683	5683	5683	5683	5683
Sample Size	282106	282106	282106	282106	282106	282106	282106	282106
Officer Fixed Effects	No	No	Yes	Yes	Yes	Yes	Yes	Yes
Date Fixed Effects	No	No	No	No	Yes	Yes	Yes	Yes
Officer Fixed Effects x Post Fixed Effects	No	No	No	No	No	No	Yes	Yes
Officer Fixed Effects x Response Team Fixed Effects	No	No	No	No	No	No	Yes	Yes
Officer Fixed Effects x Daytime (7:00-21:59) Fixed Effects	No	No	No	No	No	No	Yes	Yes
Post Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Response Team Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Daytime (7:00-21:59) Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Post Fixed Effects x Response Team Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Post Fixed Effects x Daytime (7:00-21:59) Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Response Team Fixed Effects x Daytime (7:00-21:59) Fixed Effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes

Notes: Analysis conducted on a balanced panel of officers with half-day frequency, i.e., daytime and nighttime for each date. Focus is on all emergency calls from the 1st February 2018 to the 31st July 2018, i.e., the six months surrounding the 1st May 2018, the date of adoption of the Banded Shift Pattern (BSP) in West Midlands Police (WMP). The sample size reflects that 5,683 officers were studied over 181 dates when they were on duty either during the day or during the night, resulting in a sample of 282,106 observations of officers on duty (i.e., 49.64 shifts on duty per officer on average). The balanced base panel was constructed before filtering. The dependent variable is the Count of Emergency Calls on Duty defined as the count of emergency calls an officer was dispatched to on a given half-day while on duty, i.e., at daytime or nighttime for each date. Pre 1 defined as from the 24-30 April 2018; Pre 2 defined as from the 17-23 April 2018. The Pre-Mean Count of Emergency Calls on Duty is 2.194. Standard errors are clustered by officer in all estimates.

Table 2. Raw Difference-in-Differences by Banded Shift Pattern

	Double Crewing			Crime Opening Code			Crime Detection			Crime Clearance			Violent Crime Clearance			Non-Violent Crime Clearance			Sample Size
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	(19)
	Pre	Post	Post – Pre	Pre	Post	Post – Pre	Pre	Post	Post – Pre	Pre	Post	Post – Pre	Pre	Post	Post – Pre	Pre	Post	Post – Pre	
All	0.798	0.849	0.051	0.337	0.356	0.019	0.287	0.313	0.027	0.231	0.258	0.027	0.180	0.207	0.026	0.051	0.051	0.001	270607
Banded Shift	0.814	0.895	0.081	0.362	0.376	0.014	0.321	0.349	0.028	0.261	0.293	0.032	0.200	0.231	0.031	0.062	0.061	-0.001	171943
Not Banded Shift	0.771	0.769	-0.002	0.294	0.320	0.026	0.227	0.250	0.023	0.179	0.198	0.019	0.147	0.164	0.017	0.032	0.034	0.002	98664
Difference-in-Differences			0.082			-0.012			0.004			0.013			0.015			-0.003	
			(0.015)			(0.004)			(0.004)			(0.005)			(0.004)			(0.002)	
Percent Change			10.1			-3.3			1.2			5.0			7.5			-4.8	

Notes: Post-period defined as starting from 1st May 2018, the date of adoption of the Banded Shift Pattern (BSP) in West Midlands Police (WMP). Treatment Group includes response teams during day shifts, i.e., the Early Shift and the Late Shift. Control Group includes all other teams. "Crime Opening Code" takes value 1 for calls classified by the dispatcher in the opening code as criminal offences or domestic violence incidents (value 0 otherwise). "Crime Detection" takes value 1 for calls where one or more criminal offences were detected in the closing code (value 0 otherwise). "Crime Clearance" takes value 1 for calls where one or more offenders were charged, summonsed, cautioned, arrested or identified by name by the police (value 0 otherwise). "Violent Crime Clearance" takes value 1 for calls where one or more offenders were charged, summonsed, cautioned, arrested or identified by name by the police for a violent offence (value 0 otherwise). "Non-Violent Crime Clearance" takes value 1 for calls where one or more offenders were charged, summonsed, cautioned, arrested or identified by name by the police for a non-violent offence (value 0 otherwise). The unit of observation is the emergency call. % Effect calculated as estimated coefficient divided by mean of dependent variable in Treatment teams (i.e., BSP=1) pre May 2018. Standard errors are two-way clustered by Date and Team x Hour in all estimates, resulting in 820 date clusters and 331 team-by-hour clusters.

Table 3. Difference-in-Differences Estimates

	Double Crewing	Crime Opening Code		Crime Detection		Crime Clearance		Violent Crime Clearance		Non-Violent Crime Clearance	
	(1)	(2)	(3) = (2)/(1)	(4)	(5) = (4)/(1)	(6)	(7) = (6)/(1)	(8)	(9) = (8)/(1)	(10)	(11) = (10)/(1)
	First Stage	Reduced Form	Second Stage	Reduced Form	Second Stage	Reduced Form	Second Stage	Reduced Form	Second Stage	Reduced Form	Second Stage
A. Difference-in-Differences											
Response x Day Shift x Post	0.086	-0.003		0.011		0.024		0.021		0.003	
	(0.015)	(0.006)		(0.004)		(0.005)		(0.001)		(0.003)	
Double Crewing			-0.032		0.127		0.283		0.249		0.034
			(0.070)		(0.057)		(0.064)		(0.059)		(0.035)
Percent Relative to Pre-Mean	10.6	-0.8	-8.8	3.4	39.6	9.2	108.4	10.5	124.5	4.8	54.8
B. Plus Pre-Trends											
Response x Day Shift x Post	0.089	-0.008		0.017		0.023		0.024		-0.001	
	(0.016)	(0.008)		(0.006)		(0.005)		(0.005)		(0.004)	
Double Crewing			-0.094		0.188		0.255		0.267		-0.012
			(0.092)		(0.078)		(0.072)		(0.071)		(0.042)
Response x Day Shift x Pre -1	0.029	-0.016	-0.014	0.010	0.004	-0.007	-0.014	0.006	-0.001	-0.013	-0.013
	(0.012)	(0.010)	(0.008)	(0.007)	(0.006)	(0.009)	(0.009)	(0.006)	(0.007)	(0.006)	(0.006)
Response x Day Shift x Pre -2	-0.019	-0.003	-0.005	0.010	0.014	0.001	0.006	0.002	0.007	-0.001	-0.001
	(0.012)	(0.009)	(0.010)	(0.007)	(0.008)	(0.006)	(0.008)	(0.006)	(0.007)	(0.005)	(0.005)
P-value, Pre -1 and Pre -2	0.000	0.225	0.260	0.258	0.248	0.682	0.129	0.601	0.543	0.097	0.084
Percent Relative to Pre-Mean	10.9	-2.2	-26.0	5.3	58.6	8.8	97.7	12.0	133.5	-1.6	-19.3
Days	820	820	820	820	820	820	820	820	820	820	820
Team x Hour	331	331	331	331	331	331	331	331	331	331	331
Sample Size	270607	270607	270607	270607	270607	270607	270607	270607	270607	270607	270607
Date Fixed Effects	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
BSP Fixed Effects	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Full Set of Fixed Effects	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y

Notes: Post-period defined as starting from 1st May 2018, the date of adoption of the Banded Shift Pattern (BSP) in West Midlands Police (WMP). Treatment Group includes response teams during day shifts, i.e., the Early Shift and the Late Shift. Control Group includes all other teams. "Crime Opening Code" takes value 1 for calls classified by the dispatcher in the opening code as criminal offences or domestic violence incidents (value 0 otherwise). "Crime Detection" takes value 1 for calls where one or more criminal offences were detected in the closing code (value 0 otherwise). "Crime Clearance" takes value 1 for calls where one or more offenders were charged, summonsed, cautioned, arrested or identified by name by the police (value 0 otherwise). "Violent Crime Clearance" takes value 1 for calls where one or more offenders were charged, summonsed, cautioned, arrested or identified by name by the police for a violent offence (value 0 otherwise). "Non-Violent Crime Clearance" takes value 1 for calls where one or more offenders were charged, summonsed, cautioned, arrested or identified by name by the police for a non-violent offence (value 0 otherwise). The unit of observation is the emergency call. % Effect calculated as estimated coefficient divided by mean of dependent variable in Treatment teams (i.e., BSP=1) pre May 2018. The full Set of Fixed Effects (FEs) in the equation includes, namely, Response Team FEs; Incident Hour FEs interacted with Pre 1, Pre 2 and Post; P1 vs P2 Call FEs. Standard errors are two-way clustered by Date and Team x Hour in all estimates, resulting in 820 date clusters and 331 team-by-hour clusters.

Table 4. Difference-in-Discontinuity Interrupted Time Series Estimates

	Double Crewing	Crime Opening Code		Crime Detection		Crime Clearance		Violent Crime Clearance		Non-Violent Crime Clearance	
	(1)	(2)	(3) = (2)/(1)	(4)	(5) = (4)/(1)	(6)	(7) = (6)/(1)	(8)	(9) = (8)/(1)	(10)	(11) = (10)/(1)
	First Stage	Reduced Form	Second Stage	Reduced Form	Second Stage	Reduced Form	Second Stage	Reduced Form	Second Stage	Reduced Form	Second Stage
A. 12 Months Post Introduction											
Response x Day Shift x Post	0.110	-0.009		0.016		0.031		0.027		0.004	
	(0.021)	(0.012)		(0.011)		(0.010)		(0.009)		(0.005)	
Double Crewing			-0.084		0.144		0.278		0.242		0.036
			(0.120)		(0.094)		(0.085)		(0.077)		(0.041)
Percent Relative to Pre-Mean	13.5	-2.5	-23.2	5.0	44.9	11.9	106.5	13.5	121.0	6.4	58.1
Days	667	667	667	667	667	667	667	667	667	667	667
Team x Hour	325	325	325	325	325	325	325	325	325	325	325
Sample Size	222358	222358	222358	222358	222358	222358	222358	222358	222358	222358	222358
B. +/- 6 Months Around Introduction											
Response x Day Shift x Post	0.082	-0.004		0.017		0.030		0.027		0.002	
	(0.017)	(0.012)		(0.012)		(0.011)		(0.010)		(0.005)	
Double Crewing			-0.049		0.202		0.365		0.335		0.030
			(0.145)		(0.152)		(0.138)		(0.134)		(0.060)
Percent Relative to Pre-Mean	10.0	-1.1	-13.6	5.2	62.0	11.3	137.2	13.2	164.2	3.2	47.6
Days	364	364	364	364	364	364	364	364	364	364	364
Team x Hour	318	318	318	318	318	318	318	318	318	318	318
Sample Size	121100	121100	121100	121100	121100	121100	121100	121100	121100	121100	121100
BSP Fixed Effects	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Date Trend	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
BSP Fixed Effects x Date Trend	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Post x Date Trend	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
BSP Fixed Effects x Post x Date Trend	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y

Notes: Post-period defined as starting from 1st May 2018, the date of adoption of the Banded Shift Pattern (BSP) in West Midlands Police (WMP). Treatment Group includes response teams during day shifts, i.e., the Early Shift and the Late Shift. Control Group includes all other teams. "Crime Opening Code" takes value 1 for calls classified by the dispatcher in the opening code as criminal offences or domestic violence incidents (value 0 otherwise). "Crime Detection" takes value 1 for calls where one or more criminal offences were detected in the closing code (value 0 otherwise). "Crime Clearance" takes value 1 for calls where one or more offenders were charged, summonsed, cautioned, arrested or identified by name by the police (value 0 otherwise). "Violent Crime Clearance" takes value 1 for calls where one or more offenders were charged, summonsed, cautioned, arrested or identified by name by the police for a violent offence (value 0 otherwise). "Non-Violent Crime Clearance" takes value 1 for calls where one or more offenders were charged, summonsed, cautioned, arrested or identified by name by the police for a non-violent offence (value 0 otherwise). The unit of observation is the emergency call. % Effect calculated as estimated coefficient divided by mean of dependent variable in Treatment teams (i.e., BSP=1) pre May 2018. Standard errors are two-way clustered by Date and Team x Hour in all estimates, resulting in 667 date clusters and 325 team-by-hour clusters in Panel A and in 364 date clusters and 318 team-by-hour clusters in Panel B.

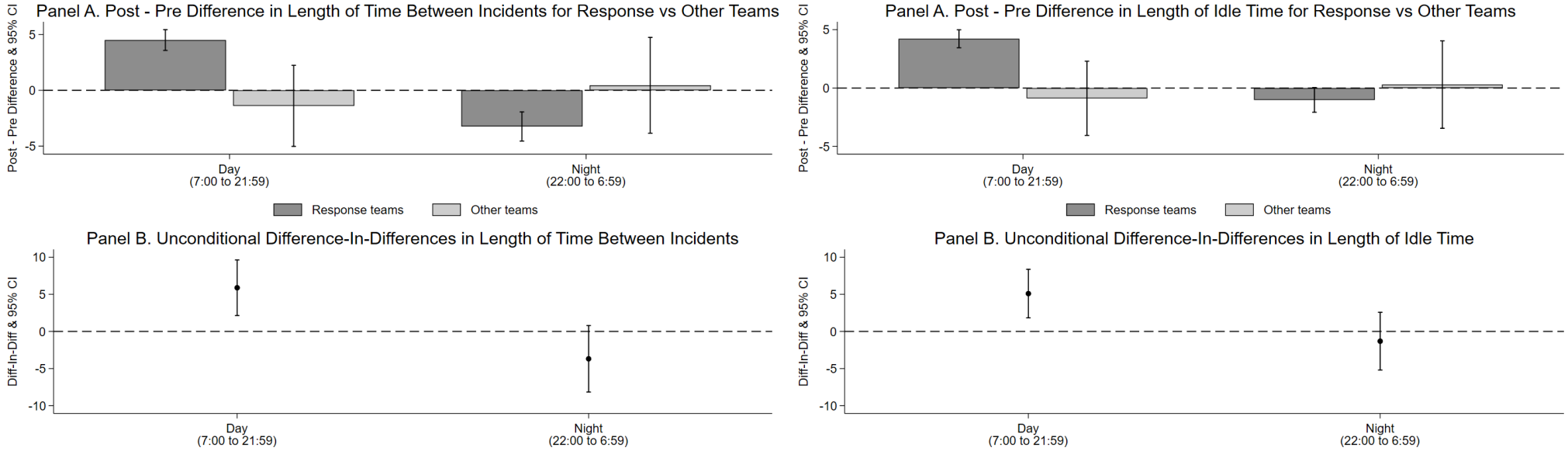
Table 5. Cost-Benefit Analysis

(1)	(2)	(3)	(4)	(5)	(6)
	Empirical / financial input	Calculation / treatment	12-month benefit	12-month cost	Result
A. Estimated benefits					
Violent-crime clearance	22,193 pre-period clearances; 10 months; +10.5%	22,193 × 12/10 × 10.5% × £1,666.19	£4,659,195		
Greater officer safety	19 pre-period assaults; 10 months; −65.3%	19 × 12/10 × 65.3% × £1,666.19	£24,807		
Overall benefits (Clearance plus safety)			£4,684,001		
B. Estimated costs					
Internal implementation and foregone output	£585,000 memo; 16,100 hours; 9,000 frontline hours	£585,000 + £124,433 foregone-output allowance		£709,433	
Accenture: Smarter Responding	Two public expenditure entries	£25,709.83 + £20,586.94		£46,296.77	
Smarter Responding capital envelope	60% of rounded 2018/19 budget	60% attributed to BSP		£900,000	
New Ways of Responding capital envelope	60% of rounded 2018/19 budget	60% attributed to BSP		£720,000	
Overall costs (explicit plus implicit costs)				£2,375,729.8	
C. Result					
Net benefit	Benefits – costs ((4)-(5))	£4,684,001 − £2,375,729.8			£2,308,271.2
Benefit-cost ratio = ((4)/(5))	Benefits / costs ((4)/(5))	£4,684,001 / £2,375,729.8			1.97
Payback time in months = 12/((4)/(5))	Uniform monthly benefit	£2,375,729.8 / (£4,684,001 / 12)			6.09 months

Notes: The calculation of £1,666.19, i.e., the estimated unitary benefit of violent crime clearance and officer safety in monetary terms, uses anticipation costs, consequence costs and response costs of violent crime without injury (i.e., a lower bound of the benefit of reduced violent crime) displayed in Table E1 of Heeks et al. (2018) available at: https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/732110/the-economic-and-social-costs-of-crime-horr99.pdf. In particular, the unitary benefit of violent crime clearance and officer safety in monetary terms was calculated as the difference between the consequence cost (£3750) and the sum of the anticipation cost (£120) and the response cost (£2,060) of a crime, expressed in 2018/19 GBP prices (i.e., 3750-120-2060 = 1570 × 100/94.227 = 1666.19). While the consequence cost of cleared violent crimes may not be avoided thanks to the increased violent crime clearance, the analysis assigns a gross economic benefit to crime clearance that is equivalent to the consequence cost of a crime; moreover, since the anticipation and response costs are realised due to the increased violent crime clearance and decreased assaults against officers, the difference between the economic benefit equivalent to the consequence cost and the (realised) anticipation and response costs is interpreted as the unit benefit of the Banded Shift Pattern (BSP). The estimated change in recorded violent crime clearance is calculated as the count of 22,193 emergency calls in the BSP group in which a violent crime was cleared prior to May 2018, i.e., over the ten-month period prior to the introduction of the BSP, multiplied by the estimated change in violent crime clearance in the BSP group of 10.5% in Table 3, Panel A, column (8), and annualised (i.e., multiplied by 12/10). The estimated change in recorded "Assault Against Officer" is calculated as the count of 19 emergency calls in the BSP group where officer assaults were detected in the ten-month period prior to May 2018 multiplied by the estimated change in assaults against officers in the BSP group of -65.3% that emerges from a descriptive difference-in-differences comparison of the means across time and annualised. Monetary values are in 2018/19-price terms except the two observed 2017 Accenture payments, which are retained at their published nominal face value. Benefits are modelled social-value proxies, not WMP cash receipts. The £709,433 internal line combines the high-friction £585,000 scenario with a £124,433 clearance-equivalent allowance for foregone frontline output; this addition may overlap with the labour opportunity cost and is retained deliberately to generate an upper bound estimate of costs. The £1.5 million and £1.2 million capital figures are the rounded envelopes published in the January 2019 capital programme, and 60% of these expenses are attributed to the BSP; the contemporaneous September 2018 monitoring values were lower (£1.476 million and £1.155 million). Public evidence establishes that BSP formed part of broader programmes but does not isolate the BSP share. The benefit-cost ratio equals total benefit divided by total cost. Payback assumes all costs at month 0 and uniform monthly benefit thereafter. Figures may differ by £1 because calculations use unrounded inputs.

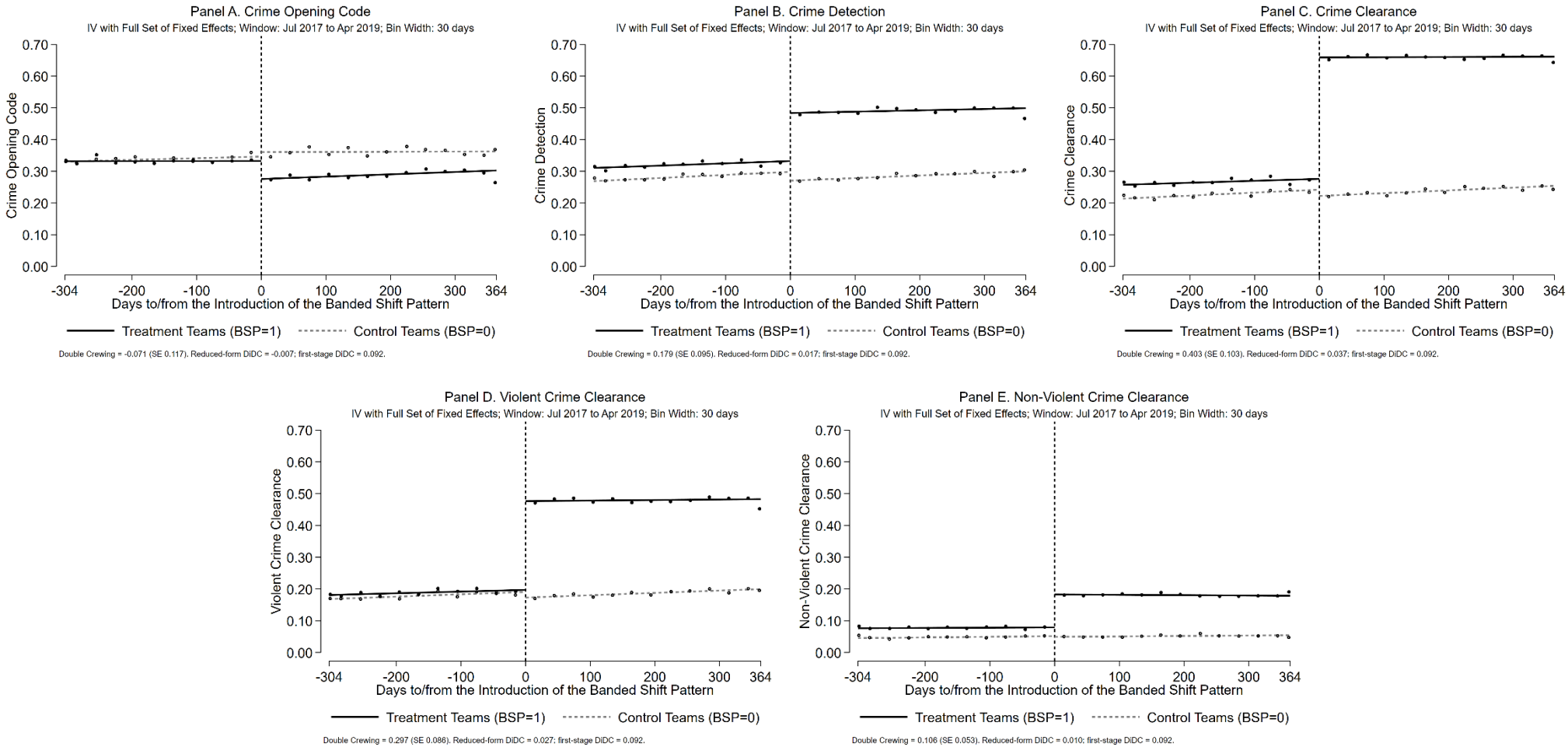
APPENDIX A. Additional Results

Appendix Figure A.1. Length of Time Between Incidents and Idle Time in West Midlands Police for Response vs Other Teams After the BSP



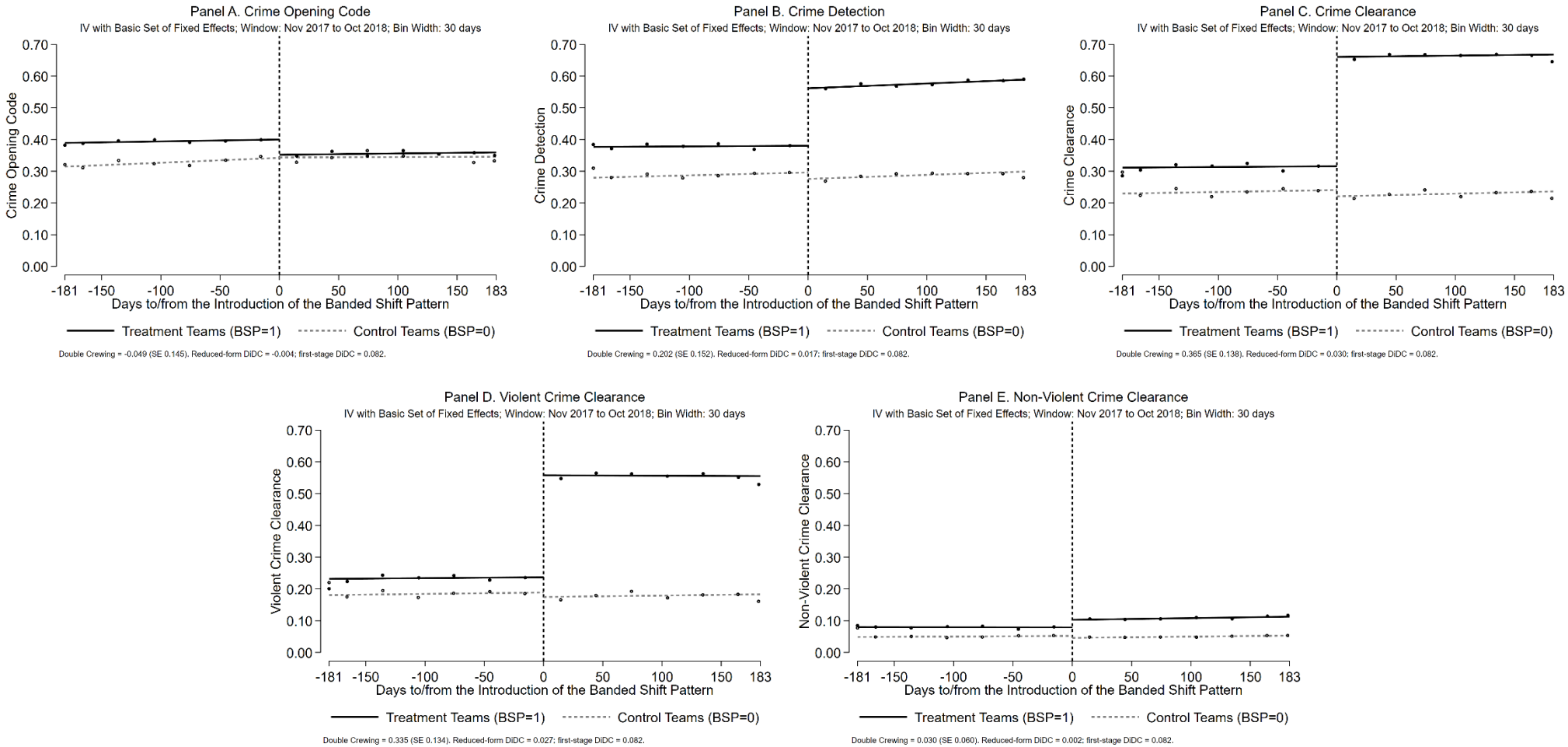
Notes: Figure shows the unconditional Post – Pre Difference in average length of time between emergency calls attended by the same officer and average length of idle time around the introduction of the Banded Shift Pattern (BSP) in May 2018 in response teams of West Midlands Police (WMP). Results are displayed separately for the Day shifts (7:00 to 21:59) and the Night shift (22:00 to 6:59). The left-hand side chart shows results for the average length of time between emergency calls and the right-hand side chart shows results for the average length of idle time. Length of time between emergency calls is calculated as the length of time between two adjacent incidents attended by the same officer. Length of idle time is calculated as the length of time between the time an officer left the previous call and the time the same officer was dispatched to the next call. Separately for response teams vs other teams and for the day shifts and the night shift, Panel A shows the difference between the average length of time between emergency calls attended by the same officer and average length of idle time after the introduction of the BSP and before the introduction of the BSP. Separately for the day shifts and the night shift, Panel B shows the unconditional difference-in-differences (DiD) estimate in length of time between emergency calls attended by the same officer and average length of idle time between response teams vs other teams.

Appendix Figure A.2. Difference-in-Discontinuity IV Estimates of the Impact of Double Crewing on Selection into Crime Calls and Productivity from July 2017 to April 2019, Full Set of FEs



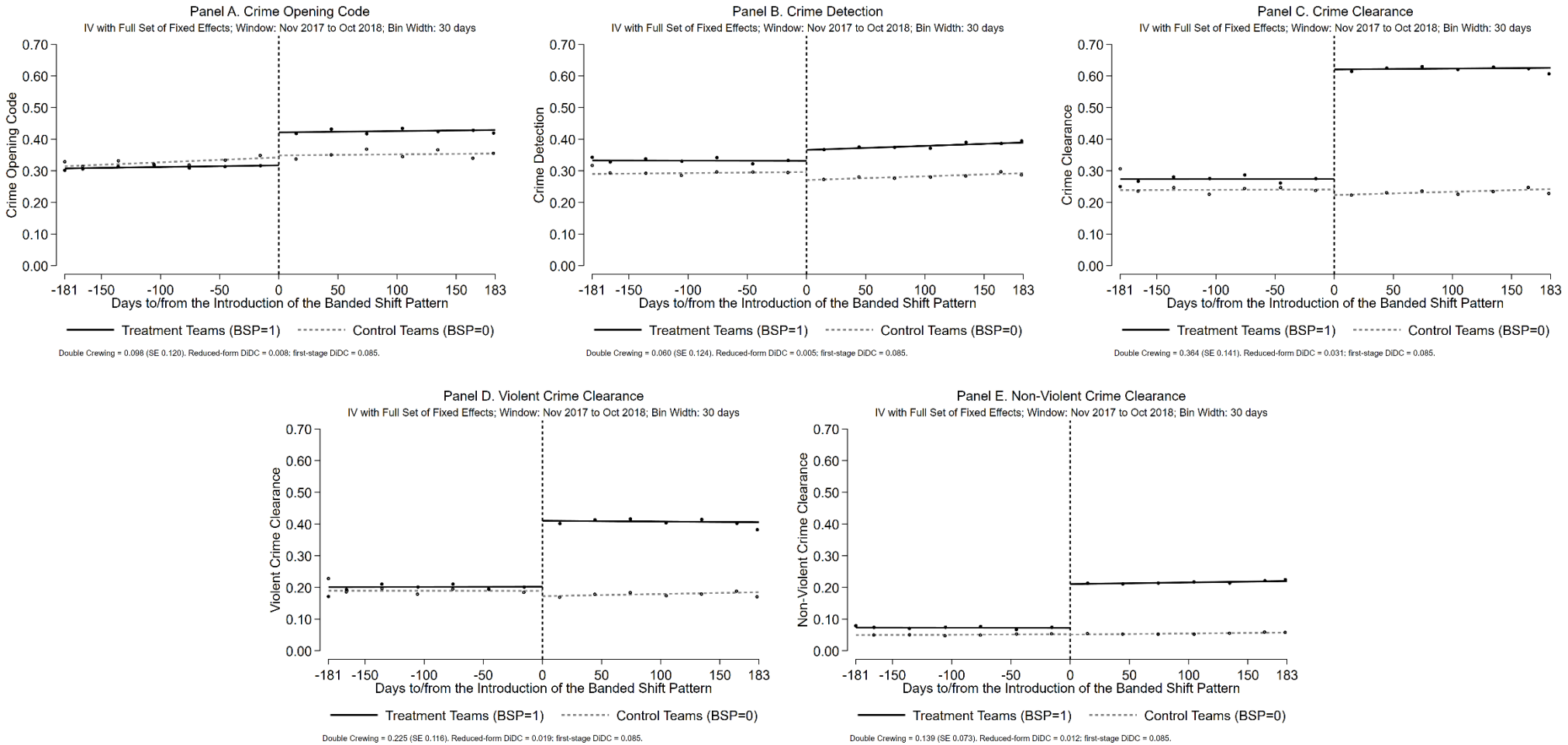
Notes: Post-period defined as starting from 1st May 2018, the date of adoption of the Banded Shift Pattern (BSP) in West Midlands Police (WMP). Treatment Group includes response teams during day shifts, i.e., the Early Shift and the Late Shift. Control Group includes all other teams. "Crime Opening Code" takes value 1 for calls classified by the dispatcher in the opening code as criminal offences or domestic violence incidents (value 0 otherwise). "Crime Detection" takes value 1 for calls where one or more criminal offences were detected in the closing code (value 0 otherwise). "Crime Clearance" takes value 1 for calls where one or more offenders were charged, summonsed, cautioned, arrested or identified by name by the police (value 0 otherwise). "Violent Crime Clearance" takes value 1 for calls where one or more offenders were charged, summonsed, cautioned, arrested or identified by name by the police for a violent offence (value 0 otherwise). "Non-Violent Crime Clearance" takes value 1 for calls where one or more offenders were charged, summonsed, cautioned, arrested or identified by name by the police for a non-violent offence (value 0 otherwise). The unit of observation is the emergency call. The full Set of Fixed Effects (FEs) in the equation includes, namely, Response Team FEs; Incident Hour FEs interacted with Pre 1, Pre 2 and Post; P1 vs P2 Call FEs. Standard errors are two-way clustered by Date and Team x Hour in all estimates, resulting in 667 date clusters and 325 team-by-hour clusters.

Appendix Figure A.3. Difference-in-Discontinuity IV Estimates of the Impact of Double Crewing on Selection into Crime Calls and Productivity from November 2017 to October 2018 (Six Months either side of BSP)



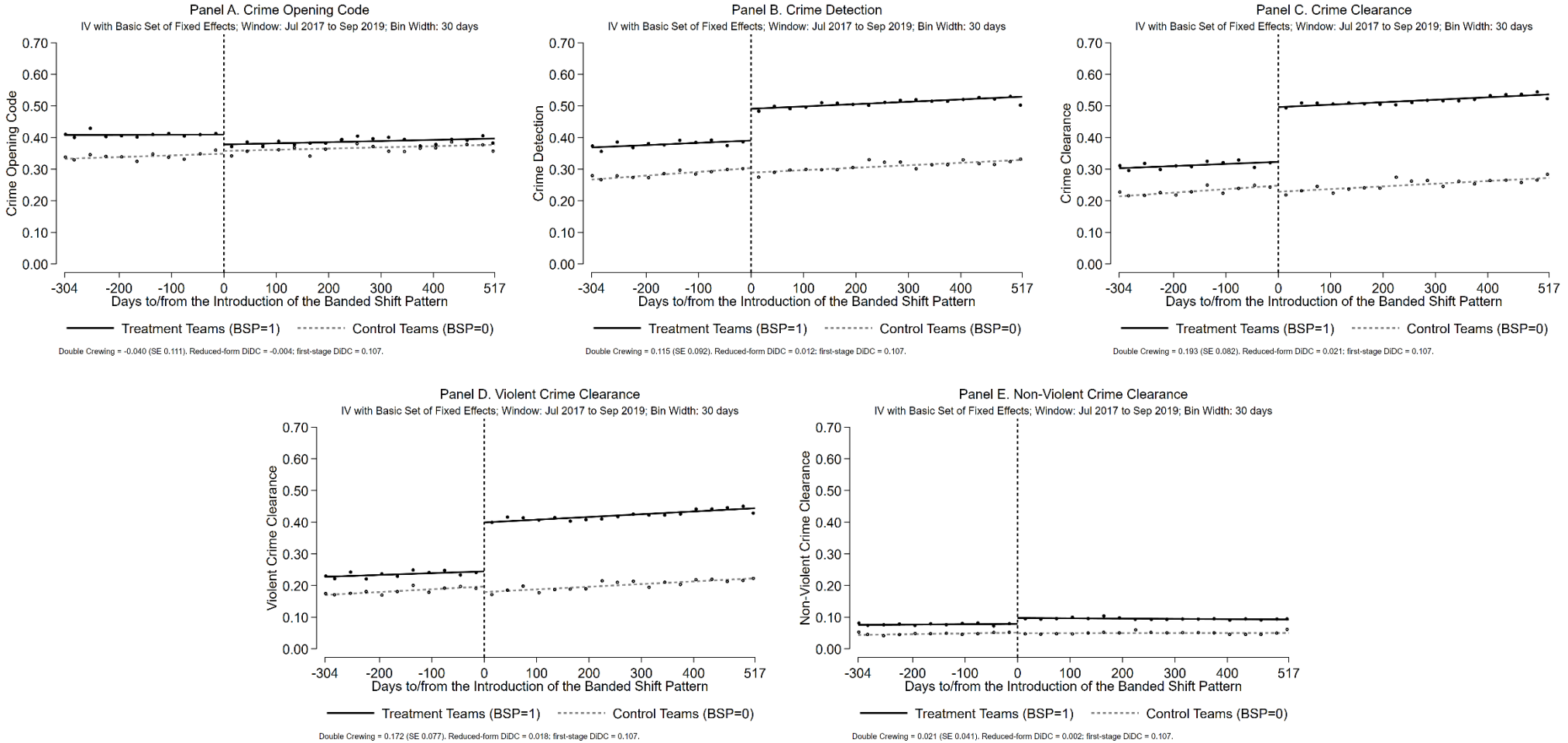
Notes: Post-period defined as starting from 1st May 2018, the date of adoption of the Banded Shift Pattern (BSP) in West Midlands Police (WMP). Treatment Group includes response teams during day shifts, i.e., the Early Shift and the Late Shift. Control Group includes all other teams. "Crime Opening Code" takes value 1 for calls classified by the dispatcher in the opening code as criminal offences or domestic violence incidents (value 0 otherwise). "Crime Detection" takes value 1 for calls where one or more criminal offences were detected in the closing code (value 0 otherwise). "Crime Clearance" takes value 1 for calls where one or more offenders were charged, summonsed, cautioned, arrested or identified by name by the police (value 0 otherwise). "Violent Crime Clearance" takes value 1 for calls where one or more offenders were charged, summonsed, cautioned, arrested or identified by name by the police for a violent offence (value 0 otherwise). "Non-Violent Crime Clearance" takes value 1 for calls where one or more offenders were charged, summonsed, cautioned, arrested or identified by name by the police for a non-violent offence (value 0 otherwise). The unit of observation is the emergency call. Standard errors are two-way clustered by Date and Team x Hour in all estimates, resulting in 364 date clusters and 318 team-by-hour clusters.

Appendix Figure A.4. Difference-in-Discontinuity IV Estimates of the Impact of Double Crewing on Selection into Crime Calls and Productivity from November 2017 to October 2018 (Six Months either side of BSP), Full Set of FEs



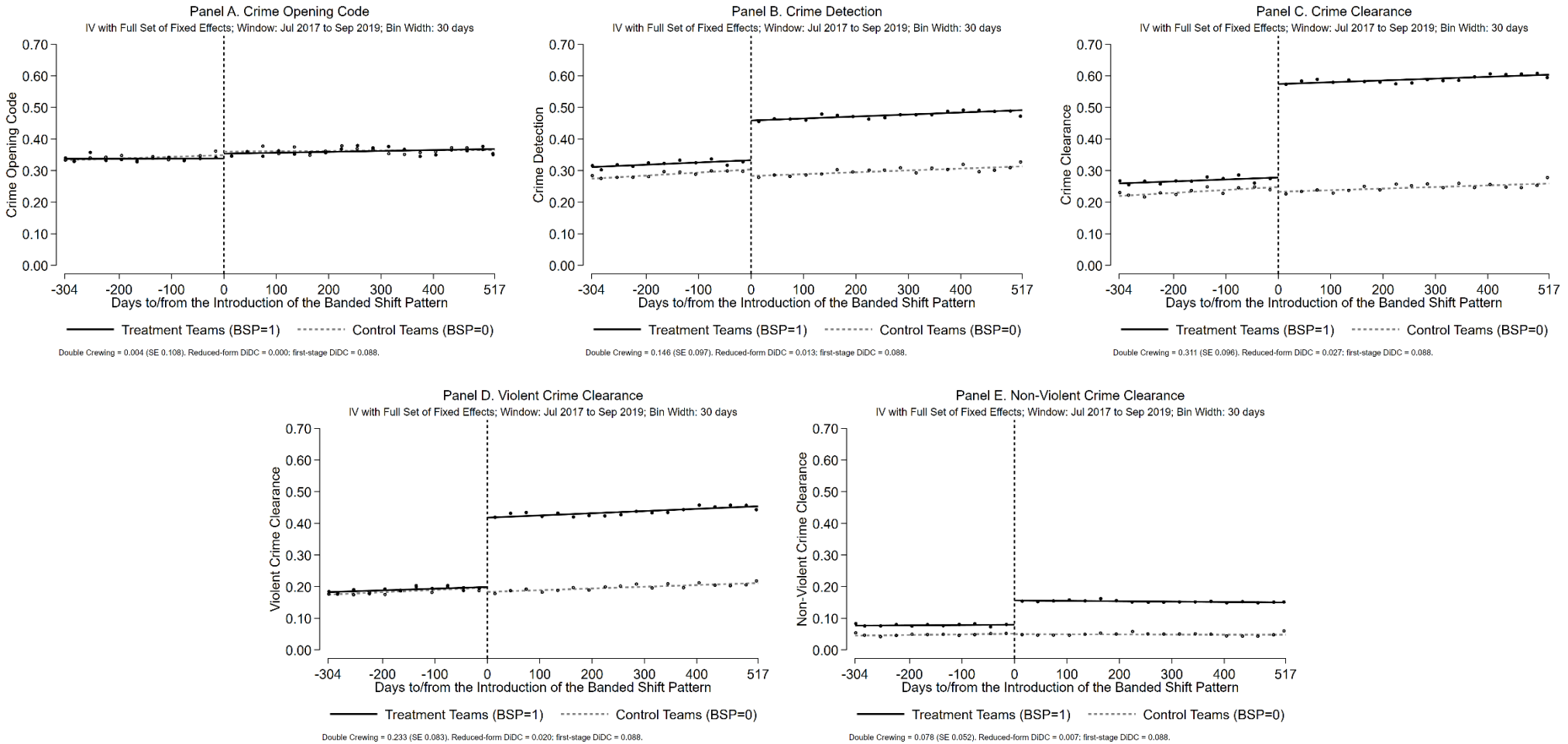
Notes: Post-period defined as starting from 1st May 2018, the date of adoption of the Banded Shift Pattern (BSP) in West Midlands Police (WMP). Treatment Group includes response teams during day shifts, i.e., the Early Shift and the Late Shift. Control Group includes all other teams. "Crime Opening Code" takes value 1 for calls classified by the dispatcher in the opening code as criminal offences or domestic violence incidents (value 0 otherwise). "Crime Detection" takes value 1 for calls where one or more criminal offences were detected in the closing code (value 0 otherwise). "Crime Clearance" takes value 1 for calls where one or more offenders were charged, summonsed, cautioned, arrested or identified by name by the police (value 0 otherwise). "Violent Crime Clearance" takes value 1 for calls where one or more offenders were charged, summonsed, cautioned, arrested or identified by name by the police for a violent offence (value 0 otherwise). "Non-Violent Crime Clearance" takes value 1 for calls where one or more offenders were charged, summonsed, cautioned, arrested or identified by name by the police for a non-violent offence (value 0 otherwise). The unit of observation is the emergency call. The full Set of Fixed Effects (FEs) in the equation includes, namely, Response Team FEs; Incident Hour FEs interacted with Pre 1, Pre 2 and Post; P1 vs P2 Call FEs. Standard errors are two-way clustered by Date and Team x Hour in all estimates, resulting in 364 date clusters and 318 team-by-hour clusters.

Appendix Figure A.5. Difference-in-Discontinuity IV Estimates of the Impact of Double Crewing on Selection into Crime Calls and Productivity from July 2017 to September 2019



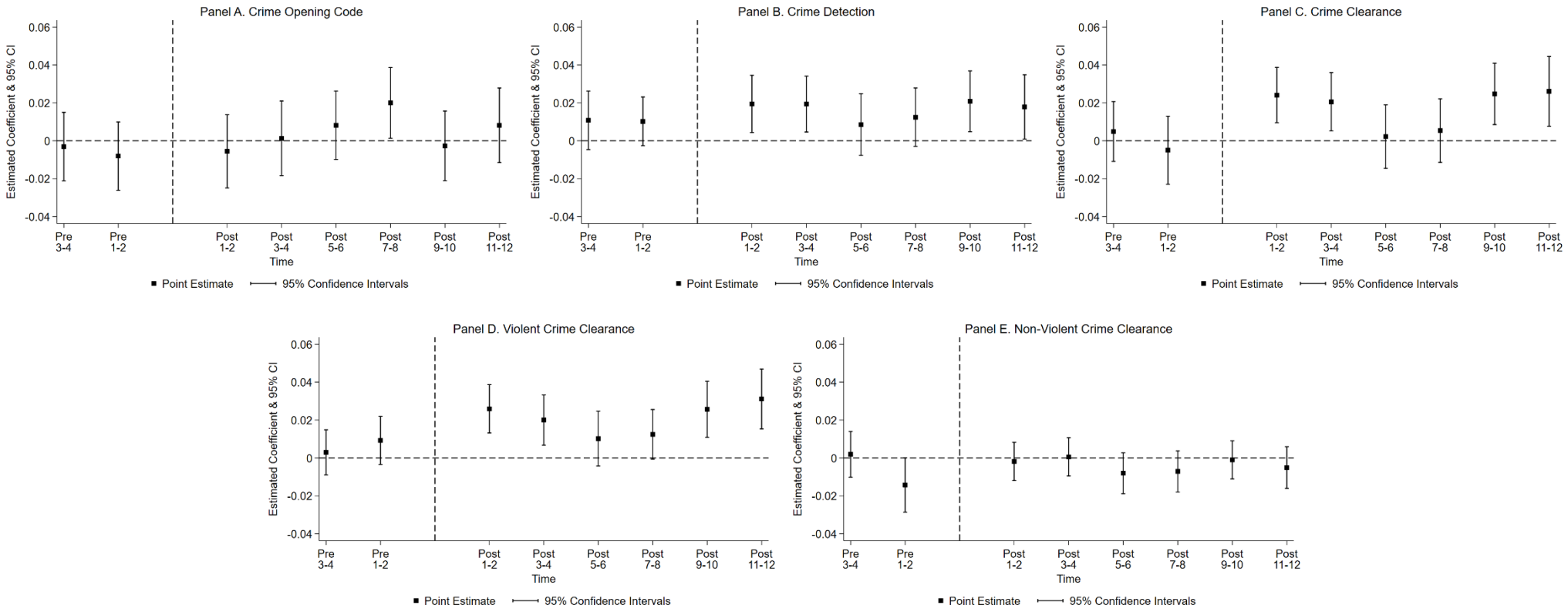
Notes: Post-period defined as starting from 1st May 2018, the date of adoption of the Banded Shift Pattern (BSP) in West Midlands Police (WMP). Treatment Group includes response teams during day shifts, i.e., the Early Shift and the Late Shift. Control Group includes all other teams. "Crime Opening Code" takes value 1 for calls classified by the dispatcher in the opening code as criminal offences or domestic violence incidents (value 0 otherwise). "Crime Detection" takes value 1 for calls where one or more criminal offences were detected in the closing code (value 0 otherwise). "Crime Clearance" takes value 1 for calls where one or more offenders were charged, summonsed, cautioned, arrested or identified by name by the police (value 0 otherwise). "Violent Crime Clearance" takes value 1 for calls where one or more offenders were charged, summonsed, cautioned, arrested or identified by name by the police for a violent offence (value 0 otherwise). "Non-Violent Crime Clearance" takes value 1 for calls where one or more offenders were charged, summonsed, cautioned, arrested or identified by name by the police for a non-violent offence (value 0 otherwise). The unit of observation is the emergency call. Standard errors are two-way clustered by Date and Team x Hour in all estimates, resulting in 820 date clusters and 331 team-by-hour clusters.

Appendix Figure A.6. Difference-in-Discontinuity IV Estimates of the Impact of Double Crewing on Selection into Crime Calls and Productivity from July 2017 to September 2019, Full Set of FEs



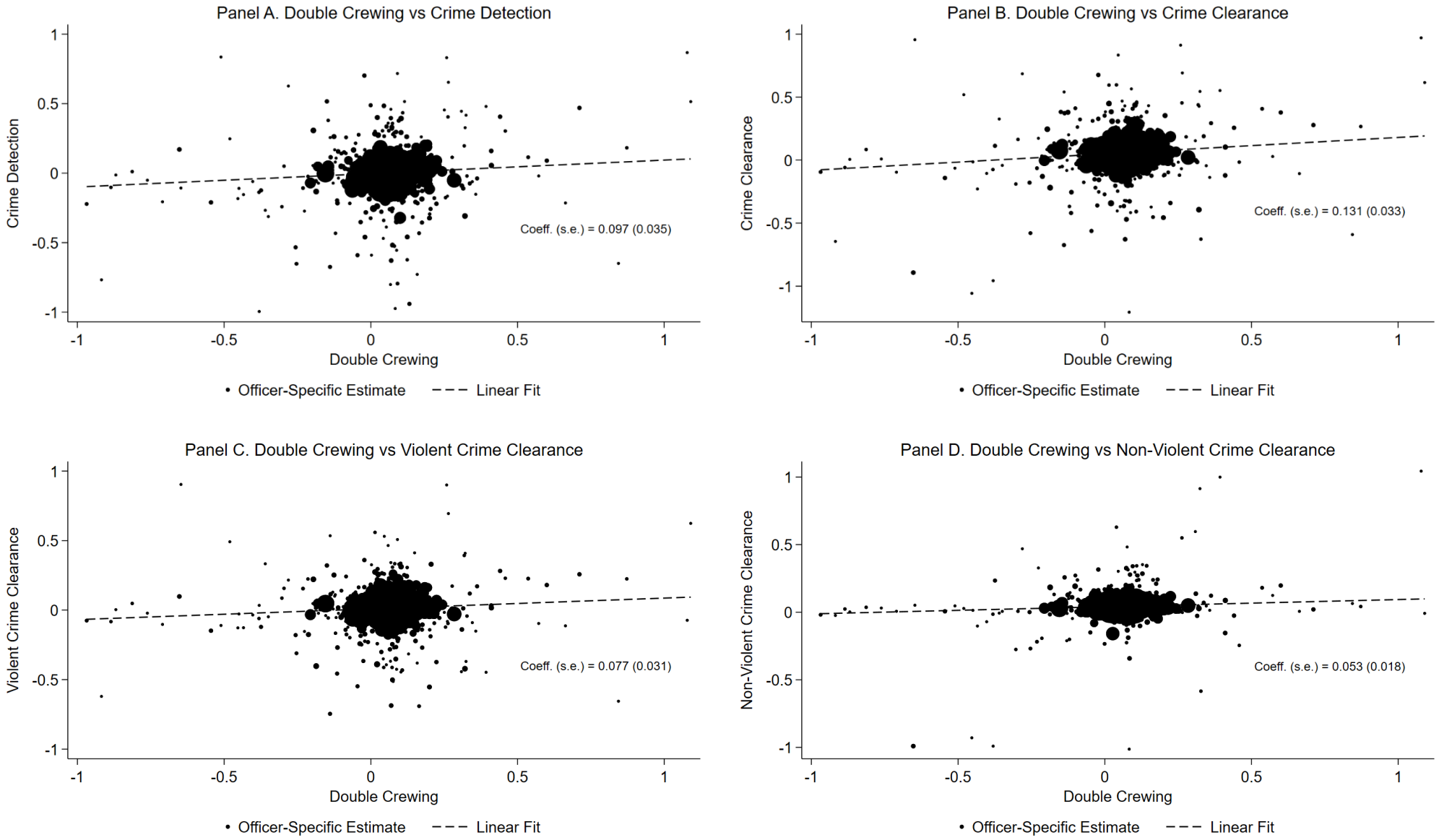
Notes: Post-period defined as starting from 1st May 2018, the date of adoption of the Banded Shift Pattern (BSP) in West Midlands Police (WMP). Treatment Group includes response teams during day shifts, i.e., the Early Shift and the Late Shift. Control Group includes all other teams. "Crime Opening Code" takes value 1 for calls classified by the dispatcher in the opening code as criminal offences or domestic violence incidents (value 0 otherwise). "Crime Detection" takes value 1 for calls where one or more criminal offences were detected in the closing code (value 0 otherwise). "Crime Clearance" takes value 1 for calls where one or more offenders were charged, summonsed, cautioned, arrested or identified by name by the police (value 0 otherwise). "Violent Crime Clearance" takes value 1 for calls where one or more offenders were charged, summonsed, cautioned, arrested or identified by name by the police for a violent offence (value 0 otherwise). "Non-Violent Crime Clearance" takes value 1 for calls where one or more offenders were charged, summonsed, cautioned, arrested or identified by name by the police for a non-violent offence (value 0 otherwise). The unit of observation is the emergency call. The full Set of Fixed Effects (FEs) in the equation includes, namely, Response Team FEs; Incident Hour FEs interacted with Pre 1, Pre 2 and Post; P1 vs P2 Call FEs. Standard errors are two-way clustered by Date and Team x Hour in all estimates, resulting in 820 date clusters and 331 team-by-hour clusters.

Appendix Figure A.7. Officer-Level Event Study Estimates of the Impact of the Banded Pattern on Selection into Crime Calls and Productivity



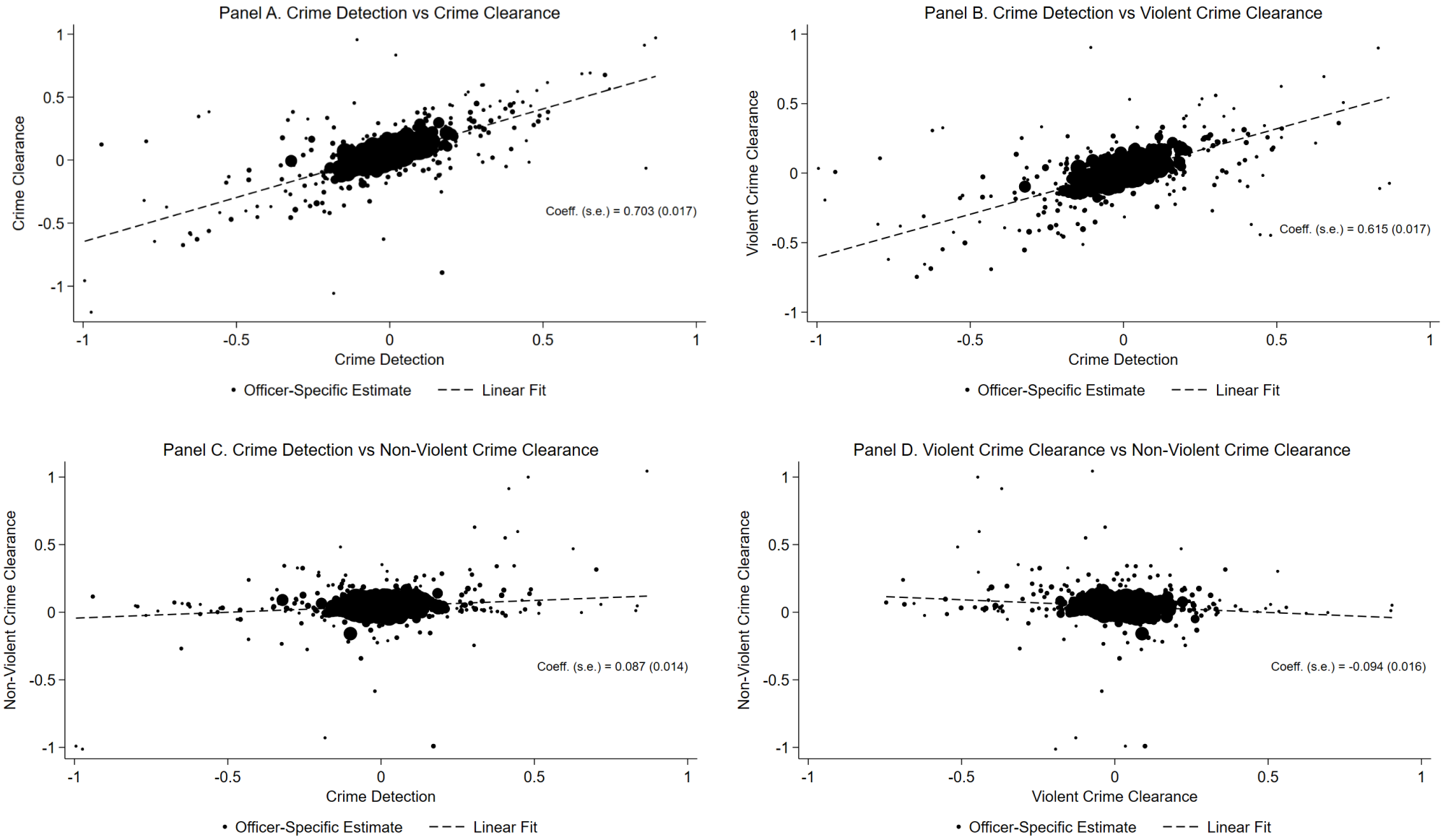
Notes: Post-period defined as starting from 1st May 2018, the date of adoption of the Banded Shift Pattern (BSP) in West Midlands Police (WMP). Treatment Group includes response teams during day shifts, i.e., the Early Shift and the Late Shift. Control Group includes all other teams. "Crime Opening Code" takes value 1 for calls classified by the dispatcher in the opening code as criminal offences or domestic violence incidents (value 0 otherwise). "Crime Detection" takes value 1 for calls where one or more criminal offences were detected in the closing code (value 0 otherwise). "Crime Clearance" takes value 1 for calls where one or more offenders were charged, summonsed, cautioned, arrested or identified by name by the police (value 0 otherwise). "Violent Crime Clearance" takes value 1 for calls where one or more offenders were charged, summonsed, cautioned, arrested or identified by name by the police for a violent offence (value 0 otherwise). "Non-Violent Crime Clearance" takes value 1 for calls where one or more offenders were charged, summonsed, cautioned, arrested or identified by name by the police for a non-violent offence (value 0 otherwise). The unit of observation is the officer attending the emergency call. Figure displays estimated coefficients in the event-study analogue to columns (2), (4), (6), (8) and (10) of Appendix Table A.9 where 90-day time periods are interacted with BSP Status and the full Set of Fixed Effects (FEs) is included in the equation. These include, namely, Officer FEs; Date FEs; BSP Status FEs; Response Team FEs; Incident Hour FEs interacted with Pre 1, Pre 2 and Post; P1 vs P2 Call FEs. Standard errors are two-way clustered by Date and Team x Hour in all estimates, resulting in 820 date clusters and 331 team-by-hour clusters.

Appendix Figure A.8. Officer-Specific Estimates of the Impact of the Banded Pattern on Double Crewing vs Officer Productivity



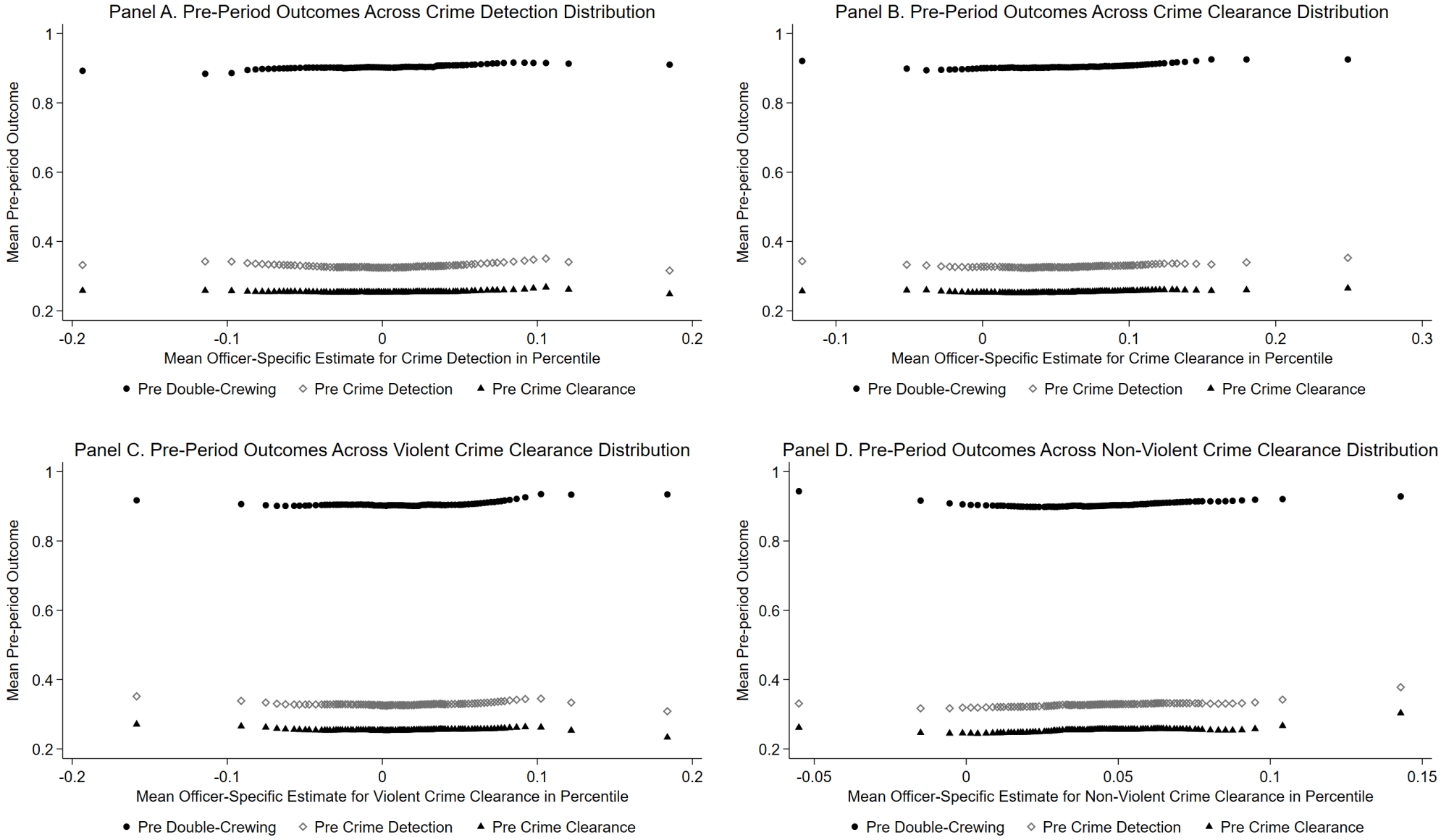
Notes: Post-period defined as starting from 1st May 2018, the date of adoption of the Banded Shift Pattern (BSP) in West Midlands Police (WMP). Treatment Group includes response teams during day shifts, i.e., the Early Shift and the Late Shift. Control Group includes all other teams. The analysis is restricted to WMP officers who were in WMP and responded to emergency calls since before May 2018. Figure displays estimated coefficients of the officer-specific impact of the BSP on double crewing vs crime detection (Panel A), double crewing vs crime clearance (Panel B), double crewing vs violent crime clearance (Panel C) and double crewing vs non-violent crime clearance (Panel D). "Crime Opening Code" takes value 1 for calls classified by the dispatcher in the opening code as criminal offences or domestic violence incidents (value 0 otherwise). "Crime Detection" takes value 1 for calls where one or more criminal offences were detected in the closing code (value 0 otherwise). "Crime Clearance" takes value 1 for calls where one or more offenders were charged, summonsed, cautioned, arrested or identified by name by the police (value 0 otherwise). "Violent Crime Clearance" takes value 1 for calls where one or more offenders were charged, summonsed, cautioned, arrested or identified by name by the police for a violent offence (value 0 otherwise). "Non-Violent Crime Clearance" takes value 1 for calls where one or more offenders were charged, summonsed, cautioned, arrested or identified by name by the police for a non-violent offence (value 0 otherwise). The unit of observation is the officer attending the emergency call. The full Set of Fixed Effects (FEs) in the equation includes, namely, Officer FEs; Response Team FEs; Incident Hour FEs interacted with Pre 1, Pre 2 and Post; P1 vs P2 Call FEs. Standard errors are two-way clustered by Date and Team x Hour in all estimates, resulting in 820 date clusters and 331 team-by-hour clusters.

Appendix Figure A.9. Officer-Specific Estimates of the Impact of the Banded Pattern on Officer Productivity



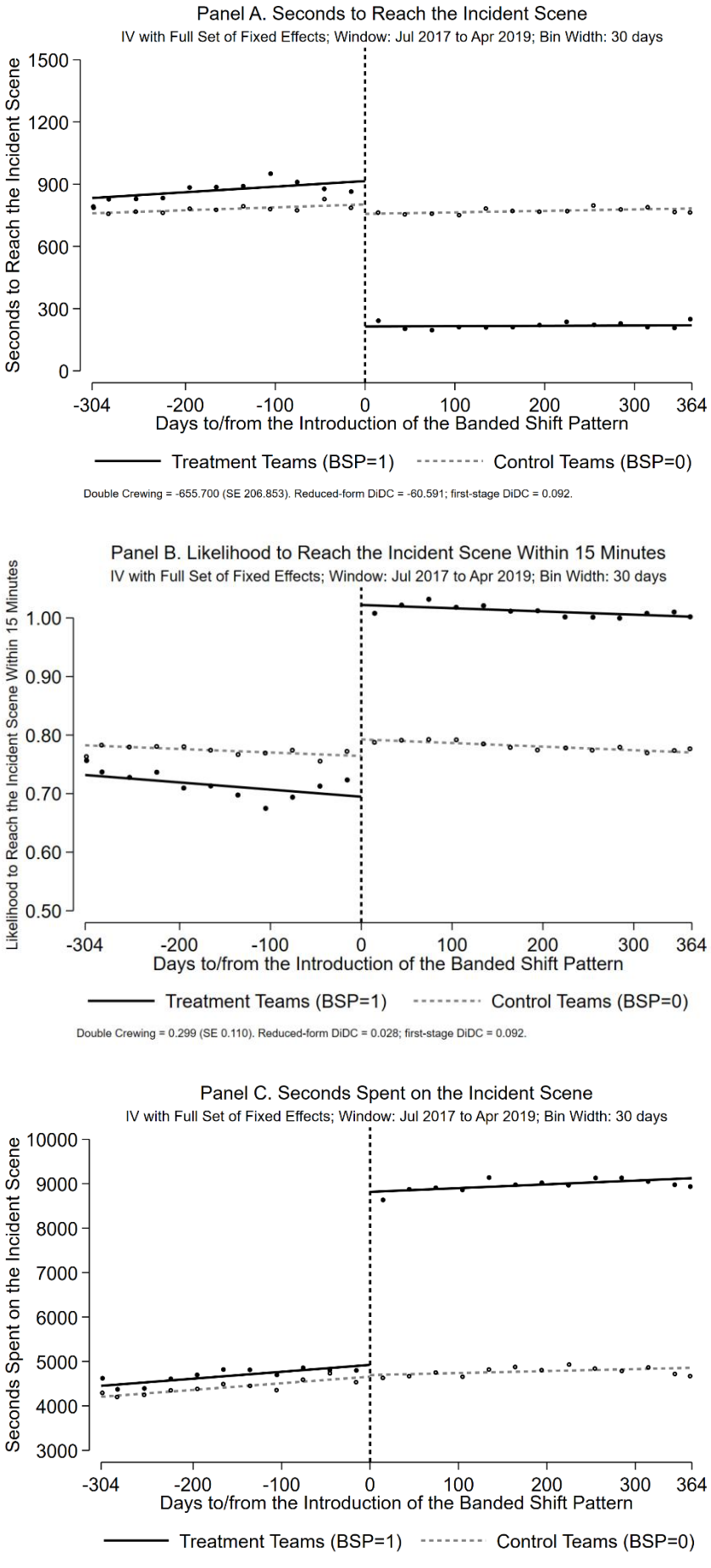
Notes: Post-period defined as starting from 1st May 2018, the date of adoption of the Banded Shift Pattern (BSP) in West Midlands Police (WMP). Treatment Group includes response teams during day shifts, i.e., the Early Shift and the Late Shift. Control Group includes all other teams. The analysis is restricted to WMP officers who were in WMP and responded to emergency calls since before May 2018. Figure displays estimated coefficients of the officer-specific impact of the BSP on crime detection vs crime clearance (Panel A), crime detection vs violent crime clearance (Panel B), crime detection vs non-violent crime clearance (Panel C) and violent crime clearance vs non-violent crime clearance (Panel D). "Crime Opening Code" takes value 1 for calls classified by the dispatcher in the opening code as criminal offences or domestic violence incidents (value 0 otherwise). "Crime Detection" takes value 1 for calls where one or more criminal offences were detected in the closing code (value 0 otherwise). "Crime Clearance" takes value 1 for calls where one or more offenders were charged, summonsed, cautioned, arrested or identified by name by the police (value 0 otherwise). "Violent Crime Clearance" takes value 1 for calls where one or more offenders were charged, summonsed, cautioned, arrested or identified by name by the police for a violent offence (value 0 otherwise). "Non-Violent Crime Clearance" takes value 1 for calls where one or more offenders were charged, summonsed, cautioned, arrested or identified by name by the police for a non-violent offence (value 0 otherwise). The unit of observation is the officer attending the emergency call. The full Set of Fixed Effects (FEs) in the equation includes, namely, Officer FEs; Response Team FEs; Incident Hour FEs interacted with Pre 1, Pre 2 and Post; P1 vs P2 Call FEs. Standard errors are two-way clustered by Date and Team x Hour in all estimates, resulting in 820 date clusters and 331 team-by-hour clusters.

Appendix Figure A.10. Distribution of Pre-Period Outcomes across Percentiles of Officer-Specific Estimates of the Impact of the Banded Pattern on Officer Productivity



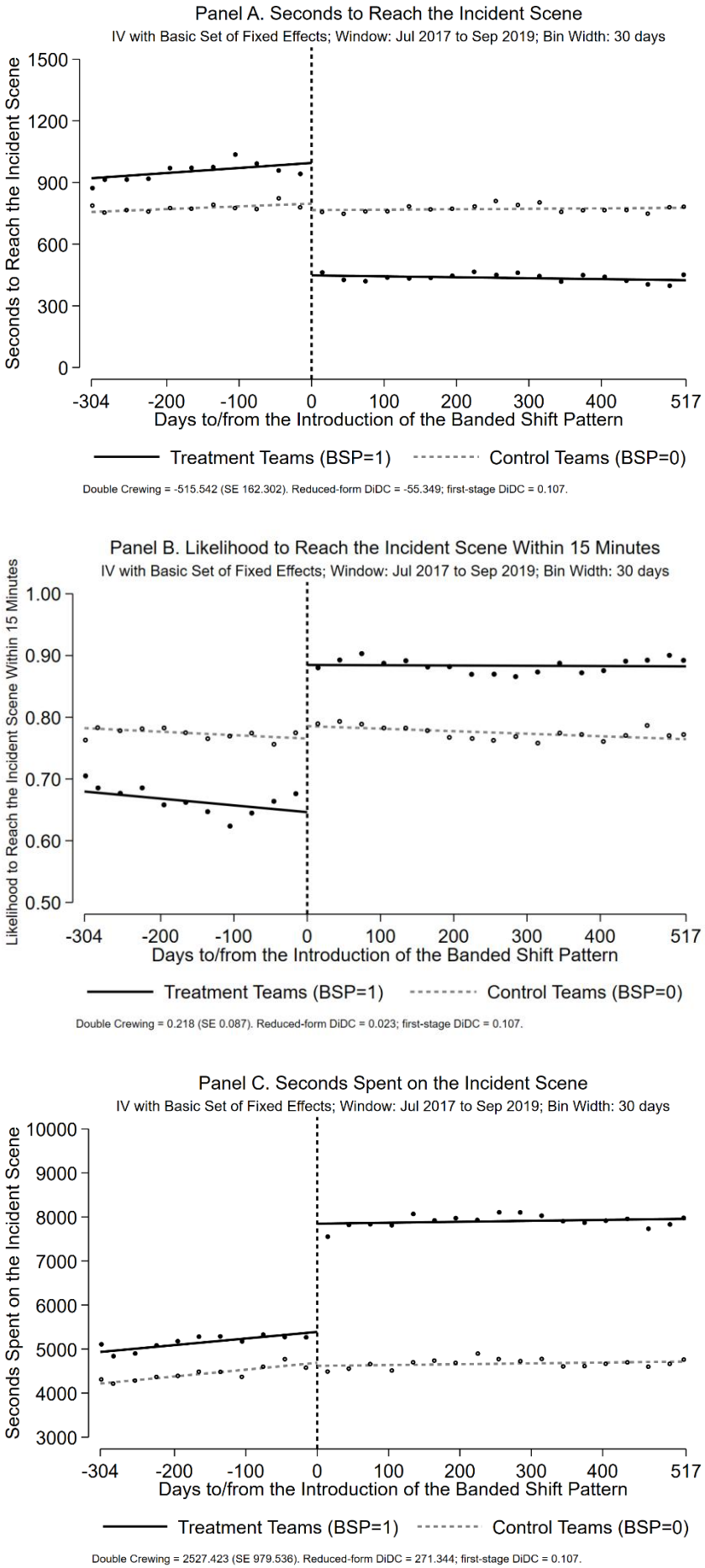
Notes: The chart shows the average double crewing, crime detection and crime clearance rates of officers prior to the Banded Shift Pattern (BSP) in each percentile of the distribution of the officer-specific estimates of the impact of the BSP on various metrics of officer productivity. "Crime Detection" takes value 1 for calls where one or more criminal offences were detected in the closing code (value 0 otherwise). "Crime Clearance" takes value 1 for calls where one or more offenders were charged, summonsed, cautioned, arrested or identified by name by the police (value 0 otherwise). "Violent Crime Clearance" takes value 1 for calls where one or more offenders were charged, summonsed, cautioned, arrested or identified by name by the police for a violent offence (value 0 otherwise). "Non-Violent Crime Clearance" takes value 1 for calls where one or more offenders were charged, summonsed, cautioned, arrested or identified by name by the police for a non-violent offence (value 0 otherwise). The unit of observation is the percentile of the officer-specific estimates of the impact of the BSP. The full Set of Fixed Effects (FEs) in the equation where officer-specific effects of the BSP were estimated includes, namely, Officer FEs; Date FEs; BSP Status FEs; Response Team FEs; Incident Hour FEs interacted with Pre 1, Pre 2 and Post; P1 vs P2 Call FEs. Standard errors are two-way clustered by Date and Team x Hour in all estimates, resulting in 820 date clusters and 331 team-by-hour clusters.

Appendix Figure A.11. Difference-in-Discontinuity IV Estimates of the Impact of Double Crewing on Response Time and Time Spent on the Incident Scene from July 2017 to April 2019, Full Set of FEs



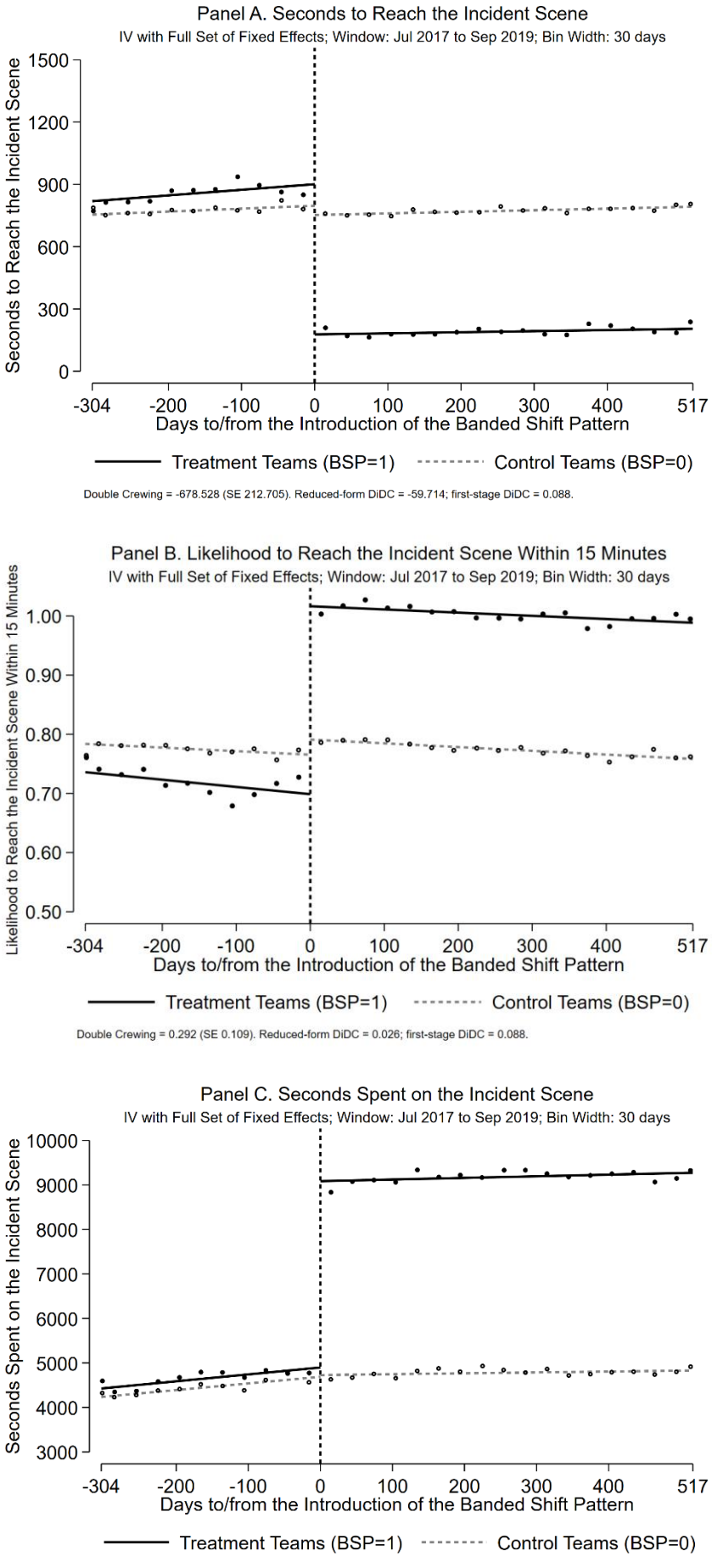
Notes: Post-period defined as starting from 1st May 2018, the date of adoption of the Banded Shift Pattern (BSP) in West Midlands Police (WMP). Treatment Group includes response teams during day shifts, i.e., the Early Shift and the Late Shift. Control Group includes all other teams. "Seconds to Reach the Incident Scene" is a continuous variable that measures (in seconds) the length of time from the moment officers were dispatched by the dispatcher to the time they reached the incident scene. "Likelihood to Reach the Incident Scene Within 15 Minutes" takes value 1 for calls where officers reached the incident scene within 15 minutes from the time of dispatch (value 0 otherwise). "Seconds Spent on the Incident Scene" is a continuous variable that measures (in seconds) the length of time from the moment officers reached the incident scene to the moment they left. The unit of observation is the emergency call. The full Set of Fixed Effects (FEs) in the equation includes, namely, Response Team FEs; Incident Hour FEs interacted with Pre 1, Pre 2 and Post; P1 vs P2 Call FEs. Standard errors are two-way clustered by Date and Team x Hour in all estimates, resulting in 667 date clusters and 325 team-by-hour clusters.

Appendix Figure A.12. Difference-in-Discontinuity IV Estimates of the Impact of Double Crewing on Response Time and Time Spent on the Incident Scene from July 2017 to September 2019



Notes: Post-period defined as starting from 1st May 2018, the date of adoption of the Banded Shift Pattern (BSP) in West Midlands Police (WMP). Treatment Group includes response teams during day shifts, i.e., the Early Shift and the Late Shift. Control Group includes all other teams. "Seconds to Reach the Incident Scene" is a continuous variable that measures (in seconds) the length of time from the moment officers were dispatched by the dispatcher to the time they reached the incident scene. "Likelihood to Reach the Incident Scene Within 15 Minutes" takes value 1 for calls where officers reached the incident scene within 15 minutes from the time of dispatch (value 0 otherwise). "Seconds Spent on the Incident Scene" is a continuous variable that measures (in seconds) the length of time from the moment officers reached the incident scene to the moment they left. The unit of observation is the emergency call. Standard errors are two-way clustered by Date and Team x Hour in all estimates, resulting in 820 date clusters and 331 team-by-hour clusters.

Appendix Figure A.13. Difference-in-Discontinuity IV Estimates of the Impact of Double Crewing on Response Time and Time Spent on the Incident Scene from July 2017 to September 2019, Full Set of FEs



Notes: Post-period defined as starting from 1st May 2018, the date of adoption of the Banded Shift Pattern (BSP) in West Midlands Police (WMP). Treatment Group includes response teams during day shifts, i.e., the Early Shift and the Late Shift. Control Group includes all other teams. "Seconds to Reach the Incident Scene" is a continuous variable that measures (in seconds) the length of time from the moment officers were dispatched by the dispatcher to the time they reached the incident scene. "Likelihood to Reach the Incident Scene Within 15 Minutes" takes value 1 for calls where officers reached the incident scene within 15 minutes from the time of dispatch (value 0 otherwise). "Seconds Spent on the Incident Scene" is a continuous variable that measures (in seconds) the length of time from the moment officers reached the incident scene to the moment they left. The unit of observation is the emergency call. The full Set of Fixed Effects (FEs) in the equation includes, namely, Response Team FEs; Incident Hour FEs interacted with Pre 1, Pre 2 and Post; P1 vs P2 Call FEs. Standard errors are two-way clustered by Date and Team x Hour in all estimates, resulting in 820 date clusters and 331 team-by-hour clusters.

Appendix Table A.1. Descriptive Determinants of Participation in the Banded Shift Pattern (BSP) Prior to May 2018

	Participation in the BSP							
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Male	-0.003						-0.007	-0.002
	(0.005)						(0.006)	(0.005)
Years of Service in WMP		0.000	0.000				-0.000	0.001
		(0.000)	(0.001)				(0.001)	(0.001)
Years of Service in WMP ^ 2			-0.000				-0.000	-0.000
			(0.000)				(0.000)	(0.000)
Age of Officer				0.000	-0.000		0.000	-0.000
				(0.000)	(0.000)		(0.001)	(0.001)
Age of Officer ^ 2					0.000		0.000	0.000
					(0.000)		(0.000)	(0.000)
Junior						0.002	0.002	-0.000
						(0.005)	(0.006)	(0.005)
Number of Officers	2687	2687	2687	2687	2687	2687	2687	2687
Sample Size	180239	180239	180239	180239	180239	180239	180239	180239
Full Set of Fixed Effects	No	No	No	No	No	No	No	Yes

Notes: Analysis conducted on emergency calls prior to 1st May 2018, the date of adoption of the Banded Shift Pattern (BSP) in West Midlands Police (WMP). The dependent variable is the Participation in the Banded Shift Pattern (BSP) defined as 1 for Response officers in day shifts, i.e., morning shift and late shift, and defined as 0 for all other officers. The unit of observation is the police officer responding to an emergency call. The full Set of Fixed Effects (FEs) in the equation includes, namely, Date FEs; Incident Hour FEs; P1 vs P2 Call FEs. Standard errors are clustered by officer in all estimates.

Appendix Table A.2. Mean Comparisons Before and After the Introduction of the Banded Shift Pattern

	(1) All (K=1, 1≤L≤2)	(2) Double crewing (K=1, L=2)	(3) Single crewing (K=1, L=1)	(4) Double crewing (K=1, L=2), BSP=1	(5) Double crewing (K=1, L=2), BSP=0	(6) Single crewing (K=1, L=1), BSP=1	(7) Single crewing (K=1, L=1), BSP=0	(8) (2)-(3)	(9) (4)-(6)	(10) (5)-(7)
					A. Crime Opening Code					
Average	0.349	0.370	0.247	0.378	0.353	0.325	0.167	0.123	0.053	0.186
								(0.006)	(0.007)	(0.011)
Average Pre	0.337	0.355	0.267	0.367	0.333	0.341	0.163	0.088	0.026	0.170
								(0.013)	(0.005)	(0.016)
Average Post	0.356	0.378	0.231	0.384	0.365	0.309	0.170	0.147	0.075	0.195
								(0.011)	(0.007)	(0.012)
Average Post – Pre	0.019	0.023	-0.036	0.017	0.032	-0.032	0.007	0.059	0.049	0.025
	(0.003)	(0.003)	(0.005)	(0.004)	(0.004)	(0.006)	(0.010)	(0.006)	(0.007)	(0.011)
Percent Relative to Average Pre in (1)								17.5	14.5	7.4
					B. Crime Detection					
Average	0.303	0.324	0.203	0.348	0.278	0.283	0.121	0.121	0.065	0.157
								(0.006)	(0.006)	(0.012)
Average Pre	0.287	0.303	0.221	0.328	0.258	0.292	0.121	0.082	0.036	0.137
								(0.012)	(0.005)	(0.015)
Average Post	0.313	0.336	0.189	0.358	0.289	0.274	0.121	0.147	0.084	0.168
								(0.010)	(0.006)	(0.011)
Average Post – Pre	0.027	0.033	-0.032	0.030	0.031	-0.018	0.000	0.065	0.048	0.031
	(0.003)	(0.003)	(0.005)	(0.004)	(0.004)	(0.006)	(0.010)	(0.006)	(0.006)	(0.012)
Percent Relative to Average Pre in (1)								22.6	16.7	10.8
					C. Crime Clearance					
Average	0.248	0.274	0.119	0.298	0.229	0.174	0.063	0.155	0.124	0.166
								(0.005)	(0.005)	(0.008)
Average Pre	0.231	0.256	0.131	0.280	0.213	0.178	0.064	0.125	0.102	0.149
								(0.007)	(0.005)	(0.008)
Average Post	0.258	0.284	0.110	0.307	0.239	0.170	0.062	0.174	0.137	0.177
								(0.006)	(0.005)	(0.007)
Average Post – Pre	0.027	0.028	-0.021	0.027	0.026	-0.008	-0.002	0.049	0.035	0.028
	(0.003)	(0.003)	(0.004)	(0.003)	(0.006)	(0.005)	(0.004)	(0.005)	(0.005)	(0.008)
Percent Relative to Average Pre in (1)								21.2	15.1	12.1
					D. Violent Crime Clearance					
Average	0.197	0.218	0.093	0.232	0.192	0.141	0.044	0.125	0.091	0.148
								(0.004)	(0.005)	(0.007)
Average Pre	0.180	0.200	0.104	0.212	0.177	0.145	0.045	0.096	0.067	0.132
								(0.007)	(0.006)	(0.007)
Average Post	0.207	0.228	0.085	0.242	0.200	0.137	0.043	0.143	0.105	0.157
								(0.005)	(0.005)	(0.006)
Average Post – Pre	0.026	0.028	-0.019	0.030	0.023	-0.008	-0.002	0.047	0.038	0.025
	(0.003)	(0.003)	(0.004)	(0.003)	(0.005)	(0.005)	(0.004)	(0.004)	(0.005)	(0.007)
Percent Relative to Average Pre in (1)								26.1	21.1	13.9
					E. Non-Violent Crime Clearance					
Average	0.051	0.056	0.026	0.066	0.037	0.033	0.020	0.030	0.033	0.017
								(0.002)	(0.003)	(0.003)
Average Pre	0.051	0.057	0.027	0.068	0.036	0.033	0.020	0.030	0.035	0.016
								(0.003)	(0.003)	(0.002)
Average Post	0.051	0.056	0.025	0.065	0.039	0.033	0.019	0.031	0.032	0.020
								(0.002)	(0.002)	(0.002)
Average Post – Pre	0.001	-0.001	-0.002	-0.003	0.003	0.000	-0.001	0.001	-0.003	0.004
	(0.001)	(0.002)	(0.001)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)	(0.003)	(0.003)
Percent Relative to Average Pre in (1)								2.0	-5.9	7.8
Sample Size	270607	224554	46053	148612	75942	23331	22722	270607	171943	98664

Notes: Post-period defined as starting from 1st May 2018, the date of adoption of the Banded Shift Pattern (BSP) in West Midlands Police (WMP). "Crime Opening Code" takes value 1 for calls classified by the dispatcher in the opening code as criminal offences or domestic violence incidents (value 0 otherwise). "Crime Detection" takes value 1 for calls where one or more criminal offences were detected in the closing code (value 0 otherwise). "Crime Clearance" takes value 1 for calls where one or more offenders were charged, summonsed, cautioned, arrested or identified by name by the police (value 0 otherwise). "Violent Crime Clearance" takes value 1 for calls where one or more offenders were charged, summonsed, cautioned, arrested or identified by name by the police for a violent offence (value 0 otherwise). "Non-Violent Crime Clearance" takes value 1 for calls where one or more offenders were charged, summonsed, cautioned, arrested or identified by name by the police for a non-violent offence (value 0 otherwise). The unit of observation is the emergency call. % Effect calculated as the Post–Pre change in the double-minus-single gap in columns (8)–(10) divided by the full-sample pre-period mean in column (1), and multiply by 100. Standard errors are two-way clustered by Date and Team x Hour in all estimates, resulting in 820 date clusters and 331 team-by-hour clusters.

Appendix Table A.3. Difference-in-Discontinuity Interrupted Time Series Estimates from July 2017 to September 2019

	Double Crewing	Crime Opening Code		Crime Detection		Crime Clearance		Violent Crime Clearance		Non-Violent Crime Clearance	
	(1)	(2)	(3) = (2)/(1)	(4)	(5) = (4)/(1)	(6)	(7) = (6)/(1)	(8)	(9) = (8)/(1)	(10)	(11) = (10)/(1)
	First Stage	Reduced Form	Second Stage	Reduced Form	Second Stage	Reduced Form	Second Stage	Reduced Form	Second Stage	Reduced Form	Second Stage
A. July 2017 to September 2019 (Full Period)											
Response x Day Shift x Post	0.107	-0.004		0.012		0.021		0.018		0.002	
	(0.023)	(0.011)		(0.011)		(0.011)		(0.010)		(0.004)	
Double Crewing			-0.040		0.115		0.193		0.172		0.021
			(0.111)		(0.092)		(0.082)		(0.077)		(0.041)
Percent Relative to Pre-Mean	13.1	-1.1	-11.0	3.7	35.8	8.0	73.9	9.0	86.0	3.2	33.9
Days	820	820	820	820	820	820	820	820	820	820	820
Team x Hour	331	331	331	331	331	331	331	331	331	331	331
Sample Size	270607	270607	270607	270607	270607	270607	270607	270607	270607	270607	270607
BSP Fixed Effects	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Date Trend	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
BSP Fixed Effects x Date Trend	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Post x Date Trend	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
BSP Fixed Effects x Post x Date Trend	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y

Notes: Post-period defined as starting from 1st May 2018, the date of adoption of the Banded Shift Pattern (BSP) in West Midlands Police (WMP). Treatment Group includes response teams during day shifts, i.e., the Early Shift and the Late Shift. Control Group includes all other teams. "Crime Opening Code" takes value 1 for calls classified by the dispatcher in the opening code as criminal offences or domestic violence incidents (value 0 otherwise). "Crime Detection" takes value 1 for calls where one or more criminal offences were detected in the closing code (value 0 otherwise). "Crime Clearance" takes value 1 for calls where one or more offenders were charged, summonsed, cautioned, arrested or identified by name by the police (value 0 otherwise). "Violent Crime Clearance" takes value 1 for calls where one or more offenders were charged, summonsed, cautioned, arrested or identified by name by the police for a violent offence (value 0 otherwise). "Non-Violent Crime Clearance" takes value 1 for calls where one or more offenders were charged, summonsed, cautioned, arrested or identified by name by the police for a non-violent offence (value 0 otherwise). The unit of observation is the emergency call. % Effect calculated as estimated coefficient divided by mean of dependent variable in Treatment teams (i.e., BSP=1) pre May 2018. Standard errors are two-way clustered by Date and Team x Hour in all estimates, resulting in 820 date clusters and 331 team-by-hour clusters.

Appendix Table A.4. Difference-in-Discontinuity Interrupted Time Series Estimates, Full Set of FEs

	Double Crewing	Crime Opening Code		Crime Detection		Crime Clearance		Violent Crime Clearance		Non-Violent Crime Clearance	
	(1)	(2)	(3) = (2)/(1)	(4)	(5) = (4)/(1)	(6)	(7) = (6)/(1)	(8)	(9) = (8)/(1)	(10)	(11) = (10)/(1)
	First Stage	Reduced Form	Second Stage	Reduced Form	Second Stage	Reduced Form	Second Stage	Reduced Form	Second Stage	Reduced Form	Second Stage
A. 12 Months Post Introduction											
Response x Day Shift x Post	0.092	-0.007		0.017		0.037		0.027		0.010	
	(0.015)	(0.011)		(0.008)		(0.008)		(0.007)		(0.005)	
Double Crewing			-0.071		0.179		0.403		0.297		0.106
			(0.117)		(0.095)		(0.103)		(0.086)		(0.053)
Percent Relative to Pre-Mean	11.3	-1.9	-19.6	5.3	55.8	14.2	154.4	13.5	148.5	16.1	171.0
Days	667	667	667	667	667	667	667	667	667	667	667
Team x Hour	325	325	325	325	325	325	325	325	325	325	325
Sample Size	222358	222358	222358	222358	222358	222358	222358	222358	222358	222358	222358
B. +/- 6 Months Around Introduction											
Response x Day Shift x Post	0.085	0.008		0.005		0.031		0.019		0.012	
	(0.017)	(0.011)		(0.010)		(0.011)		(0.009)		(0.006)	
Double Crewing			0.098		0.060		0.364		0.225		0.139
			(0.120)		(0.124)		(0.141)		(0.116)		(0.073)
Percent Relative to Pre-Mean	10.4	2.2	27.1	1.5	18.4	11.6	136.8	9.3	110.3	19.0	220.6
Days	364	364	364	364	364	364	364	364	364	364	364
Team x Hour	318	318	318	318	318	318	318	318	318	318	318
Sample Size	121100	121100	121100	121100	121100	121100	121100	121100	121100	121100	121100
C. July 2017 to September 2019 (Full Period)											
Response x Day Shift x Post	0.088	0.000		0.013		0.027		0.020		0.007	
	(0.017)	(0.010)		(0.008)		(0.008)		(0.006)		(0.005)	
Double Crewing			0.004		0.146		0.311		0.233		0.078
			(0.108)		(0.097)		(0.096)		(0.083)		(0.052)
Percent Relative to Pre-Mean	10.8	0.0	1.1	4.0	45.5	10.3	119.2	10.0	116.5	11.3	125.8
Days	820	820	820	820	820	820	820	820	820	820	820
Team x Hour	331	331	331	331	331	331	331	331	331	331	331
Sample Size	270607	270607	270607	270607	270607	270607	270607	270607	270607	270607	270607
BSP Fixed Effects	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Date Trend	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
BSP Fixed Effects x Date Trend	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Post x Date Trend	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
BSP Fixed Effects x Post x Date Trend	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y

Notes: Post-period defined as starting from 1st May 2018, the date of adoption of the Banded Shift Pattern (BSP) in West Midlands Police (WMP). Treatment Group includes response teams during day shifts, i.e., the Early Shift and the Late Shift. Control Group includes all other teams. "Crime Opening Code" takes value 1 for calls classified by the dispatcher in the opening code as criminal offences or domestic violence incidents (value 0 otherwise). "Crime Detection" takes value 1 for calls where one or more criminal offences were detected in the closing code (value 0 otherwise). "Crime Clearance" takes value 1 for calls where one or more offenders were charged, summonsed, cautioned, arrested or identified by name by the police (value 0 otherwise). "Violent Crime Clearance" takes value 1 for calls where one or more offenders were charged, summonsed, cautioned, arrested or identified by name by the police for a violent offence (value 0 otherwise). "Non-Violent Crime Clearance" takes value 1 for calls where one or more offenders were charged, summonsed, cautioned, arrested or identified by name by the police for a non-violent offence (value 0 otherwise). The unit of observation is the emergency call. % Effect calculated as estimated coefficient divided by mean of dependent variable in Treatment teams (i.e., BSP=1) pre May 2018. The full Set of Fixed Effects (FEs) in the equation includes, namely, Response Team FEs; Incident Hour FEs interacted with Pre 1, Pre 2 and Post; P1 vs P2 Call FEs. Standard errors are two-way clustered by Date and Team x Hour in all estimates, resulting in 667 date clusters and 325 team-by-hour clusters in Panel A, in 364 date clusters and 318 team-by-hour clusters in Panel B and in 820 date clusters and 331 team-by-hour clusters in Panel C.

Appendix Table A.5. Robustness Difference-In-Differences Estimates on Matched Emergency Calls

	Double Crewing	Crime Opening Code		Crime Detection		Crime Clearance		Violent Crime Clearance		Non-Violent Crime Clearance	
	(1)	(2)	(3) = (2)/(1)	(4)	(5) = (4)/(1)	(6)	(7) = (6)/(1)	(8)	(9) = (8)/(1)	(10)	(11) = (10)/(1)
	First Stage	Reduced Form	Second Stage	Reduced Form	Second Stage	Reduced Form	Second Stage	Reduced Form	Second Stage	Reduced Form	Second Stage
A. Difference-in-Differences											
Response x Day Shift x Post	0.066	-0.011		0.009		0.024		0.021		0.003	
	(0.014)	(0.000)		(0.005)		(0.006)		(0.005)		(0.004)	
Double Crewing			-0.162		0.129		0.371		0.323		0.048
			(0.123)		(0.089)		(0.110)		(0.101)		(0.059)
Percent Relative to Pre-Mean	8.1	-3.0	-44.7	2.8	40.2	9.2	142.1	10.5	161.5	4.8	77.4
B. Plus Pre-Trends											
Response x Day Shift x Post	0.079	-0.018		0.015		0.024		0.023		0.001	
	(0.016)	(0.011)		(0.008)		(0.007)		(0.006)		(0.005)	
Double Crewing			-0.233		0.189		0.302		0.293		0.009
			(0.141)		(0.109)		(0.104)		(0.099)		(0.065)
Response x Day Shift x Pre 1	0.041	-0.023	-0.014	0.013	0.005	-0.000	-0.013	0.009	-0.003	-0.009	-0.010
	(0.012)	(0.013)	(0.010)	(0.009)	(0.007)	(0.010)	(0.010)	(0.008)	(0.008)	(0.007)	(0.006)
Response x Day Shift x Pre 2	0.004	-0.004	-0.003	0.010	0.009	-0.002	-0.003	-0.002	-0.004	0.001	0.001
	(0.014)	(0.011)	(0.011)	(0.009)	(0.009)	(0.008)	(0.008)	(0.007)	(0.007)	(0.005)	(0.005)
P value, Pre 1 and Pre 2	0.000	0.189	0.376	0.308	0.563	0.976	0.403	0.365	0.839	0.262	0.216
Percent Relative to Pre-Mean	9.71	-5.0	-64.4	4.7	58.9	9.2	115.7	11.5	146.5	1.6	14.5
Days	820	820	820	820	820	820	820	820	820	820	820
Team x Hour	214	214	214	214	214	214	214	214	214	214	214
Sample Size	182195	182195	182195	182195	182195	182195	182195	182195	182195	182195	182195
Date Fixed Effects	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
BSP Fixed Effects	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Full Set of Fixed Effects	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y

Notes: Post-period defined as starting from 1st May 2018, the date of adoption of the Banded Shift Pattern (BSP) in West Midlands Police (WMP). Treatment Group includes response teams during day shifts, i.e., the Early Shift and the Late Shift. Control Group includes all other teams. "Crime Opening Code" takes value 1 for calls classified by the dispatcher in the opening code as criminal offences or domestic violence incidents (value 0 otherwise). "Crime Detection" takes value 1 for calls where one or more criminal offences were detected in the closing code (value 0 otherwise). "Crime Clearance" takes value 1 for calls where one or more offenders were charged, summonsed, cautioned, arrested or identified by name by the police (value 0 otherwise). "Violent Crime Clearance" takes value 1 for calls where one or more offenders were charged, summonsed, cautioned, arrested or identified by name by the police for a violent offence (value 0 otherwise). "Non-Violent Crime Clearance" takes value 1 for calls where one or more offenders were charged, summonsed, cautioned, arrested or identified by name by the police for a non-violent offence (value 0 otherwise). The unit of observation is the emergency call. % Effect calculated as estimated coefficient divided by mean of dependent variable in Treatment teams (i.e., BSP=1) pre May 2018. The full Set of Fixed Effects (FEs) in the equation includes, namely, Response Team FEs; Incident Hour FEs interacted with Pre 1, Pre 2 and Post; P1 vs P2 Call FEs. Standard errors are two-way clustered by Date and Team x Hour in all estimates, resulting in 820 date clusters and 214 team-by-hour clusters.

Appendix Table A.6. Difference-in-Differences Estimates on Emergency Calls Attended by Officers in WMP Since Before May 2018

	Double Crewing	Crime Opening Code		Crime Detection		Crime Clearance		Violent Crime Clearance		Non-Violent Crime Clearance	
	(1)	(2)	(3) = (2)/(1)	(4)	(5) = (4)/(1)	(6)	(7) = (6)/(1)	(8)	(9) = (8)/(1)	(10)	(11) = (10)/(1)
	First Stage	Reduced Form	Second Stage	Reduced Form	Second Stage	Reduced Form	Second Stage	Reduced Form	Second Stage	Reduced Form	Second Stage
A. Difference-in-Differences											
Response x Day Shift x Post	0.079	-0.002		0.007		0.018		0.018		0.000	
	(0.014)	(0.006)		(0.005)		(0.000)		(0.004)		(0.000)	
Double Crewing			-0.022		0.087		0.234		0.234		-0.000
			(0.081)		(0.062)		(0.071)		(0.066)		(0.042)
Percent Relative to Pre-Mean	9.7	-0.6	-6.1	2.2	27.1	6.9	89.7	9.0	117.0	0.0	-0.0
B. Plus Pre-Trends											
Response x Day Shift x Post	0.081	-0.007		0.012		0.017		0.021		-0.004	
	(0.015)	(0.008)		(0.006)		(0.006)		(0.005)		(0.004)	
Double Crewing			-0.088		0.154		0.206		0.254		-0.048
			(0.103)		(0.086)		(0.080)		(0.079)		(0.048)
Response x Day Shift x Pre 1	0.027	-0.016	-0.014	0.010	0.005	-0.006	-0.012	0.006	-0.001	-0.013	-0.011
	(0.012)	(0.010)	(0.008)	(0.007)	(0.006)	(0.009)	(0.008)	(0.006)	(0.006)	(0.006)	(0.006)
Response x Day Shift x Pre 2	-0.019	-0.002	-0.004	0.010	0.013	0.000	0.004	0.001	0.006	-0.001	-0.002
	(0.012)	(0.009)	(0.010)	(0.007)	(0.008)	(0.006)	(0.007)	(0.006)	(0.007)	(0.005)	(0.005)
P value, Pre 1 and Pre 2	0.000	0.233	0.255	0.271	0.697	0.713	0.204	0.626	0.605	0.115	0.152
Percent Relative to Pre-Mean	9.9	-1.9	-24.3	3.7	48.0	6.5	78.9	10.5	127.0	-6.4	-77.4
Days	820	820	820	820	820	820	820	820	820	820	820
Team x Hour	328	328	328	328	328	328	328	328	328	328	328
Sample Size	226897	226897	226897	226897	226897	226897	226897	226897	226897	226897	226897
Date Fixed Effects	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
BSP Fixed Effects	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Full Set of Fixed Effects	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y

Notes: Post-period defined as starting from 1st May 2018, the date of adoption of the Banded Shift Pattern (BSP) in West Midlands Police (WMP). Treatment Group includes response teams during day shifts, i.e., the Early Shift and the Late Shift. Control Group includes all other teams. "Crime Opening Code" takes value 1 for calls classified by the dispatcher in the opening code as criminal offences or domestic violence incidents (value 0 otherwise). "Crime Detection" takes value 1 for calls where one or more criminal offences were detected in the closing code (value 0 otherwise). "Crime Clearance" takes value 1 for calls where one or more offenders were charged, summonsed, cautioned, arrested or identified by name by the police (value 0 otherwise). "Violent Crime Clearance" takes value 1 for calls where one or more offenders were charged, summonsed, cautioned, arrested or identified by name by the police for a violent offence (value 0 otherwise). "Non-Violent Crime Clearance" takes value 1 for calls where one or more offenders were charged, summonsed, cautioned, arrested or identified by name by the police for a non-violent offence (value 0 otherwise). The unit of observation is the emergency call. % Effect calculated as estimated coefficient divided by mean of dependent variable in Treatment teams (i.e., BSP=1) pre May 2018. The full Set of Fixed Effects (FEs) in the equation includes, namely, Response Team FEs; Incident Hour FEs interacted with Pre 1, Pre 2 and Post; P1 vs P2 Call FEs. Standard errors are two-way clustered by Date and Team x Hour in all estimates, resulting in 820 date clusters and 328 team-by-hour clusters.

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Appendix Table A.7. Falsification Difference-in-Differences IV Estimates on Adjacent Emergency Calls

	(1)	(2)
	Emergency Call Before	Emergency Call After
	Second Stage	Second Stage
	A. Crime Opening Code	
Double Crewing	-0.034	0.094
	(0.091)	(0.093)
Percent Relative to Pre-Mean	-9.4	26.0
	B. Crime Detection	
Double Crewing	0.101	0.048
	(0.098)	(0.092)
Percent Relative to Pre-Mean	31.5	14.9
	C. Crime Clearance	
Double Crewing	0.142	-0.089
	(0.103)	(0.087)
Percent Relative to Pre-Mean	54.4	-34.1
	D. Violent Crime Clearance	
Double Crewing	0.090	0.012
	(0.076)	(0.089)
Percent Relative to Pre-Mean	45.0	6.0
	E. Non-Violent Crime Clearance	
Double Crewing	0.012	0.036
	(0.063)	(0.061)
Percent Relative to Pre-Mean	19.3	58.1
First Stage	0.086	0.086
	(0.015)	(0.015)
Days	820	820
Team x Hour	331	331
Sample Size	270606	270606
Date Fixed Effects	Y	Y
BSP Fixed Effects	Y	Y
Full Set of Fixed Effects	Y	Y

Notes: Post-period defined as starting from 1st May 2018, the date of adoption of the Banded Shift Pattern (BSP) in West Midlands Police (WMP). Treatment Group includes response teams during day shifts, i.e., the Early Shift and the Late Shift. Control Group includes all other teams. "Crime Opening Code" takes value 1 for calls classified by the dispatcher in the opening code as criminal offences or domestic violence incidents (value 0 otherwise). "Crime Detection" takes value 1 for calls where one or more criminal offences were detected in the closing code (value 0 otherwise). "Crime Clearance" takes value 1 for calls where one or more offenders were charged, summonsed, cautioned, arrested or identified by name by the police (value 0 otherwise). "Violent Crime Clearance" takes value 1 for calls where one or more offenders were charged, summonsed, cautioned, arrested or identified by name by the police for a violent offence (value 0 otherwise). "Non-Violent Crime Clearance" takes value 1 for calls where one or more offenders were charged, summonsed, cautioned, arrested or identified by name by the police for a non-violent offence (value 0 otherwise). The unit of observation is the emergency call. % Effect calculated as estimated coefficient divided by mean of dependent variable in Treatment teams (i.e., BSP=1) pre May 2018. The full Set of Fixed Effects (FEs) in the equation includes, namely, Response Team FEs; Incident Hour FEs interacted with Pre 1, Pre 2 and Post; P1 vs P2 Call FEs. Standard errors are two-way clustered by Date and Team x Hour in all estimates, resulting in 820 date clusters and 331 team-by-hour clusters.

Appendix Table A.8. Difference-in-Differences IV Estimates on Characteristics of Offenders

	(1)	(2)	(3)
	Second Stage	**Second Stage**	**Second Stage**
	Offender Aged 40 or Younger	**Male Offender**	**White British Offender**
Double Crewing	0.119	0.120	0.050
	(0.491)	(0.489)	(0.588)
Percent Relative to Pre-Mean	15.8	15.2	9.5
First Stage	0.083	0.083	0.083
	(0.027)	(0.027)	(0.027)
Days	820	820	820
Team x Hour	331	331	331
Sample Size	63170	63170	63170
Date Fixed Effects	Y	Y	Y
BSP Fixed Effects	Y	Y	Y
Full Set of Fixed Effects	Y	Y	Y

Notes: Post-period defined as starting from 1st May 2018, the date of adoption of the Banded Shift Pattern (BSP) in West Midlands Police (WMP). Treatment Group includes response teams during day shifts, i.e., the Early Shift and the Late Shift. Control Group includes all other teams. The unit of observation is the emergency call. % Effect calculated as estimated coefficient divided by mean of dependent variable in Treatment teams (i.e., BSP=1) pre May 2018. The full Set of Fixed Effects (FEs) in the equation includes, namely, Response Team FEs; Incident Hour FEs interacted with Pre 1, Pre 2 and Post; P1 vs P2 Call FEs. Standard errors are two-way clustered by Date and Team x Hour in all estimates, resulting in 820 date clusters and 331 team-by-hour clusters.

Appendix Table A.9. Officer-Level Difference-in-Differences Estimates

	Double Crewing	Crime Opening Code		Crime Detection		Crime Clearance		Violent Crime Clearance		Non-Violent Crime Clearance	
	(1)	(2)	(3) = (2)/(1)	(4)	(5) = (4)/(1)	(6)	(7) = (6)/(1)	(8)	(9) = (8)/(1)	(10)	(11) = (10)/(1)
	First Stage	Reduced Form	Second Stage	Reduced Form	Second Stage	Reduced Form	Second Stage	Reduced Form	Second Stage	Reduced Form	Second Stage
A. Difference-in-Differences											
Response x Day Shift x Post	0.059	0.007		0.010		0.017		0.017		0.000	
	(0.011)	(0.006)		(0.000)		(0.005)		(0.000)		(0.004)	
Double Crewing			0.124		0.177		0.297		0.289		0.007
			(0.107)		(0.086)		(0.093)		(0.078)		(0.060)
Percent Relative to Pre-Mean	6.6	1.9	34.3	3.1	55.7	6.4	112.5	8.5	145.2	0.0	10.8
B. Plus Pre-Trends											
Response x Day Shift x Post	0.067	0.004		0.017		0.017		0.021		-0.003	
	(0.011)	(0.008)		(0.006)		(0.006)		(0.005)		(0.005)	
Double Crewing			0.059		0.248		0.257		0.308		-0.051
			(0.118)		(0.102)		(0.104)		(0.087)		(0.073)
Response x Day Shift x Pre 1	0.030	-0.008	-0.010	0.010	0.003	-0.005	-0.013	0.009	-0.000	-0.014	-0.013
	(0.011)	(0.009)	(0.007)	(0.006)	(0.006)	(0.009)	(0.008)	(0.006)	(0.006)	(0.007)	(0.006)
Response x Day Shift x Pre 2	-0.003	-0.003	-0.003	0.011	0.011	0.005	0.006	0.003	0.004	0.002	0.002
	(0.009)	(0.009)	(0.009)	(0.008)	(0.008)	(0.008)	(0.008)	(0.006)	(0.006)	(0.006)	(0.006)
P value, Pre 1 and Pre 2	0.000	0.681	0.418	0.249	0.365	0.516	0.154	0.364	0.829	0.063	0.091
Percent Relative to Pre-Mean	7.5	1.1	16.3	5.3	78.0	6.4	97.3	10.5	154.8	-4.6	-78.5
Days	820	820	820	820	820	820	820	820	820	820	820
Team x Hour	331	331	331	331	331	331	331	331	331	331	331
Sample Size	495161	495161	495161	495161	495161	495161	495161	495161	495161	495161	495161
Date Fixed Effects	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
BSP Fixed Effects	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Full Set of Fixed Effects	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y

Notes: Post-period defined as starting from 1st May 2018, the date of adoption of the Banded Shift Pattern (BSP) in West Midlands Police (WMP). Treatment Group includes response teams during day shifts, i.e., the Early Shift and the Late Shift. Control Group includes all other teams. "Crime Opening Code" takes value 1 for calls classified by the dispatcher in the opening code as criminal offences or domestic violence incidents (value 0 otherwise). "Crime Detection" takes value 1 for calls where one or more criminal offences were detected in the closing code (value 0 otherwise). "Crime Clearance" takes value 1 for calls where one or more offenders were charged, summonsed, cautioned, arrested or identified by name by the police (value 0 otherwise). "Violent Crime Clearance" takes value 1 for calls where one or more offenders were charged, summonsed, cautioned, arrested or identified by name by the police for a violent offence (value 0 otherwise). "Non-Violent Crime Clearance" takes value 1 for calls where one or more offenders were charged, summonsed, cautioned, arrested or identified by name by the police for a non-violent offence (value 0 otherwise). The unit of observation is the officer attending the emergency call. % Effect calculated as estimated coefficient divided by mean of dependent variable in Treatment teams (i.e., BSP=1) pre May 2018. The full Set of Fixed Effects (FEs) in the equation includes, namely, Officer FEs, Response Team FEs; Incident Hour FEs interacted with Pre 1, Pre 2 and Post; P1 vs P2 Call FEs. Standard errors are two-way clustered by Date and Team x Hour in all estimates, resulting in 820 date clusters and 331 team-by-hour clusters.

Appendix Table A.10. Officer-Level Difference-in-Differences Estimates on Officers in WMP Since Before May 2018

	Double Crewing	Crime Opening Code		Crime Detection		Crime Clearance		Violent Crime Clearance		Non-Violent Crime Clearance	
	(1)	(2)	(3) = (2)/(1)	(4)	(5) = (4)/(1)	(6)	(7) = (6)/(1)	(8)	(9) = (8)/(1)	(10)	(11) = (10)/(1)
	First Stage	Reduced Form	Second Stage	Reduced Form	Second Stage	Reduced Form	Second Stage	Reduced Form	Second Stage	Reduced Form	Second Stage
A. Difference-in-Differences											
Response x Day Shift x Post	0.063	0.009		0.008		0.014		0.016		-0.001	
	(0.011)	(0.000)		(0.000)		(0.005)		(0.004)		(0.004)	
Double Crewing			0.147		0.123		0.228		0.251		-0.024
			(0.103)		(0.083)		(0.090)		(0.075)		(0.058)
Percent Relative to Pre-Mean	7.0	2.5	40.7	2.5	38.7	5.3	86.4	8.0	126.1	-1.5	-36.9
B. Plus Pre-Trends											
Response x Day Shift x Post	0.070	0.006		0.014		0.013		0.019		-0.005	
	(0.011)	(0.008)		(0.007)		(0.007)		(0.005)		(0.005)	
Double Crewing			0.085		0.193		0.192		0.269		-0.077
			(0.113)		(0.099)		(0.100)		(0.085)		(0.070)
Response x Day Shift x Pre 1	0.028	-0.008	-0.010	0.009	0.004	-0.006	-0.011	0.008	0.001	-0.014	-0.012
	(0.011)	(0.009)	(0.008)	(0.007)	(0.006)	(0.009)	(0.008)	(0.006)	(0.006)	(0.007)	(0.006)
Response x Day Shift x Pre 2	-0.004	-0.003	-0.003	0.010	0.011	0.004	0.004	0.002	0.003	0.001	0.001
	(0.010)	(0.009)	(0.009)	(0.008)	(0.008)	(0.008)	(0.008)	(0.006)	(0.006)	(0.006)	(0.006)
P value, Pre 1 and Pre 2	0.000	0.701	0.410	0.294	0.388	0.531	0.217	0.438	0.881	0.069	0.123
Percent Relative to Pre-Mean	7.8	1.7	23.5	4.4	60.7	4.9	72.7	9.5	135.2	-7.7	-118.5
Days	820	820	820	820	820	820	820	820	820	820	820
Team x Hour	328	328	328	328	328	328	328	328	328	328	328
Sample Size	407975	407975	407975	407975	407975	407975	407975	407975	407975	407975	407975
Date Fixed Effects	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
BSP Fixed Effects	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Full Set of Fixed Effects	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y

Notes: Post-period defined as starting from 1st May 2018, the date of adoption of the Banded Shift Pattern (BSP) in West Midlands Police (WMP). Treatment Group includes response teams during day shifts, i.e., the Early Shift and the Late Shift. Control Group includes all other teams. "Crime Opening Code" takes value 1 for calls classified by the dispatcher in the opening code as criminal offences or domestic violence incidents (value 0 otherwise). "Crime Detection" takes value 1 for calls where one or more criminal offences were detected in the closing code (value 0 otherwise). "Crime Clearance" takes value 1 for calls where one or more offenders were charged, summonsed, cautioned, arrested or identified by name by the police (value 0 otherwise). "Violent Crime Clearance" takes value 1 for calls where one or more offenders were charged, summonsed, cautioned, arrested or identified by name by the police for a violent offence (value 0 otherwise). "Non-Violent Crime Clearance" takes value 1 for calls where one or more offenders were charged, summonsed, cautioned, arrested or identified by name by the police for a non-violent offence (value 0 otherwise). The unit of observation is the officer attending the emergency call. % Effect calculated as estimated coefficient divided by mean of dependent variable in Treatment teams (i.e., BSP=1) pre May 2018. The full Set of Fixed Effects (FEs) in the equation includes, namely, Officer FEs, Response Team FEs; Incident Hour FEs interacted with Pre 1, Pre 2 and Post; P1 vs P2 Call FEs. Standard errors are two-way clustered by Date and Team x Hour in all estimates, resulting in 820 date clusters and 328 team-by-hour clusters.

APPENDIX B. Breakdown of calculations behind Table 5

The cost-benefit analysis in Table 5 is measured over the 12 months following the May 2018 implementation date. Inception and transition costs are assigned to month 0, while benefits are allowed to accrue over months 1–12. No benefit after month 12 is counted. This convention is conservative if BSP effects persisted but delays payback relative to a model in which some costs were incurred before launch. From WMP's structural-budget perspective, redeployment of existing officers creates no incremental salary bill. From an economic/social perspective, time diverted from policing, supervision and administration has an opportunity cost, and improved clearance and officer safety can generate social value. The reported net benefit is therefore not an accounting profit or cash saving to WMP. The headline Benefit Cost Ratio in Table 5 is £4,684,001 / £2,375,729.8 = 1.9716051, reported as 1.97. The corresponding net benefit is £2,308,271.2.

Appendix Table B.1. Benefit Construction

Step	Formula	Result	Interpretation
Annualise cleared violent calls	22,193 × 12/10	26,631.6	The manuscript's baseline covers ten months.
Additional violent clearances	26,631.6 × 10.5%	2,796.318	Uses the BSP reduced-form policy effect.
2018/19 unit value	£1,570 × 100/94.227	£1,666.19	Unit-benefit logic.
Clearance benefit	2,796.318 × £1,666.19	£4,659,195	Unrounded unit value.
Annualise officer assaults	19 × 12/10	22.8	Pre-period count.
Avoided assaults	22.8 × 65.3%	14.8884	Descriptive effect.
Officer-safety benefit	14.8884 × £1,666.19	£24,807	0.5% of total benefit.
Unrounded Total 12-month benefit	£4,659,195 + £24,807	£4,684,001	Unrounded total £4,684,001.45.

Appendix Table B.2. Internal Opportunity Cost and Foregone Policing Output

Cost centre	Hours / equivalents	Cost	Basis
Strategic design	3,200	£160,000	Demand profiling, policy writing, executive/legal sign-off
Local implementation	3,600	£145,000	Roster builds, notices, welfare meetings and grievances
Frontline transition	9,000	£270,000	Three hours for about 3,000 officers and sergeants
Systems and IT	300	£10,000	CARM mapping, scripting, testing and database updates
Memo subtotal	16,100	£585,000	High-friction scenario; not an observed invoice
Foregone clearance-equivalents	74.68	£124,433	9,000 × 0.008298 × £1,666.19
Expanded internal cost		£709,433	Rounded subtotal used in the headline cost

The foregone-output allowance is intentionally conservative on cost. Only the 9,000 frontline hours are translated into clearance-equivalents. Senior, HR, analyst and IT time is not assigned a frontline output rate because its alternative use is already represented in the memo's loaded labour value. Even so, adding lost output to the loaded value of the same frontline hours can partly double count opportunity cost. The overlap is retained because the headline scenario is designed to be an extreme upper bound.

Appendix Table B.3. Explicit Consulting and Capital Costs

Source line	Public description	Amount	Headline treatment
Accenture, 28 Sep 2017	Smarter Responding / professional services	£25,709.83	Observed payment; fully attributed
Accenture, 23 Oct 2017	Smarter Responding / professional services	£20,586.94	Observed payment; fully attributed
Smarter Responding	60% of rounded 2018/19 capital envelope	£900,000	Broad programme; 60% attributed
New Ways of Responding	60% of rounded 2018/19 capital envelope	£720,000	Broader programme; 60% attributed
Explicit/capital subtotal	All above	£1,666,296.8	Deliberately exceeds BSP-specific evidence
Grand total cost	£709,433 internal + explicit/capital	£2,375,729.8	Headline denominator

The direct Accenture total is the only public expenditure located that is explicitly coded to Smarter Responding. It is not possible to identify from the ledger whether every pound supported BSP rather than other Smarter Responding activities; the headline charges 100% of it and the two observed payments are retained at nominal face value. Because they account for only 1.95% of total cost, reasonable deflation or inflation treatment would not alter the conclusion. The capital programme published in January 2019 reports rounded current budgets of £1.5 million and £1.2 million, and 60% of these costs are attributed to the BSP. A September 2018 monitoring report gives more precise and lower figures of £1.476 million and £1.155 million (West Midlands Police and Crime Commissioner, 2018c). Using 60% of those precise values would slightly reduce total costs, increase net benefit and shorten payback, but it would not alter the substantive conclusions. The headline deliberately retains the larger rounded envelopes. Attributing 60% of the rounded envelopes to the BSP is equivalent to attributing most of these expenses to this programme, while recognising that some of these expenses were also sustained towards separate goals. Since the manuscript does not calculate month-specific benefit flows, payback is therefore an interpolation: monthly benefit = £4,684,001 / 12 = £390,333.42; payback = £2,375,729.8 / £390,333.42 = 6.0864115 months, reported as 6.09. Treating every cost as paid at month 0 maximises the time to recovery relative to a phased implementation-cost profile.