

Ferguson, Gray, and Davis
An Analysis of Recorded Crime Incidents
and Arrests in Baltimore City,
March 2010 through December 2015

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[See also Appendix 1 for details of the coding of arrest categories, Appendix 2 for additional models of crime incidents, and Appendix 3 for additional models of arrests. These appendices are available at the webpage: <http://socweb.soc.jhu.edu/faculty/morgan/workingpapers.html>]

Executive Summary

Motivation

The sometimes fraught relations between the Baltimore city community and its police officers intensified in April 2015, after the arrest of Freddie Gray and his subsequent death from injuries sustained while in police custody. Immediately following his funeral, an episode of street activity erupted – one that has been labeled on a continuum of terms from a riot to an uprising. This unrest triggered both a weeklong deployment of the National Guard and a night-time curfew.

A widely reported spike in gun violence and homicide emerged soon thereafter, alongside claims that the Baltimore Police Department had pulled back from routine police work in protest against a lack of support from the city’s leadership. The sitting police commissioner was replaced in July, and changes in police practice were introduced in subsequent months, some adopted to foster stronger cooperation with the community.

These events unfolded in Baltimore as a discussion on crime and policing was developing in the national press, sparked by the protests in Ferguson, Missouri but focused on the impact of dashcam and cellphone videos of police conduct. Debates over the existence of a so-called “Ferguson effect” continue to feature opposing positions on whether the new attention is a welcome spotlight on police misconduct with no consequences for underlying patterns of crime, or instead a constraint on appropriate policing that generates opportunistic crime.

For Baltimore, the effects of Freddie Gray’s arrest, and the unrest that followed, cannot be separated from the need to examine whether a preexisting Ferguson effect had already taken hold before April 2015. Likewise, any discussion of a Ferguson effect in Baltimore after April 2015 cannot be separated from a careful assessment of the consequences of the unrest that followed Freddie Gray’s arrest.

Design

The Baltimore Police Department releases crime incident data and arrest data to the public through the Open Baltimore data portal. This report offers conclusions based on the analysis of two related but distinct collections of data – 292,721 recorded crime incidents from 2010 through 2015 and 110,755 arrests of individuals from 2013 through 2015. In our analysis, crimes and arrests are both disaggregated by type, when appropriate, and estimates of effects are tied to five carefully defined intervals of time. Altogether, this report offers support for six primary conclusions, two for the period before Freddie Gray was arrested, and four for the period after he was arrested.

Conclusions for the Time Period Before the Arrest of Freddie Gray

1. Adjusting for seasonality, evidence of a Ferguson effect on crime is very weak for the eight months after the Ferguson protests were widely publicized and before Freddie Gray was arrested.

- Demarcating the post-Ferguson, pre-Gray period as the interval from August 11, 2014 through April 19, 2015, many categories of crime decreased slightly relative to the expected seasonal trend, such as homicide (down 3%), automobile theft (down 7%), common assault (down 13%), and larceny (down 12%). Other categories of crime were unchanged, such as street robbery and burglary. Small increases were recorded for larceny from automobiles (up 3%) and aggravated assault (up 6%). Against such stability and what we regard as trendless fluctuation, the only substantial increases in recorded crime were themselves modest in comparison to the changes that unfolded from April 20, 2015 onward. These increases included shootings (up 13%) and commercial robbery (up 19%).
- Overall, we conclude that it is unlikely that the full profile of change in recorded crime in this period reflects any substantial response to protest events in Ferguson, or a reaction to any other police conduct that received national press coverage before the arrest of Freddie Gray.

2. During this same time period, changes in arrest rates are consistent with a Ferguson effect on police conduct. Arrests decreased substantially for many areas of less serious crimes, and these declines occurred during a period characterized by typical fluctuation in recorded crime incidents.

- The total arrest count, which is not subject to under-reporting, fell by 19% between August 11, 2014 through April 19, 2015 in comparison to the prior 52-week period, and after adjustments for seasonality. In particular, the average weekly total of 800 arrests declined by 152 arrests per week. These changes unfolded alongside a mostly stable period in recorded crime incidents (see, above, for our first conclusion on crime incidents).
- Although the charges associated with each arrest are very difficult to categorize, the declines are most substantial for categories of less serious crime, such as property destruction (down 34%), driving violations (down 33%), prostitution (down 33%), and disorderly conduct (down 34%). Many categories of arrest for violent crimes, such as murder, attempted murder, robbery, and aggravated assault did not decrease over the same time period, suggesting that the declines in arrests were in areas where police have discretionary alternatives to arrest.

Taken together, these two conclusions for the period before Freddie Gray was arrested suggest that the only evidence in support of a “Ferguson effect” in Baltimore is for the pattern of arrests. Recorded crime varied as expected, but arrests declined nonetheless. Baltimore’s

police officers may have used discretionary alternatives to arrest more frequently in this time period, possibly out of concern that the appropriateness of their conduct could become the subject of controversy.

Conclusions for the Time Period After the Arrest of Freddie Gray

3. The heavily reported spike in shootings and homicides that emerged in the three months following the arrest of Freddie Gray occurred alongside large increases in other types of crime.

- Adjusting for the seasonality of crime, and removing the week of unrest from the calculations, shootings and homicides increased by 140% and 92%, respectively, in the interval from April 20, 2015 through July 12, 2015. Over the same time period, street robbery increased by 31%, commercial robbery increased by 82%, carjacking increased by 33%, and automobile theft increased by 53%.

4. Arrests declined further from April 20, 2015 through July 12, 2015, even after removing the complex pattern of arrests that emerged during the week of unrest. These declines are consistent with the widely discussed conjecture that the Baltimore police pulled back from some routine policing in response to a perceived lack of support from the city's leadership. These declines are also consistent with other narratives, such as the onset of a period of recovery following the overtime work of the police during the week of unrest, an accentuation of a Ferguson effect on arrests that had already emerged during the post-Ferguson, pre-Gray period, and a decline in cooperation from the community that made police work more challenging.

- The total arrest count declined by an additional 30% between April 20, 2015 and July 12, 2015, excluding the disrupted pattern of arrests during the week of unrest that began on Monday, April 27th, 2015.
- Among the areas of arrest that declined during the post-Ferguson, pre-Gray period and that may reflect a Ferguson effect on police activity, many of these areas of arrest continued to decline. Arrests for driving violations, prostitution, and disorderly conduct declined by an additional 44%, 40%, and 49%, respectively.
- Some areas of arrest that did not decline substantially during the post-Ferguson, pre-Gray period contributed to the 30% decline in the total arrest count during this period. Arrests for burglary and larceny declined by 37% and 39%, respectively, while arrests for a broad category that we label "police noncompliance" declined by 58%. Arrests for murder and attempted murder decreased by 30%, and arrests for deadly weapons violations decreased by 18%.

5. It is fundamentally unclear whether the crime spike after April 20, 2015 should be regarded as evidence in support of a Ferguson effect on crime in Baltimore.

- It is notable, as detailed above for our first conclusion, that crime incidents evolved as expected over the eight months that followed the protests in Ferguson and that preceded the arrest of Freddie Gray. At the same time, arrests declined in many areas of less serious crime. In this sense, there is little or no evidence of a Ferguson effect on crime in Baltimore for many months when there could have been such evidence.
- It is undeniable that the unrest and its aftermath were shaped deeply by the media coverage of Freddie Gray's arrest, including the available cellphone video of it. These influential journalistic treatments drew connections to the nationwide focus on police conduct. In view of these explicit connections, it would be unreasonable to conclude that the week of unrest was an inward-focused event, disconnected from the emergent national discourse on police conduct.
- One reasonable interpretation is that the crime spike is a Ferguson effect that might have remained dormant had it not been ignited by a localized Gray effect. Nonetheless, the size and duration of the crime spike is almost certainly attributable to particular features of the unrest and its aftermath, possibly including an increase in gang-related conflict over drug distribution as well as a police pullback in protest of the city's leadership. These accelerants have little or no connection to the core narrative of the Ferguson effect, although they may have been shaped to some extent by the cumulative events of spring 2015, which appear to include a decline in community cooperation with the police.

6. Arrests increased during the remainder of 2015, after the appointment of a new police commissioner. During the same time period, recorded crime incidents declined.

- Adjusting for seasonality, the weekly total arrest count increased by 20% between July 13, 2015 and the end of the year, bringing the count back up to 77% of the weekly total arrest count that prevailed in the year before the Ferguson protests.
- These increases in arrests surely reflect a natural response to types of crime that increased in the summer of 2015, such as arrests for murder and attempted murder, which increased by 43%, and arrests for deadly weapons violations, which increased by 39%.
- Arrests in other areas that had declined before Commissioner Davis was appointed also increased. Arrests for burglary, larceny, and driving violations increased by 28%, 19%, and 25%, respectively. Arrests for our category of "police noncompliance" increased by 25% as well.
- With the exception of carjacking, which continued to increase, recorded crime incidents decreased during the remainder of 2015. Shootings and homicides decreased by 64% and 29%, respectively, leaving net increases at the end of the year of 76% and 63% relative to the period before Freddie Gray was arrested. Street

robbery, commercial robbery, and automobile theft declined by 12%, 68%, and 28%, leaving net increases of 19%, 14%, and 26%.

All six of these conclusions have attendant qualifications, subtle caveats, and other particulars that are fully explained in the main body of this report. Most importantly, crime incidents are notoriously under-reported in some categories, arrests are challenging to categorize because of multiple charges and unclear recording, and various necessary modeling assumptions have been introduced that a fair critic could challenge. Nonetheless, we are confident that our conclusions above are valid, even as we invite others to challenge our models and interpretations.

1. Introduction

Many journalists, politicians, community activists, and law enforcement officials have offered claims about the relationship between trends in crime and police activity across the nation since the summer of 2014. The relevance of police shootings captured on cellphone and dashcam video, as well as protest events such as those in Ferguson, Missouri, remain a source of speculation and debate.

In Baltimore, the sometimes fraught relations between the community and its police officers intensified in 2015, after the arrest of Freddie Gray and his subsequent death. Following his funeral, an episode of street activity erupted – one that has been labeled on a continuum of terms from a riot to an uprising – and it triggered a large mobilization of state and federal law enforcement resources. These events were followed by an undisputed spike in gun violence and homicides, as well as claims that, for a period of time, the Baltimore Police Department pulled back from routine police work in protest against a lack of support from the city's leadership.

1.1. The “Ferguson Effect” Debate

Consider this extended excerpt from a speech that James B. Comey, Director of the FBI, delivered at the University of Chicago Law School on October 23, 2015:

Most of America's 50 largest cities have seen an increase in homicides and shootings this year, and many of them have seen a huge increase. These are cities with little in common except being American cities—places like Chicago, Tampa, Minneapolis, Sacramento, Orlando, Cleveland, and Dallas. In Washington, D.C., we've seen an increase in homicides of more than 20 percent in neighborhoods across the city. Baltimore, a city of 600,000 souls, is averaging more than one homicide a day—a rate higher than that of New York City, which has 13 times the people. Milwaukee's murder rate has nearly doubled over the past year.

And who's dying? Police chiefs say the increase is almost entirely among young men of color, at crime scenes in bad neighborhoods where multiple guns are being recovered. That's yet another problem that white America can drive around, but if we really believe that all lives matter, as we must, all of us have to understand what is happening. Communities of color need to demand answers. Police and civilian leaders need to demand answers. Academic researchers need to hit this hard.

What could be driving an increase in murder in some cities across all regions of the country, all at the same time? What explains this map and this calendar? Why is it happening in all of these different places, all over and all of a sudden?

I've been part of a lot of thoughtful conversations with law enforcement, elected officials, academics, and community members in recent weeks. I've heard a lot of theories—reasonable

theories. Maybe it's the return of violent offenders after serving jail terms. Maybe it's cheap heroin or synthetic drugs. Maybe after we busted up the large gangs, smaller groups are now fighting for turf. Maybe it's a change in the justice system's approach to bail or charging or sentencing. Maybe something has changed with respect to the availability of guns. These are all useful suggestions, but to my mind none of them explain both the map and the calendar in disparate cities over the last 10 months.

But I've also heard another explanation, in conversations all over the country. Nobody says it on the record, nobody says it in public, but police and elected officials are quietly saying it to themselves. And they're saying it to me, and I'm going to say it to you. And it is the one explanation that does explain the calendar and the map and that makes the most sense to me.

Maybe something in policing has changed. In today's YouTube world, are officers reluctant to get out of their cars and do the work that controls violent crime? Are officers answering 911 calls but avoiding the informal contact that keeps bad guys from standing around, especially with guns?

I spoke to officers privately in one big city precinct who described being surrounded by young people with mobile phone cameras held high, taunting them the moment they get out of their cars. They told me, "We feel like we're under siege and we don't feel much like getting out of our cars."

I've been told about a senior police leader who urged his force to remember that their political leadership has no tolerance for a viral video. So the suggestion, the question that has been asked of me, is whether these kinds of things are changing police behavior all over the country.

And the answer is, I don't know. I don't know whether this explains it entirely, but I do have a strong sense that some part of the explanation is a chill wind blowing through American law enforcement over the last year. And that wind is surely changing behavior.

Part of that behavior change is to be welcomed, as we continue to have important discussions about police conduct and de-escalation and the use of deadly force. Those are essential discussions and law enforcement will get better as a result. But we can't lose sight of the fact that there really are bad people standing on the street with guns. The young men dying on street corners all across this country are not committing suicide or being shot by the cops. They are being killed, police chiefs tell me, by other young men with guns.

Lives are saved when those potential killers are confronted by a strong police presence and actual, honest-to-goodness, up-close "What are you guys doing on this corner at one o'clock in the morning?" policing. All of us, civilian and law enforcement, white, black, and Latino, have an interest in that kind of policing. We need to be careful it doesn't drift away from us in the age of viral videos, or there will be profound consequences.

By the time Director Comey delivered this speech, the “Ferguson effect” had been a matter of debate for nearly five months, at least since a May 29, 2015 opinion piece by Heather Mac Donald was published in the *Wall Street Journal* with the title “The New Nationwide Crime Wave” and the subtitle “The consequences of the ‘Ferguson effect’ are already appearing. The main victims of growing violence will be the inner-city poor.” This op-ed was followed by many other journalistic pieces challenging her claims. Among the most robust pieces was one offered by Brentin Mock, published for the Citylab Blog of the *The Atlantic* on June 17th, with the title “Busting the Myth of ‘The Ferguson Effect’” and the subtitle “Pundits are fanning fears of new ‘crime waves’ across cities. Criminologists aren’t buying it.” Getting to the point more directly, Ta-Nehisi Coates offered a short piece on September 1, 2015 for the Notes blog of *The Atlantic*, titled “There is No Ferguson Effect.”

Director Comey did not use the phrase “Ferguson effect,” adopting instead the more ambiguous language of “a chill wind blowing through American law enforcement over the last year.” However, the speech quoted at length above is widely recognized as the definitive statement of its constitution, and one that he made clear was shaped by discussions with police chiefs across the country. Recall, as quoted above, his careful wording: “Nobody says it on the record, nobody says it in public, but police and elected officials are quietly saying it to themselves. And they’re saying it to me, and I’m going to say it to you.”

1.2. The Ferguson Effect, Entangled with a Gray Effect

Baltimore has been central to this debate, especially after the arrest of Freddie Gray, and the unrest that followed his death. Given the timing of the debate, it is clear that – for Baltimore at least, and perhaps elsewhere – it is not possible to consider any possible Ferguson effect from May 2015 onward without considering it a compound effect entangled with what might be labeled a “Gray effect.”

Consider an excerpt from a *Baltimore Sun* article published on May 20, 2015 (nine days before the publication of the *Wall Street Journal* op-ed that ignited the debate on the Ferguson effect and five months before Director Comey’s speech distilled the primary claim). The article pits then-Police-Commissioner Anthony Batts against the community activist and current Baltimore Mayoral candidate Deray McKesson:

“Officers tell me and their supervisors, any time they pull up to respond to a call, they have 30 to 50 people surrounding them,” Batts said. “We have to send in multiple units just to do basic police work, which says we have to work on community engagement.” ...

Batts said police are trying to investigate killings in West Baltimore, but have been slowed by the large crowds that often surround them.

"It makes it very difficult to follow up on violence that takes place there," he said. "Clearly, they're not holding back. They're getting to those locations and getting surrounded. You have many citizens with hand-held cameras that they're sticking in the faces of officers, an inch off the officer's face."

Batts said police do not want to cause a "bigger issue" by sending in backup, but they want to "make sure the officers are safe and citizens are safe."

The *Baltimore Sun* article continues with an alternative perspective:

That description of events did not sit well with Deray McKesson, a community activist and organizer prominent on social media.

"What Batts is doing is trying to use fear to take the focus away from the intense violence that the police have inflicted on the communities of Baltimore as long as any of us can remember," he said. "What Batts is worried about is that people are more aware and more willing to hold police accountable in the Western District."

McKesson said West Baltimore residents unified during protests over Gray's death, finding out they share common experiences in dealings with police. They no longer feel isolated and powerless against a police force that McKesson said has routinely abused African-Americans.

"It's a scary day in America when a chief of police says people are watching us and we can't do our jobs," he said.

For crime in Baltimore, the effects of Freddie Gray's arrest, and the unrest that followed, cannot be separated from the need to examine whether a preexisting Ferguson effect had already taken hold. Likewise, any discussion of a Ferguson effect in Baltimore after April 2015 cannot be separated from a careful assessment of the consequences of the unrest that followed Freddie Gray's arrest.

1.3. A Davis Effect in Response

Police Commissioner Anthony Batts was fired on July 9, 2015 after pressure from the police union and the city council turned the Baltimore mayor, Stephanie Rawlings-Blake, against him. His interim replacement, Kevin Davis, began to reorganize the police department almost immediately, announcing substantial changes in staffing on August 2, 2015. At the same time, ten federal agents were embedded in the department's homicide unit, a violence prevention war room was established, and discussions began about new forms of community policing.

After his confirmation by the city council as the permanent police commissioner on October 19, 2015, Davis began to implement new patrols in areas where violent crime had

increased, moved forward in cooperation with the city's leadership with plans for body cameras for all police officers, and has offered measured remarks on whether a Ferguson/Gray effect has constrained police activity.

1.4. The Goal of this Report

Against this background, a dispassionate analysis of trends in crime and police activity over the past several years may be of value to multiple audiences that are collectively committed to improving the living conditions of Baltimore residents and the performance of vital local institutions. The Baltimore Police Department facilitates such analysis by releasing abundant data on crime incidents and arrests through the city's data portal, Open Baltimore. In the next section, we introduce these data sources, as well as our plan for analysis.

2. Design, Data, and Measures

In this section, we first explain why we model both crime incidents and arrests. Then, we present the focal time intervals of our analysis, as well as the effects that underlie changes across them. We conclude by considering the data sources and specific measures that we utilize in the subsequent analysis to adjust for the seasonality of crimes and arrests.

2.1. Crime Incidents and Arrests as Outcome Measures

We will consider two types of outcomes in this report: 292,721 recorded crime incidents from 2010 to 2015 and 110,755 arrests of adults from 2013 to 2015. These two outcomes are related to each other, but they are distinct for many reasons, including: (1) for many crime incidents, suspects are never identified and, as a result, arrests never occur; (2) individuals can commit more than one offense but be arrested for a subset of them; (3) more than one individual can be arrested for the same incident; and (4) many arrests are discretionary. This last point is particularly important for this report. Consider some examples. Arrests for drug possession are determined, frequently, by whether an officer chooses to initiate a search through a frisk. Similarly, arrests for “failure to obey” and “disorderly conduct” are more common for some officers than for others, based both on their own choices and directives from their superiors. Because arrests and crime incidents are related but distinct, arrest counts can change even if the pattern of crime does not change. Indeed, as we will show in this report, divergent patterns for crime incidents and for arrests suggest conclusions about the existence and timing of both Ferguson and Gray effects.

2.2. Time Intervals for the Analysis

With this report, we consider how trends in both recorded crimes and arrests changed in four periods of time that have shaped public debate. The periods, demarcated in weeks that begin with Mondays, are:

1. the *Ferguson Period*:

August 11, 2014 – April 19, 2015

The interval beginning with the nationally broadcast protests in Ferguson, Missouri and ending before substantial protests began in Baltimore in response to the arrest of Freddie Gray

2. the *Gray Period*:

April 20, 2015 – July 12, 2015

The interval beginning with substantial protests following the death of Freddie Gray and ending with the week of the firing of Baltimore Police Commissioner Anthony Batts

3. the *Unrest Week*:

April 27, 2015 – May 3, 2015

The week that began with a riot/uprising, was followed by large-scale peaceful protest activity, and was accompanied by the deployment of the National Guard and the imposition of a night-time curfew

4. the *Davis Period*:

July 13, 2015 – December 28, 2015

The first full week during which Acting Police Commissioner Davis was appointed, through his confirmation as Police Commissioner, and continuing to the end of 2015, which includes the reintroduction of some forms of community policing, as well as the events surrounding the first trial of a police officer involved in Freddie Gray's arrest

Note that intervals 1, 2, and 4 are sequential, but interval 3 lies within interval 2.

To consider how crime and arrests evolved in these four periods, we consider as much data as is publicly available prior to August 11, 2014. We make the simplifying assumption that this pretreatment period (or as we will usually label it, the “pre-Ferguson” period) is a stable and undifferentiated interval, by which we mean that we regard Baltimore – both the community and its public safety officers – as engaged in what researchers sometimes label “business as usual.” This does not imply that the pre-Ferguson period is without trends, only that the relationships among factors that generate any trends are in a stable state so that the interval can serve as a coherent baseline.

To proactively engage with all of the obvious criticism that can be leveled at the analysis decisions just revealed, we offer the following clarification:

Caveat: Nominal Time Intervals Only

These periods were selected because of their prominence in discussions over crime and policing in Baltimore and across the nation, not because they are sharply enough delineated to be regarded as episodes with straightforward period-specific effects. Thus, even though we will often use shorthand labels, as above and in graphical and tabular depictions, we fully recognize that these are nominal labels for broad periods of time, during which many heterogeneous and consequential events transpired. Each of these embedded events may have effects, and these effects may persist beyond the time period in which they are initiated.

This first caveat will be followed by others in this report. To readers unaccustomed to academic writing, we apologize if these boxed callouts read as unnecessary hedging or, worse yet, fatuous handwringing. Their intent is to clarify our analysis decisions and, in so doing, enhance the discussion of just how complicated interpretations of these trends can be. We hope that this forthright and measured writing on the complications of our analysis may also be useful for understanding the claims of others who may not have had the time or inclination to give related issues sufficient thought.

2.3. The Effects of Interest

As explained in the introduction, our interest is the assessment of change in response to the events in Ferguson, the emergent national dialogue on police conduct, the arrest of Freddie Gray and its aftermath, punctuated by the week that started with a riot/uprising, and finally the appointment of a new police commissioner in Baltimore that restored confidence in the department's leadership and generated some changes in policing practice.

In this section, we define these effects of interest more precisely, with reference to the time periods just delineated. As we will explain, we will interpret period-by-period changes and relate these changes to underlying events that we assume generate effects. However, we will not always be able to isolate finely articulated effects that are uniquely attributable to specific events.

The Ferguson Effect. A Ferguson effect on crime in Baltimore would exist, by our reasoning, if the number of crime incidents recorded after the beginning of the Ferguson period differs from the number that would have been recorded if the events in Ferguson had not set off a shift in the national dialogue on policing. The Ferguson effect for arrests would have the same basic structure and would not necessarily align with the Ferguson effect for crime. Indeed, there is good reason to expect substantial divergence. Consider the following possibilities. Suppose that police officers, because of concerns about additional monitoring and the need to document the appropriateness of their conduct, take a more deliberate approach to routine police activity. Or suppose that they decide to refrain from some discretionary police activity in order to minimize the odds that they will find themselves in encounters that are hard to control. In either case, the arrest count would decrease, especially for discretionary arrests, and a Ferguson effect on arrests would emerge. This decrease could occur regardless of changes in the pattern of crime incidents. Suppose, however, that individuals inclined to commit crimes anticipate that the police may be about to back off from aggressive policing, or, more plausibly, observe a decline in discretionary arrests in their communities. In these circumstances, crime incidents might increase, and such a change would qualify, by our reasoning, as a Ferguson effect on crime. This effect on crime could accompany or follow a Ferguson effect on arrests.

The structure of these sorts of effects is established through a comparison of what is observed to an expectation of what would have been observed in the absence of the cause,

which in this case is the shift in the national dialogue on police conduct that emerged following the protests in Ferguson. In the language of academic research, the assessment of such effects requires the modeling of counterfactual values: what would have happened in the absence of something that actually did happen. In order to make any progress in an empirical assessment of effects such as these, the analyst needs to develop a model of unobserved counterfactual trajectories that yield comparison values.

The Gray Effect. If this type of analysis were not challenging enough already, additional complications immediately arise when considering the onset of effects in response to the arrest of Freddie Gray. As with the Ferguson effect, we can start by defining a Gray effect using a simple counterfactual: the difference in crime incidents or arrests between what is observed and what would have been observed if Freddie Gray had not been arrested and had not died from the injuries he sustained while in police custody. The complication with this definition is the possible presence of a preexisting Ferguson effect during the post-Ferguson, pre-Gray time interval, labeled above as the “Ferguson period.” There is no good reason to believe that a preexisting Ferguson effect would vanish the moment a Gray effect begins. Rather, it would be most reasonable to assume that the existence of any ongoing Ferguson effect would then shape the nature of a subsequent Gray effect, either for crime incidents, or arrests, or both.

Moreover, the Gray effect itself has two components, each of which is clearly observable in the raw data that we will analyze below: (1) changes during the dramatic events of the week of unrest that began on April 27, 2015 and ended when the National Guard stood down seven days later, and (2) the more encompassing period delineated above, which began after the death of Freddie Gray on April 19th, and which included substantial journalistic coverage of both peaceful and violent protests. Furthermore, it is reasonable to assume that substantial discussion of Freddie Gray’s arrest would have been present in the ranks of the Baltimore police before April 27th, given that he was arrested on April 12th and his death was widely reported on April 19th. Indeed, the officers involved in his arrest were suspended on April 21st, which was six days before the riot/uprising began.

Altogether, our strategy is to interpret changes that are observed in the Gray period relative to the Ferguson period in counterfactual terms, but with the stipulation that the changes produced by a Gray effect are not cleanly separable from any preexisting Ferguson effect. We will not attempt to estimate complex counterfactuals, such as the Gray effect that would have occurred if the Ferguson protests and all associated events had not occurred in the months prior to it. Similarly, we will not attempt to evaluate the Ferguson effect in the Gray period, as if Freddie Gray had not been arrested or had been arrested but had not died. Rather, we will allow all change in the Gray period to be attributed to a nominal Gray effect. But we will then discuss in our subsequent interpretations how the Ferguson and Gray effects may be fundamentally entangled because of how the size of the Gray effect may depend on the nature of an underlying Ferguson effect.

Finally, even though we will model the nominal Gray effect in two pieces, generating estimates that allow us to separate the piece of the Gray effect that is attributable to the Gray period as a whole from the additional spike that occurred during the week of unrest, this separation is artificial as well, since the overall Gray period cannot be fundamentally separated into these two pieces. The pattern of crime and arrests in the weeks following the unrest would not have been the same if the week of unrest had not occurred.

The Davis Effect. The Davis effect has the same basic layered structure as our discussion of the Ferguson and Gray effects above has introduced. Again, we will not consider complex counterfactuals that are too remote from the events that actually transpired. For example, we will not consider what would have occurred if Commissioner Davis had been appointed but the arrest of Freddie Gray had not occurred before his appointment.

We will make one simplification for the Davis effect estimated during the Davis period. We will allow the Ferguson effect to be implicitly embedded within the Davis period just as in the Gray period, but we will only allow part of the Gray effect to be implicitly embedded within the Davis period. More specifically, we will estimate the unrest week's effects as a transitory shock that occurred during the Gray period and that did not persist into the Davis period. As such, the change that is measured for the Davis period is a comparison against a world in which the Ferguson protests occurred and part of the Gray effect occurred, but the week of unrest is excluded. We regard this as a more reasonable set of comparison values than a trajectory that incorporates the totals from an anomalous week with quite limited relevance to the changes in police practice that Commissioner Davis' appointment initiated. In other words, while it is true that Commissioner Davis was appointed because of the totality of the effects that occurred during the Gray period, it is more helpful to model the change that occurred after his appointment by first removing the specific week of unrest from the outcomes modeled.

2.3. Data Sources and Measures

Setting. The Baltimore Police Department divides the city into the nine police districts depicted in Figure 1. The shading in each district is for the percentage of the population that is non-White, as estimated for each US Census block group from the 2009-13 five-year files of the American Community Survey (ACS). Table 1 presents population distributions, and the full names of the districts are included in the row labels (as opposed to the abbreviations in Figure 1). Because these distributions are based on small area estimation techniques, the distributions in Table 1 may vary to a slight degree from the true population distributions.

For details on the definitions for the elements of Figure 1 and Table 1, see the notes to Table 1. As shown by both Figure 1 and Table 1, the police districts differ substantially by geographic and population size, and the districts are strongly patterned by racial segregation. The Western and Eastern districts are among the smallest. A categorization of ACS block group estimates suggest that they are 97% and 94% black, respectively, and that they have average levels of income about half as large as the Northern and Southeastern districts.

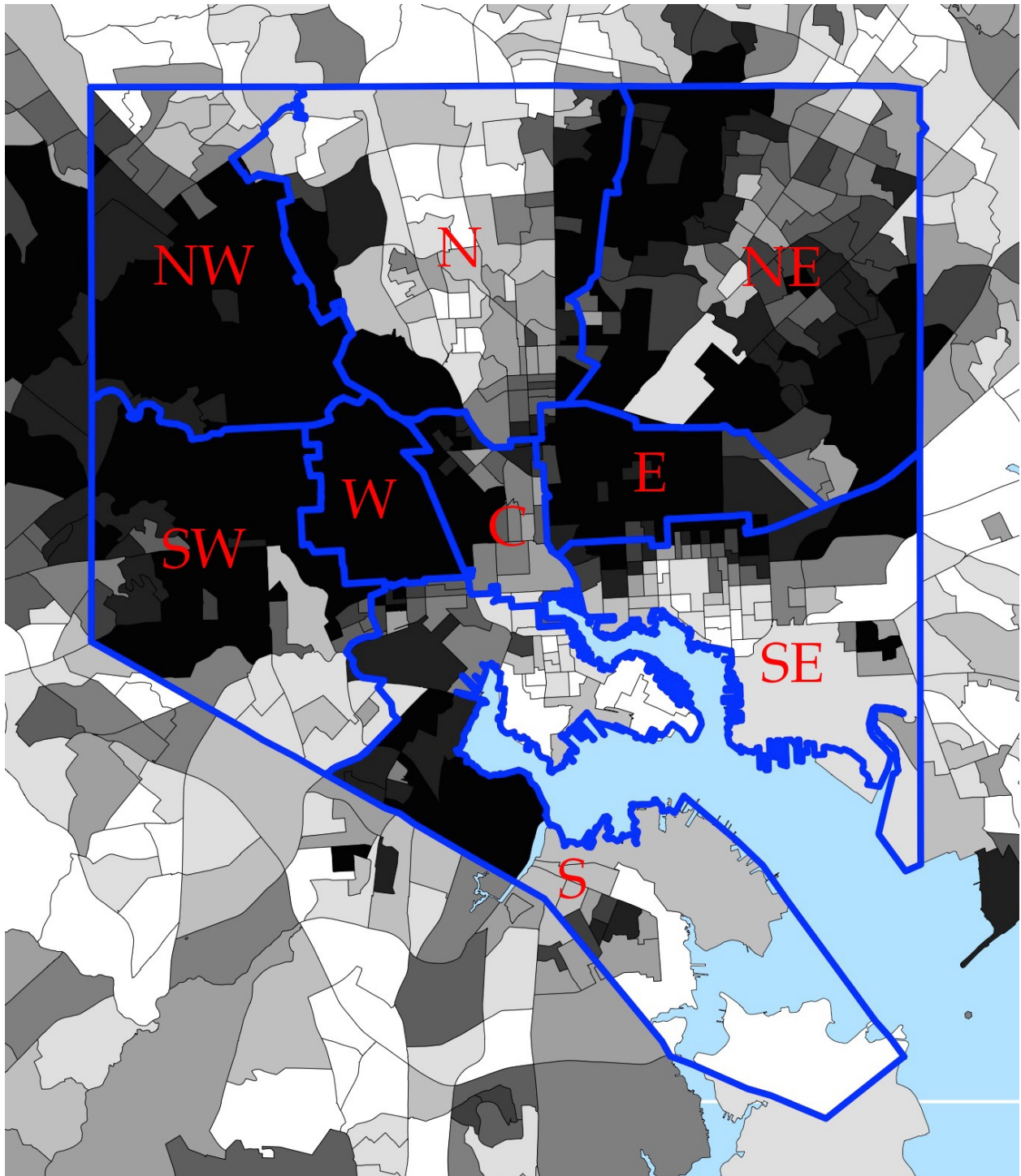


Figure 1. The Nine Baltimore City Police Districts, Outlined Within the Baltimore Metropolitan Area, with Block Groups Shaded by the Percent of Residents Claiming a Racial Identity Other Than White, Estimated from the American Community Survey

Table 1. Population Characteristics of the Nine Baltimore Police Districts

	Population Count	Percent of Total Population	Percent of District Non-White	Percent of District Black	Mean Income for Adults
Northwestern (NW)	85,200	13.3	78.7	72.4	23,500
Northern (N)	96,000	14.9	46.1	32.4	31,000
Northeastern (NE)	139,000	21.6	80.2	74.3	28,000
Western (W)	38,000	5.9	99.0	96.8	16,000
Central (C)	41,700	6.5	69.7	57.5	24,000
Eastern (E)	42,200	6.6	96.9	93.6	14,000
Southwestern (SW)	61,400	9.6	81.7	76.6	23,000
Southern (S)	69,800	10.9	54.3	43.1	28,000
Southeastern (SE)	69,000	10.7	44.0	22.2	30,000
Total	642,300	100.0			

Notes: ACS-estimated population counts are rounded to the nearest one hundred, and they include those who are resident in both households and in group quarters (e.g., college and university dormitories, group homes, nursing facilities, and correctional facilities). Percent non-white is calculated as one hundred minus the percent of the district population that claims only non-Hispanic for ethnicity and only white for race. Percent black is calculated as the percent of the district population that claims to be either black and non-Hispanic or black and Hispanic, and excludes those who select black as a race category in combination with another race category, such as white or Asian. ACS-estimated mean income, rounded to five hundred dollars, is the district average of individual income, estimated for the subpopulation that has positive income.

Crime and Arrest Data by Week. The Baltimore City Police Department releases data, over the citywide Open Baltimore data portal, on a near-weekly basis. In this analysis, we consider 292,721 recorded crime incidents beginning on March 1, 2010 through the end of 2015. We tossed some available data on crime incidents from January and February 2010 because of data quality issues. This also made sense because the seasonality of crime suggests that the yearly takeoff begins in March, and even when dropping these two months, we have four entire years of crime data to analyze before the Ferguson events unfolded.

For arrests, we use all data that are publicly available to us: 110,755 arrests of individuals from January 1, 2013 through the end of 2015. This shorter interval for arrests gives us only a little more than one and half years of pre-Ferguson data to model. Accordingly, as we will discuss below, our models of pre-Ferguson trends in arrests are therefore less informed than our models of pre-Ferguson crime incidents.

Although the crime and arrest data available on Open Baltimore are incident-based data, with an entry for each recorded crime and arrest, we bin these events into weeks beginning on Monday and ending on Sunday in order to cumulate rare events into meaningful counts. Accordingly, all of the outcomes we consider are weekly counts for crime incidents and for arrests.

For types of crime, we use BPD's own released categories, which themselves are shaped by national standards for crime reporting. The specific categories of crime will be presented below, and they range from violent crime, such as homicides and shootings, to petty property crime, such as larceny from automobiles. We will also use a total crime count per week, which is the summation of all recorded crime incidents in the week. This measure is useful for some purposes, such as for specifying models without falling into what statisticians label specification traps that lead to false inference. But, the total crime incident count each week also has substantial limitations. Because of the distribution of types of crime, it is dominated by high frequency recorded crimes, such as larceny, burglary, and assault, instead of types of crime that may be of substantial importance but have a lower frequency, such as shootings.

Caveat: Crime is Under-Reported, and the Under-Reporting is Not Random

It is vitally important to recognize, as we will discuss at several points in this report, that crime is notoriously subject to non-random patterns of under-reporting. Although recorded homicides and shootings are probably subject to only small amounts of under-reporting, many types of street crime and property crime may be grossly under-reported, and hence become under-recorded. The common view among criminologists is that such under-reporting is most pronounced in high crime areas, and especially those areas in which residents have complicated relationships with the police.

For arrests, no similar pattern of under-reporting is present. All non-juvenile arrests are recorded and released on Open Baltimore. Our assumption is that these data are complete, which seems reasonable because all of those arrested are taken to a single facility, the Baltimore Central Booking and Intake Center.

Of course, analyzing arrest data is not without its own challenges. Most importantly, the charge descriptions and charge codes for the 700 or so arrests per week are highly variable. The total arrest count can be analyzed without considering variation in types of arrest, but to probe deeper one must categorize arrests in some reasonable way. We describe our coding procedure in Appendix 1, which shows how we categorized more than 10,000 types of charge descriptions into 25 meaningful categories.

Seasonal Adjustment. We utilize external data sources to account for temperature, daylight, snowfall, precipitation, and whether K-12 schooling was in session in Baltimore City. The values for our five measures are presented in Figure 2, with the horizontal axis representing time as the index and with the measurements in the panels representing weekly averages of the variables enumerated on the vertical axes.

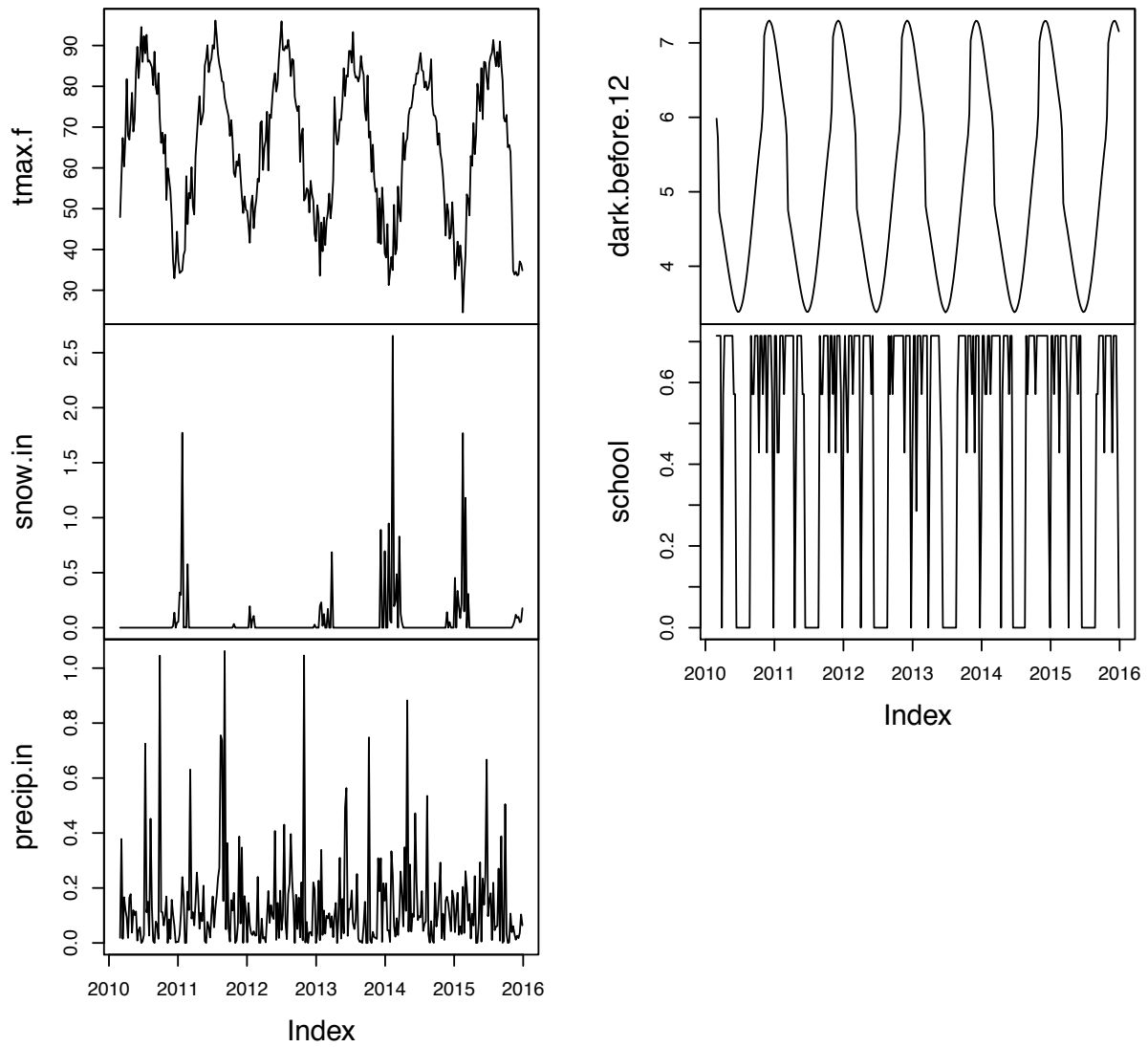


Figure 2. Seasonal Adjustment Variables Utilized in Subsequent Models

In particular, `tmax.f` is the weekly average of the daily maximum temperature, measured in degrees Fahrenheit; `snow.in` is the weekly average of total daily snowfall, measured in inches; `precip.in` is the weekly average of total daily precipitation, measured in inches; `dark.before.12` is the weekly average of daily hours between sunset and midnight; and `school` is the proportion of days of the week when school was scheduled for Baltimore City Schools.

The temperature and precipitation data were retrieved from the NOAA.gov Web Services-v2 API. Our values are daily averages across weather stations in the Baltimore metropolitan area, which we then averaged to generate weekly values.

Hours of darkness before midnight was calculated from sunset data, using the online tool created by Horizon Network Security (HNS), which we verified for accuracy using US Naval Observatory data. With our calculation, twilight is counted as darkness. We then created weekly averages of the daily number of hours of darkness. The comparatively swift changes in spring and fall of each year are generated by the the beginning and ending of daylight saving time.

Caveat: Even Our Adjustment Measures Should Not Be Considered Flawless

Some of the measures that we will use for adjustment may seem flawless, such as hours of darkness before midnight. But, of course, nothing is flawless. In this case, we do not consider phases of the moon or cloud cover, both of which shape how much genuine darkness is present.

The proportion of the week that school was in session was determined using the school calendar of the Baltimore City school district. Although we demarcated school as out of session for professional development days, etc., this measure does not include cancellations (e.g., snow days).

2.4. Methods of Analysis

Our primary results are derived from estimation of what are often labeled interrupted time series models, within which we embed a least squares model for seasonal adjustment. As academic researchers are aware, statisticians and econometricians have invented many arcane alternatives to our simple models. After some exploration of alternatives, we concluded that the improvements generated by more sophisticated models were not large enough to justify the reporting burden their use would entail.

We invite others to take the data and code that we have released with the final report and try alternatives on their own. We also offer comprehensive results for crime in Appendix 2 and for arrests in Appendix 3. In these appendices, we include additional results with diagnostic value that support our decision to use simple methods: estimated autocorrelation function graphs for the residuals from the seasonally adjusted models and alternative poisson regression coefficients for the period change models.

Caveat: Statistical Significance Is An Interpretive Crutch That We Will Not Utilize

Nowhere in this report do we indicate whether the changes and differences that generate our conclusions are “statistically significant.” We are analyzing administrative data, alleged to be the complete record of crime incidents and arrests available, not data gathered from a random sample of a larger population of units.

Whether the estimates of change that we offer are small, medium, or large is a matter for substantive interpretation. Our interpretations are informed by the distributions of the outcomes of interest, which are the primary guides for understanding when changes are large enough to be meaningful. However, the interpretations we offer reflect our own judgments, and readers need not agree with our positions on substantive magnitude.

A note of clarification: In much social science research, a common reporting strategy is to conduct tests of statistical significance for changes/differences and then to discuss only those changes/differences that pass these tests of significance. In many cases, changes/differences that do not pass these tests are interpreted as zero effects, implying that no evidence of change/difference is present in the data. The former practice is permissible, but the latter is not. We engage in neither of these reporting practices for the reasons stated above. Nonetheless, our conclusions are not without some inherent uncertainty and hence are not beyond reasonable critique. See our caveat above on under-reporting for crime incidents as well as our next caveat on model uncertainty for both crime incidents and arrests.

Caveat: Model Uncertainty is the Most Serious Threat to Our Interpretations

Our estimates of change are determined by our study design choices, including: (1) the measures and specifications we use to model seasonality, (2) the boundaries of our nominal time intervals, and (3) our decision to fit an overall parameter for time to model a latent linear trajectory, which we then assume is invariant after the beginning of the Ferguson period.

Although there are proposals for how to quantify and convey the uncertainty implied by decisions such as these, our position is that these methods would only be useful if we were to be engaged in recommending a particular decision to the reader, such as whether or not to implement a new form of community-responsive policing. In this case, we could weight the plausibility of estimates from alternative models by our confidence in them as well as the consequences of believing in them when selecting an optimal decision.

Because we are not evaluating a particular course of action, we will instead convey model uncertainty in different and less formal ways, such as: (1) showing the fit of the seasonal model against the observed data, (2) showing the

variation from the counterfactual trend that generates the estimates from our preferred model, (3) offering an important alternative model for each outcome considered, and (4) deliberately deemphasizing (through the use of gray typeface) and carefully discussing some estimates that we believe should be regarded with suspicion (even though they align quite well with the overall set of conclusions).

Our position is that this four-part reporting strategy is a reasonable way to convey model uncertainty, but readers may not agree. Partly for this reason, we encourage critical readers to estimate models beyond those we offer. The data analyzed here are publicly available, and we are releasing the version of the data that we analyzed for this report to facilitate replication and critique.

3. Results for Crime Incidents

Our analysis strategy is to first estimate a model of the cyclical crime trend through Sunday August 10, 2014 and then use this estimated model to predict a counterfactual crime trend, as if the protest events, emergent national dialogue on police conduct, and changes in policing after August 10, 2014 had not occurred. We then estimate our effects of interest as layered average differences between observed and counterfactual values from August 11, 2014 onward. We conclude this section by laying out three conclusions for trends in crime incidents.

3.1. Primary Findings

Our main results are presented below in Table 2. After summarizing these findings for our analysis of crime, we will explain in the next subsection how the numbers in the cells of Table 2 were calculated. As part of that explanation, we will offer time series graphs that reveal the variation that generates the percentage change estimates offered in Table 2.

Baseline Counts. The first column of Table 2 presents baseline counts of recorded crime incidents per week. These values are the average of predicted weekly counts for the year prior to the beginning of the Ferguson period, separately for each type of crime, and with the total presented in the last row of the table. These baseline counts demonstrate the wide variation in weekly recorded crime incidents, which span a range from low frequency crimes such as arson and homicide (at 4.3 incidents per week each) to high frequency crimes such as common assault and larceny (at 157.3 and 224.5 incidents per week, respectively).

The Ferguson Period and Crime. The values in the second column are the estimated percentage changes in recorded crime during the weeks after the Ferguson protests were publicized (on August 11, 2014) but before the Freddie Gray protests commenced (on April 20, 2015). Overall, evidence for a crime response in the form of Ferguson effect in Baltimore is very weak during this post-Ferguson, pre-Gray period.

Many categories of crime decreased slightly, such as homicide (down 3%), automobile theft (down 7%), common assault (down 13%), and larceny (down 12%). Other categories of crime were unchanged, such as street robbery and burglary. Small increases were present for larceny from automobiles (up 3%) and aggravated assault (up 6%). Against such stability and mostly trendless fluctuation in many types of recorded crime, the only substantial increases were modest in comparison to the changes that unfolded from April 2015 onward, as we discuss below. In particular, during the Ferguson period shootings increased by 13%, commercial robbery by 19%, and arson by 17%. Carjacking increased even more substantially (up 62%), but because this has the lowest baseline count of all crimes the raw increase was only from 2.6 to 4.2 incidents per week. These are all meaningful increases, but given changes in reporting, the range of expected variability, and inherent model uncertainty, our overall judgment is that these few increases are too small to be regarded as evidence in favor of a substantial Ferguson effect on crime before Freddie Gray was arrested.

Table 2. Baseline and Percentage Change in the Weekly Count of Recorded Crime Incidents

	Baseline Count Per Week	Ferguson Period (percent change)	Gray Period (percent change)	Unrest Period (percent change)	Davis Period (percent change)
Homicide	4.3	-2.9	91.9	19.8	-28.5
Shooting	7.1	13.4	139.6	-39.2	-64.0
Rape	5.3	-2.6	22.1	-28.9	-33.4
Robbery (carjacking)	2.6	62.3	32.9	396.7	35.8
Robbery (street)	51.4	0.0	30.8	-33.9	-11.8
Robbery (commercial)	11.0	19.3	82.0	-0.4	-68.0
Robbery (residence)	9.8	-12.3	17.5	15.6	-34.3
Aggravated assault	82.2	5.5	25.6	-7.4	-8.5
Assault by threat	10.9	-5.4	5.0	-63.0	23.4
Common assault	157.3	-12.7	0.4	-31.1	2.8
Burglary	138.7	-0.4	12.0	188.0	1.2
Larceny from auto	123.1	3.0	11.5	-56.2	0.5
Larceny	224.5	-11.6	-15.7	-24.9	5.2
Auto theft	85.6	-7.0	53.4	-52.1	-27.6
Arson	4.3	17.4	18.2	652.6	8.2
Total	918.3	-4.5	11.6	5.2	-3.6

The Gray Period, Unrest Period, and Crime. The third and fourth columns of Table 2 present two interrelated estimates of percent change in crime, first for the overall Gray period from April 20, 2015 through July 12, 2015 and second for a supplementary shock for the Unrest period (the week of April 27, 2015).

During the Gray period, shootings and homicides increased by 140% and 92%, respectively, in comparison to the Ferguson period that preceded it. In addition, street robbery increased by 31%, commercial robbery increased by 82%, carjacking increased by 33%, and automobile theft increased by 53%.

On top of these changes, during the week of unrest the crimes of arson, burglary, and carjacking increased by 653%, 188%, and 397%, respectively. Yet, during that same week, shootings, street robbery, and automobile theft were lower by 39%, 34%, and 52%, respectively, relative to the overall Gray period.

To be clear, these are additive effects, such that the total percentage change during the week of unrest, relative to the Ferguson period, is equal to the sum of the effect in columns three and four. For example, carjacking was higher by 430 percent ($396.7 + 32.9 = 429.6$) while

shootings were higher 100 percent ($139.6 - 39.2 = 100.4$) during the week of unrest in comparison to the Ferguson period that preceded it.

Overall, the pattern is one where all but one type of crime increased during the Gray period (larceny being the exception), but the shock from the unrest included both some dramatic supplemental increases and other less dramatic decreases. The increases are likely the unrest itself, and the decreases are responses to the curfew and presence of extra law enforcement officials on the streets.

The Davis Period and Crime. With the exception of carjacking, which continued to increase through the end of the year, the categories of crime that increased during the Gray period then decreased somewhat after Commissioner Davis was appointed. Shootings and homicides decreased by 64% and 29%, respectively, leaving still large net increases at the end of the year of 76% and 63% in comparison to rates estimated for the Ferguson period. At the same time, street robbery, commercial robbery, and automobile theft declined by 12%, 68%, and 28%, leaving modest net increases of 19%, 14%, and 26%.

We describe in the next section how we estimated the changes in Table 2, based on models of underlying period-by-period variation, de-trended using an invariant estimated model for the seasonality of crime. After this explanation, we will reiterate the core findings just presented, discussing the layered effects they represent, and then motivate the subsequent analysis of arrests.

3.2. The Models Beneath the Primary Findings for Crime

Figure 3 presents changes over time in the total weekly count of recorded crime incidents from March 2010 through the end of 2015, which is the same outcome analyzed for the last row of Table 2. For Figure 3, the gray dots are the observed weekly totals, plotted according to the week of each year. Seasonal variation in crime is clear, consistently rising to the highest intensity in the summer months, before falling back in the fall, and reaching its lowest point in the winter. The three vertical bars in the figure demarcate the beginning of the Ferguson, Gray, and Davis periods.

The jagged black line is a predicted time series from a model that uses the data on weather, hours of darkness, and school days (see Figure 2 above and Table 3 below) to predict the weekly total count of crime incidents for the pre-Ferguson period. This is the interval before the Ferguson period began on August 11, 2014. The jagged red line is then an extrapolated cyclical trend, generated by forming predictions from the parameters of the pre-Ferguson model when applied to the observed values for weather, hours of darkness, and school days from August 11, 2014 onward. The differences between the gray dots and the red line, within the three intervals that begin to the right of the three vertical bars, is the source of variation that generates the estimates for percentage change reported in Table 2 for the Ferguson, Gray, and Davis periods.

Consider now Table 3, which offers results from three related models. The first column presents coefficients for the model that generates the predictions plotted as the jagged black line in Figure 3. The predictor variables for the model are presented in the row labels, and they collectively generate a model that explains 68 percent of the variance of weekly crime totals in the pre-Ferguson period from March 1, 2010 through August 10, 2014. Although we caution against attaching too much meaning to any single coefficient, since most of these predictor variables move together in seasonal fashion, it is clear that temperature, snowfall, precipitation, and hours of darkness are strongly predictive. The nonlinear partial relationship between temperature and crime is notable, with the effects appearing to accelerate with changes in the 50s, before leveling off in the 70s and then further in the 80s and above. These associations, however, are net of snowfall and precipitation, which themselves are temperature related. Overall, it is clear that the black jagged line in Figure 3 traces the core of the variation in the gray dots very well.

The coefficients in the second column represent our preferred model, and they provide the values that, when scaled by an appropriate baseline count for the outcome, determine the percent change findings reported above in Table 2. The coefficients are calculated by first “detrrending” the outcome variables, which in this case is equivalent to transforming the total crime counts in each week by subtracting from each week’s value the corresponding value in that week for the value on the jagged line (the black line before the Ferguson period began and the red line afterwards). As a result, for this model, the outcome variable is the difference between the raw observed total crime count (the gray dots) and the modeled value represented by the black/red line. The coefficients for the model in the second column are then determined by fitting coefficients for indicator variables for each time period, with the Ferguson, Gray, and Davis periods switching on from 0 to 1 when each period begins (and remaining on at 1 through the end of the time series). In contrast, the indicator variable for the week of unrest switches on from 0 to 1 during its single week, and then switches off from 1 to 0 for all subsequent weeks.

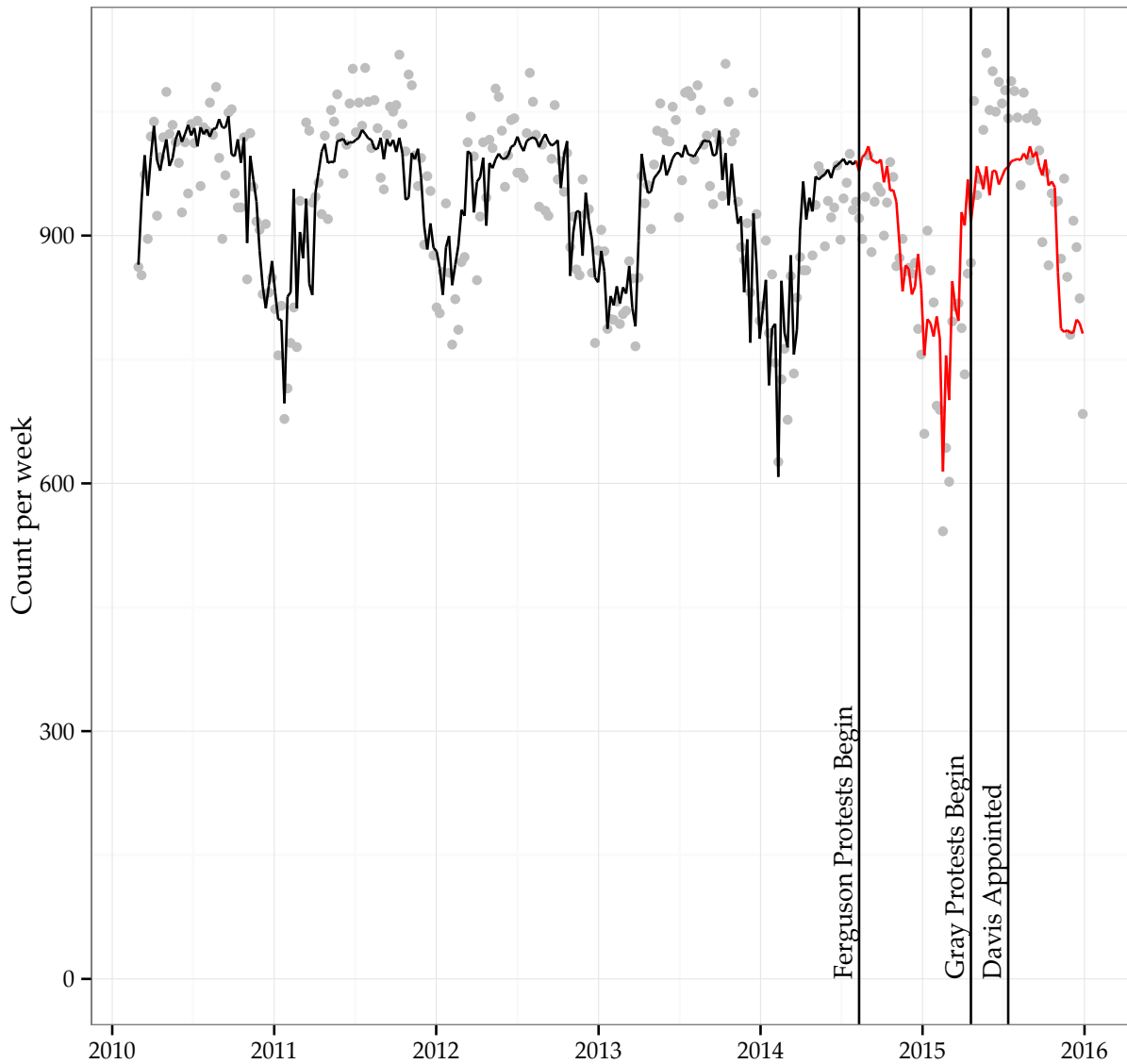


Figure 3. Total Weekly Recorded Crime Incidents (gray dots) with Predicted Values from the Model Before the Ferguson Protests Began (black line) and Extrapolated Counterfactual Values After the Ferguson Protests Began (red line)

Table 3. Coefficients from Three Models for Total Weekly Recorded Crime Incidents

	3/1/2010 – 8/10/2014 Model	Preferred Model	Alternative Model
Time Counter (in weeks)	-0.14		-0.14
After Ferguson Protests Begin (week of 8/11/14 onward)		-41.08	-42.48
After Gray Protests Begin (week of 4/20/15 onward)		106.85	109.81
Unrest and National Guard (during week of 4/27/15)		48.18	56.99
After Commissioner Davis Hired (week of 7/13/15 onward)		-32.79	-38.87
Average Maximum Temperature to 50 Degrees	4.25		4.04
Plus Degrees in the 50s	6.27		4.27
Plus Degrees in the 60s	-4.42		-1.62
Plus Degrees in the 70s	-3.59		-3.10
Plus Degrees Greater Than 80	-1.08		-0.70
Snowfall (inches)	-65.45		-81.31
Precipitation (inches)	-24.70		-14.51
Darkness Before Midnight (hours)	20.87		22.60
School Days (proportion of week)	-5.73		11.07
Observations (weeks)	232	305	305
Proportion of variance explained (R-squared)	0.68	0.13	0.71

Notes: The outcome variable for the first and third columns is the same – the total weekly recorded crime count – but the R-squared values cannot be compared across the two columns because the weeks for the model differ. Relatedly, the outcome for the second column is a residualized total weekly crime count, and as such the R-squared value of 0.13 cannot be meaningfully compared to either 0.68 or 0.71 in the first and third columns, even though the models in the second and third columns are estimated for the same weeks.

The first coefficient for our preferred model is -41.08. This value is interpretable as a decline of 41 reported crime incidents per week on average after the onset of the Ferguson period. Dividing this coefficient by the baseline count of 918.3 crimes per week from Table 2 results in a scaled change of -0.0447, which yields the value of -4.5% in the last row of Table 2 in the column for the Ferguson period. Likewise, the coefficient for the Gray period, 106.85, when divided by 918.3, is equal to 0.1163, and that is the 11.6% in the last row of the Table 2 in the column for the Gray period. The unrest spike of 48.18, followed by the Davis period’s coefficient of -32.79, are then the changes of 5.2% and -3.6%, respectively.

We offer one additional model in Table 3, which is reported in the final column. It is an alternative to our preferred model, and it fits coefficients for weather, hours of darkness, and school days simultaneously with coefficients for the four period indicator variables. The

advantage of the model is that it uses additional data on the seasonal adjustment variables, which could provide better estimates of the underlying seasonal trend. The disadvantage is that the periods of interest are not randomly distributed relative to the adjustment variables, and thus the model is forced to simultaneously estimate all coefficients at once, which may generate misleading estimates of the period effects. Our preferred model assumes that the model for the cyclical trend identified in the first column of Table 3 is invariant across the full time series (i.e., even after the Ferguson period commences), and we can cleanly estimate this pre-Ferguson model without contamination from the subsequent period effects of primary interest. Nonetheless, we offer the alternative model to show that even if we were to allow for less controlled estimates of the effects, the qualitative conclusions of the report would not differ substantially.

Figure 4 highlights an important source of model uncertainty. This figure is similar to Figure 3, but we have smoothed the raw outcome data across weeks in order to promote visual clarity. The light blue line is the three-week moving average of the observed weekly totals that were represented instead by gray dots for each week in Figure 3.

Recall that the estimated pre-Ferguson model is represented by the jagged black line. On the one hand, it is undeniably a good fit, capturing the main components of seasonal change. But, not all years are the same, and the requirement of the model that the same coefficients apply to all years without variation means that the pattern of divergence between the black and blue lines differs by year. Consider the crucial late spring and summer months. The model fits these months best in 2010 and 2012, undershoots them in 2011 and 2013, and then overshoots them in the months just preceding the Ferguson period in 2014. The pattern of model fit varies with time, even though the overall model fit is quite good.

Now consider the differences between the red and blue lines. Again, the red line is a counterfactual extrapolation. The divergence between the red line and the blue line in the Gray period, for example, is the 11.6 percent increase that emerges on top of the Ferguson effect that was initiated in the prior interval (see above in Table 2). If the counterfactual model is as reasonable for 2015 as the pre-Ferguson model was for the same months in 2010 and 2012, then there is no reason to question the result. If the model is, unbeknownst to us, undershooting the “true” counterfactual seasonal trend in 2015, as the pre-Ferguson model did slightly in 2011 and 2013, then we may be overestimating the increase in recorded crime in the Gray period.

To appreciate the complex pattern of results beneath our primary findings, inspection of analogs to Figures 3 and 4 for each of the outcomes analyzed in Table 2 is helpful. These are provided in Appendix 2, which offers such figures, along with coefficients from models analogous to those reported in Table 3. We offer, in this main report, six of these figures as a taste of the full results available there.

Figures 5 through 10 present analogs to Figure 4 for homicides, shootings, street robbery, aggravated assault, burglary, and automobile theft. The week-by-week fluctuation of

the blue line for the three-week moving average decreases as the prevalence of the type of crime increases, with considerably more variation for homicides and shootings than for the other four. The fitted model varies for the same reason, but also because some types of crime may be more seasonal in nature. Overall, however, the patterns demonstrate the power of the seasonality adjustment model, and the visual differences between the red and blue jagged lines demonstrate the variation that generates the main results, which are presented in precise form in Table 2.

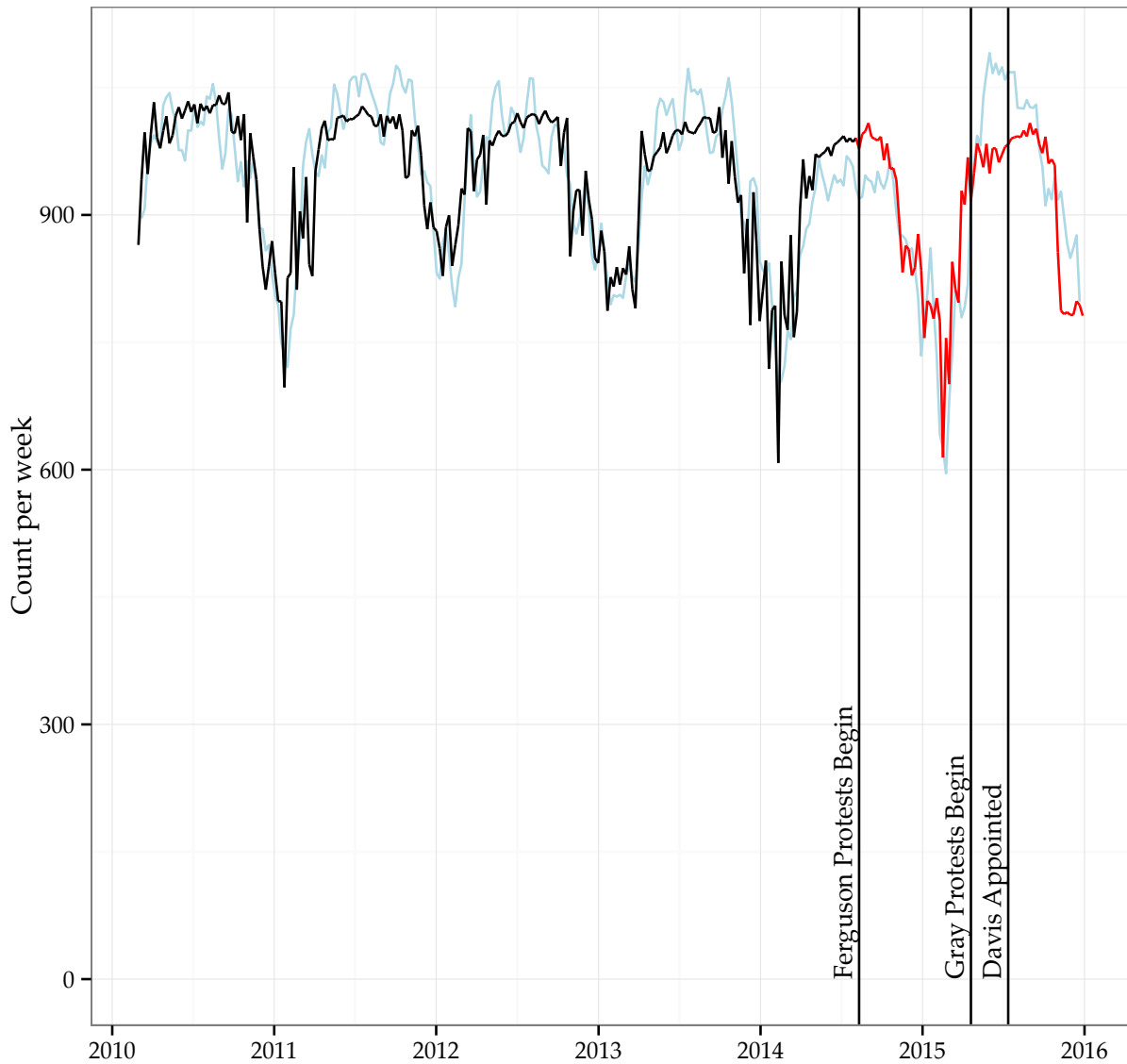


Figure 4. Total Weekly Recorded Crime Incidents (three-week moving average, blue line) with Predicted Values from the Model Before the Ferguson Protests Began (black line) and Extrapolated Counterfactual Values After the Ferguson Protests Began (red line)

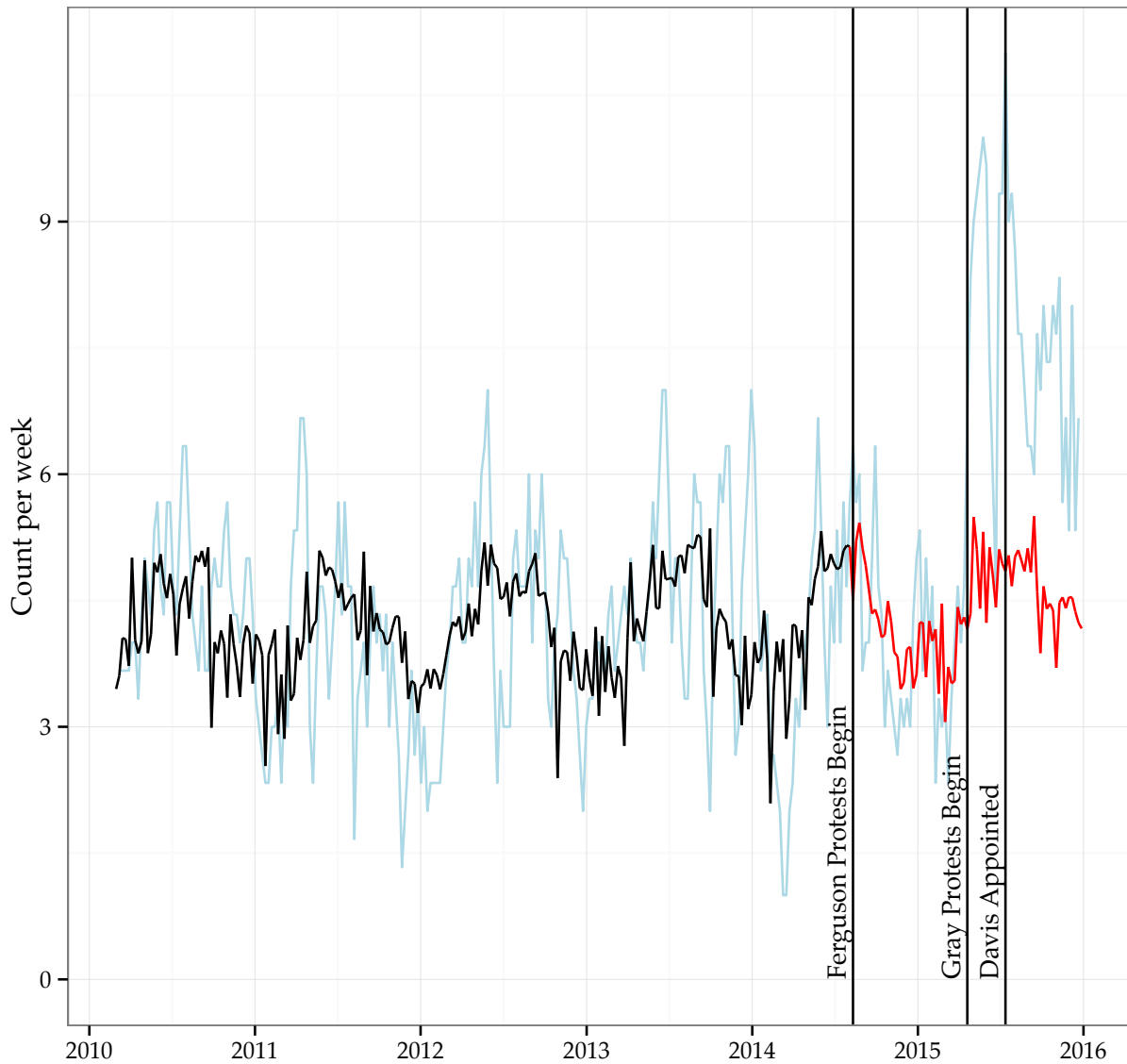


Figure 5. Total Weekly Homicide Count (three-week moving average, blue line) with Predicted Values from the Model Before the Ferguson Protests Began (black line) and Extrapolated Counterfactual Values After the Ferguson Protests Began (red line)

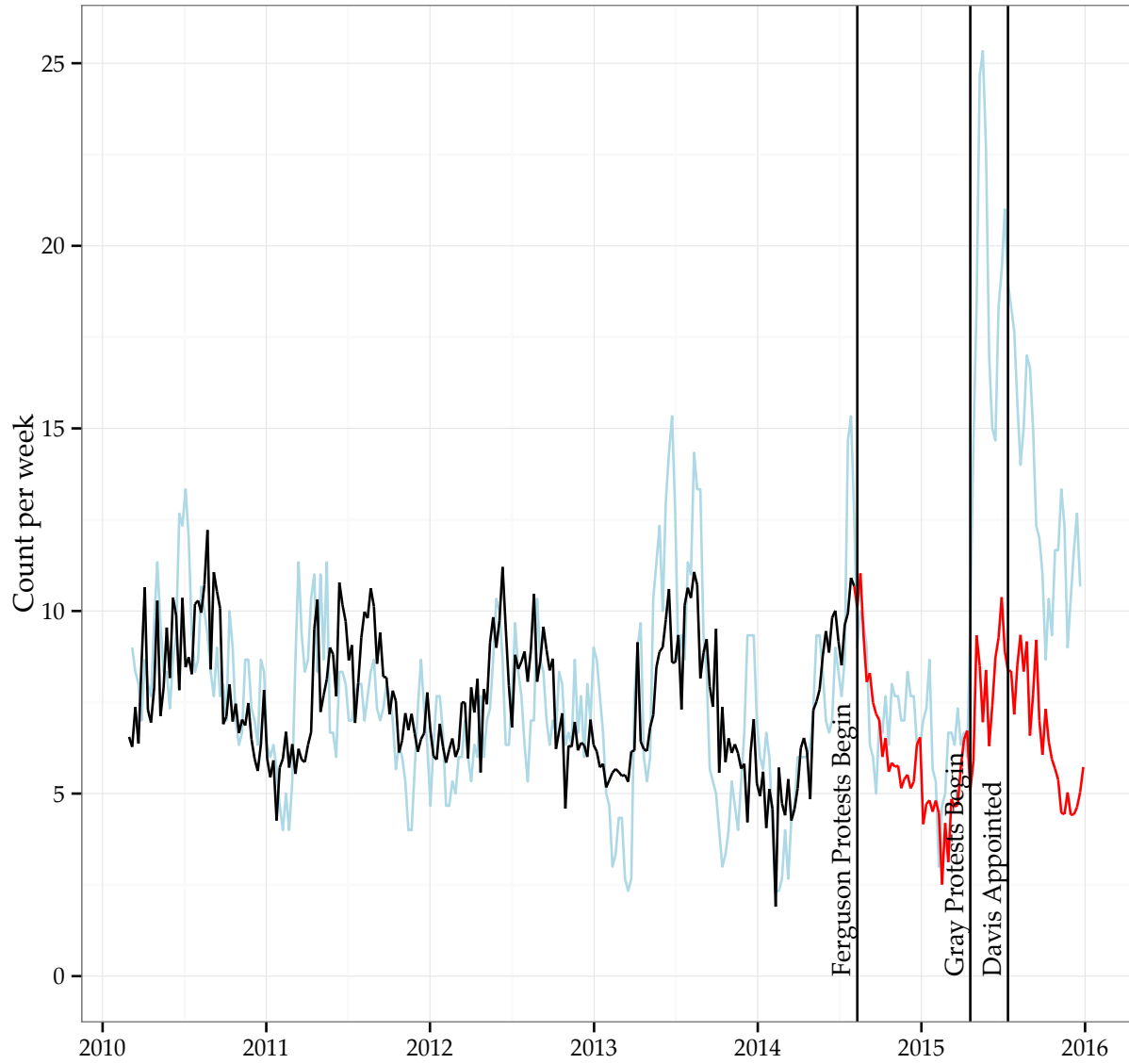


Figure 6. Total Weekly Shootings Count (three-week moving average, blue line) with Predicted Values from the Model Before the Ferguson Protests Began (black line) and Extrapolated Counterfactual Values After the Ferguson Protests Began (red line)

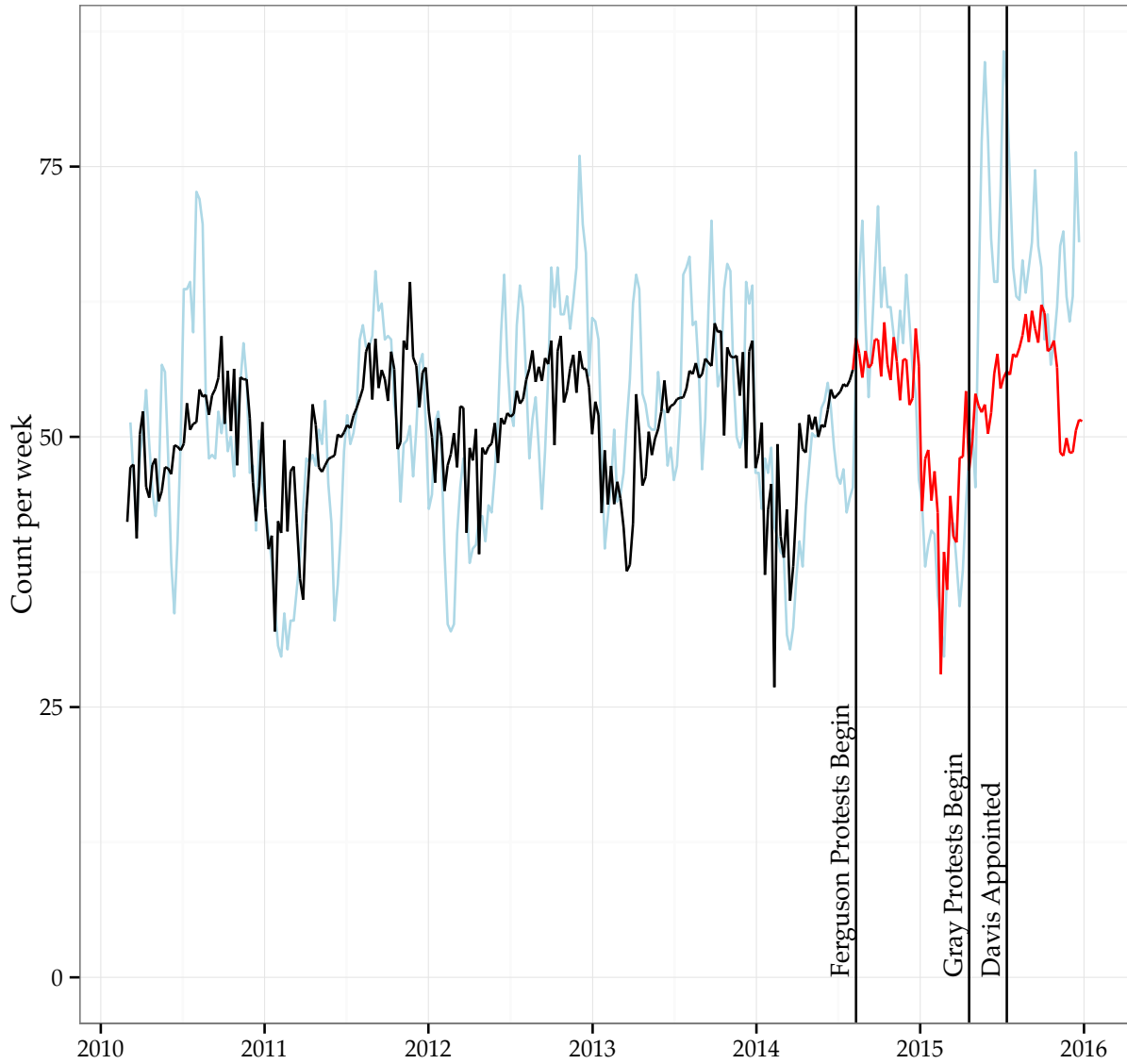


Figure 7. Total Weekly Street Robbery Count (three-week moving average, blue line) with Predicted Values from the Model Before the Ferguson Protests Began (black line) and Extrapolated Counterfactual Values After the Ferguson Protests Began (red line)

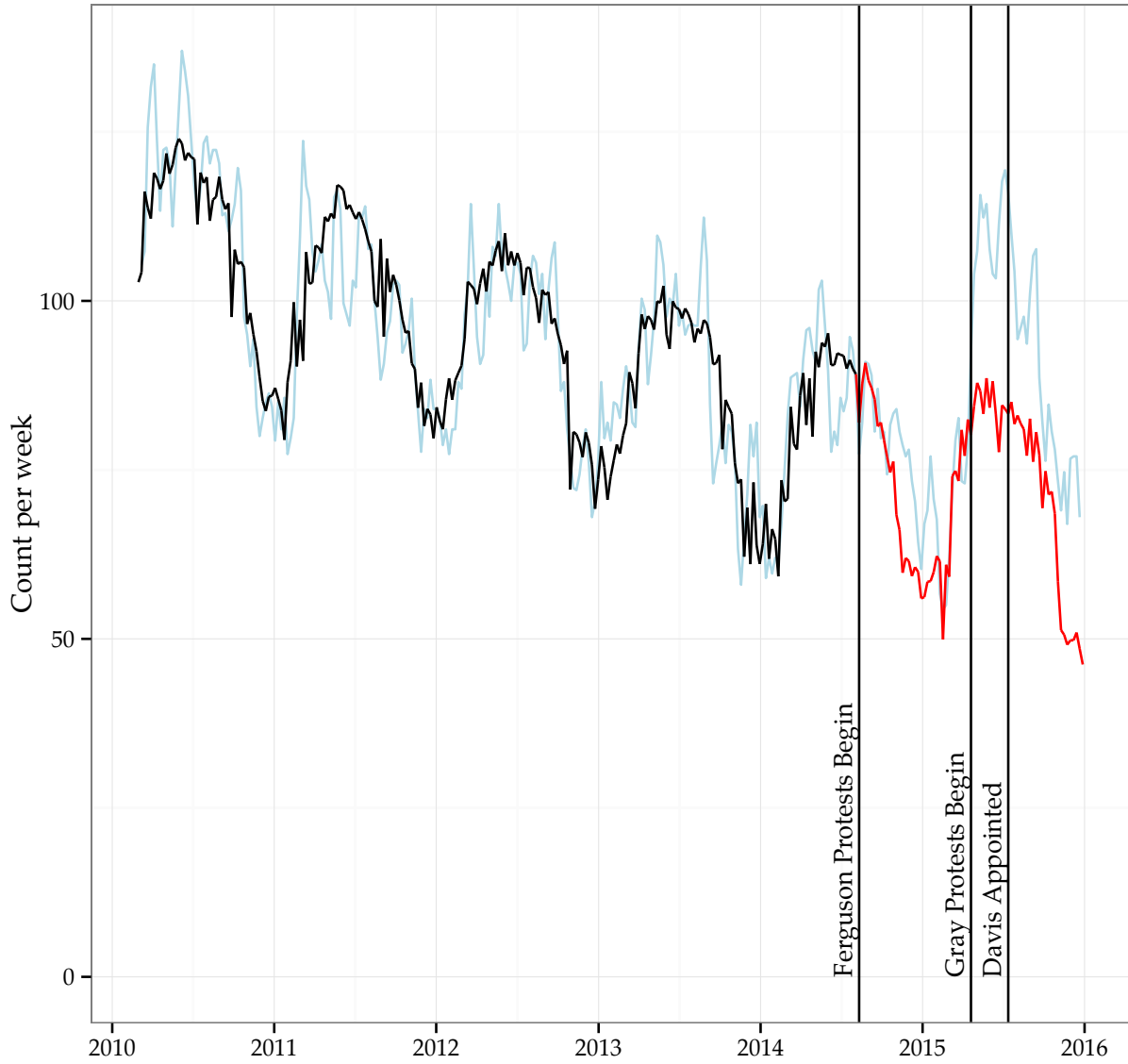


Figure 8. Total Weekly Aggravated Assault Count (three-week moving average, blue line) with Predicted Values from the Model Before the Ferguson Protests Began (black line) and Extrapolated Counterfactual Values After the Ferguson Protests Began (red line)

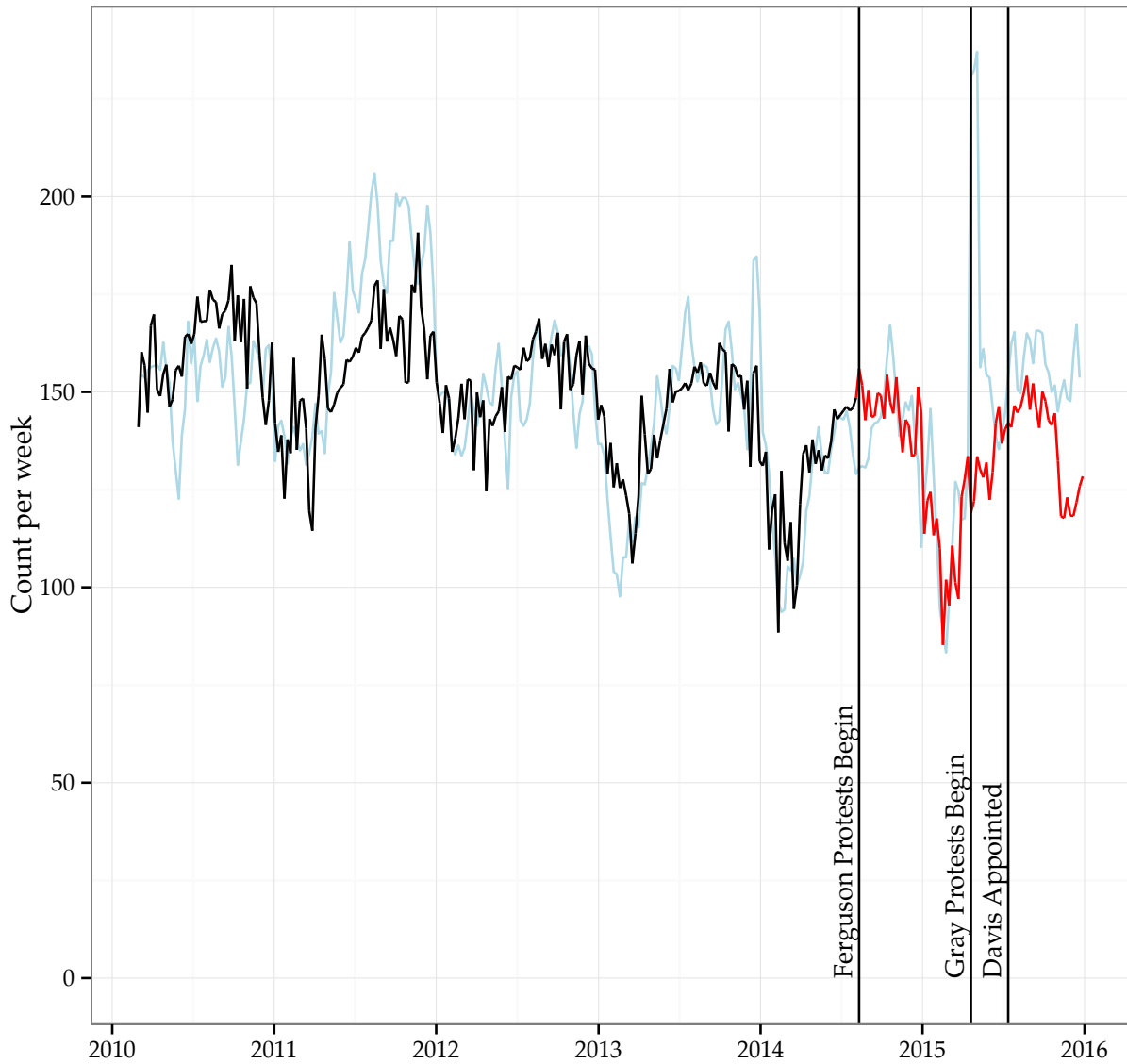


Figure 9. Total Weekly Burglary Count (three-week moving average, blue line) with Predicted Values from the Model Before the Ferguson Protests Began (black line) and Extrapolated Counterfactual Values After the Ferguson Protests Began (red line)

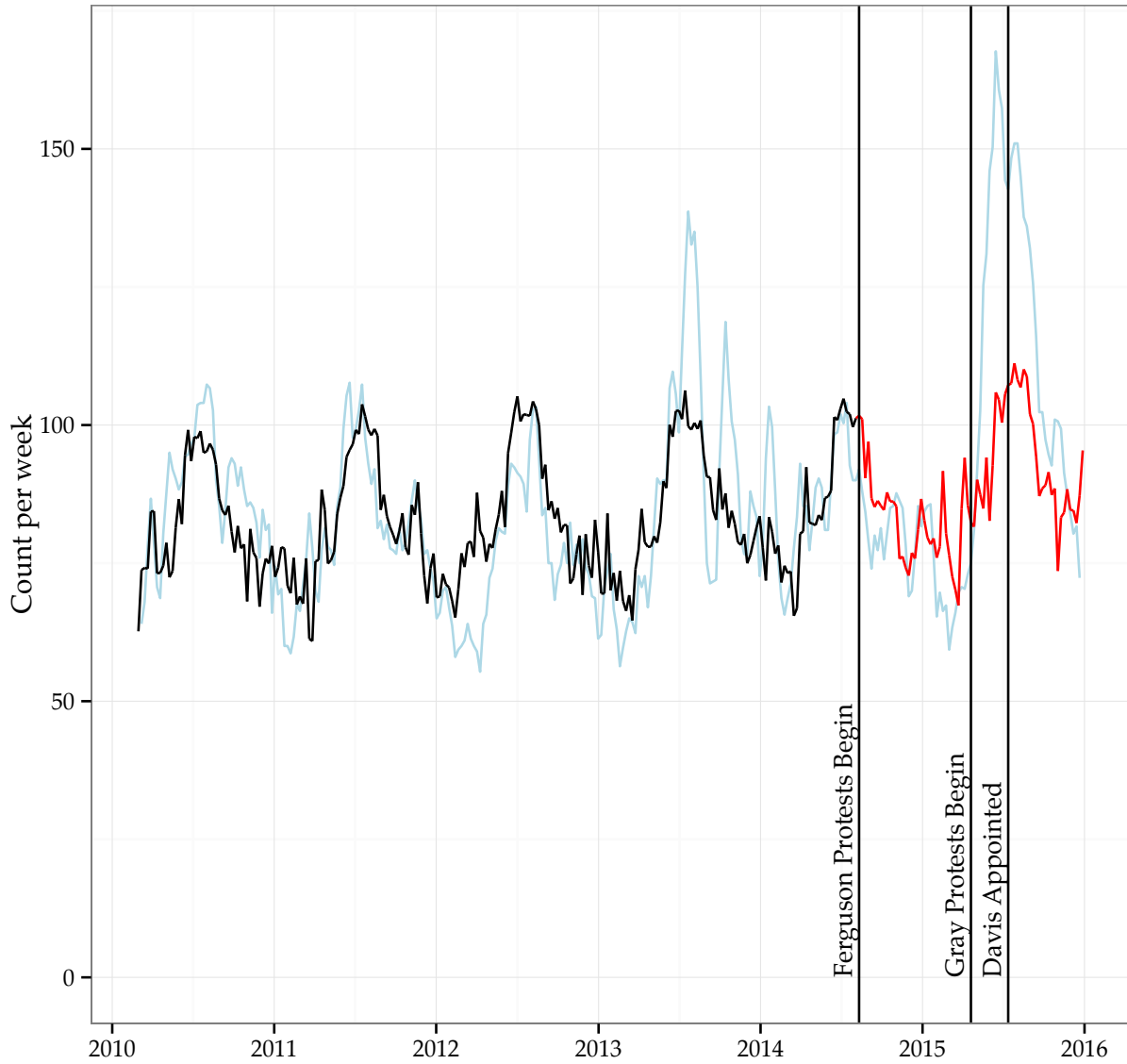


Figure 10. Total Weekly Automobile Theft Count (three-week moving average, blue line) with Predicted Values from the Model Before the Ferguson Protests Began (black line) and Extrapolated Counterfactual Values After the Ferguson Protests Began (red line)

3.3. Additional Findings: Spatial Variation in Shootings and Homicides

Considerable attention has focused on the spike in gun violence in Baltimore from the Gray period onward, which led to a concomitant increase in homicides. We presented the overall increase in both types of crime incident in Table 2 above, but interest has also focused on the spatial variation of these widely reported increases.

Table 4 presents changes in shootings and homicides, using the same models and strategy, but now separately for Baltimore's nine police districts and now with raw effects that convey the underlying scale of the changes (rather than percentage changes, which can swing wildly because of low frequencies when subdivided across districts). Figure 11 presents shootings and homicides by location for the Gray period. The higher density of shootings and homicides in and near the Western and Eastern districts is clear (see Figure 1 for labeling of the districts), although no district was spared from at least some violence.

The raw changes in Table 4 clarify several prominent features of the pattern. Consider shootings first. Across districts, there was little change in shootings during the Ferguson period, with swings of no more than 0.5 incidents per week across all districts. Although one might consider some of the increases (e.g., shootings in the Northwestern and Western districts) to be worthy of note, we favor the interpretation that these changes are quite modest and in line with the range of expected variation in shootings across the full pre-Ferguson time interval.

For the Gray period, shootings increased in all districts, even though some of the small increases may reflect slightly larger than average predicted seasonal variation. Nonetheless, the increases in some districts were dramatic, such as for the Western and Eastern districts, where shootings increased by 3.3 and 3.1 incidents per week, relative to baseline counts of 1.2 and 1.1 shootings per week. Shootings in the Southern district increased a lot as well, by 1.0 incidents per week, relative to a baseline count of 0.7 incidents per week.

For shootings in the Western and Eastern districts, the Gray effect was then effectively mitigated in the Davis period. The Gray increases of 3.3 and 3.1 shootings per week declined by 3.0 and 2.4 shootings per week, leaving a small net increase at the end of the year for the Western district and a more sizable one for the Eastern district. Shootings in the Southern district did not decline during the Davis period, leaving a net increase that was larger than for any other district.

The pattern for homicides is somewhat similar. Homicides increased in the Western and Eastern districts, although with lower raw values than for shootings. In addition, homicides increased just as much in the Southern and Southwestern districts as in the Eastern district. For the Davis effect, the mitigation was substantially smaller, especially for the Western and Eastern districts.

Figures 12 through 15 present the findings in granular form for the Western and Eastern districts, with three-week moving averages in shootings and homicides plotted against the counterfactual expected trajectories.

Table 4. Baseline and Raw Change in the Weekly Count of Shootings and Homicides by Police District

	Baseline Count Per Week	Ferguson Effect (raw change)	Gray Effect (raw change)	Unrest Effect (raw change)	Davis Effect (raw change)
Shootings					
Northwestern	0.7	0.5	0.1	3.0	0.6
Northern	0.4	0.1	0.1	-0.4	0.8
Northeastern	0.9	0.0	0.8	1.5	-0.3
Western	1.2	0.4	3.3	-2.7	-3.0
Central	0.5	-0.3	0.9	-0.9	-0.7
Eastern	1.1	0.0	3.1	-4.0	-2.4
Southwestern	1.0	0.2	0.5	0.4	0.3
Southern	0.7	-0.1	1.0	-0.9	0.0
Southeastern	0.5	0.1	0.2	1.3	0.1
Homicide					
Northwestern	0.7	-0.1	0.4	1.8	-0.3
Northern	0.4	0.0	0.1	-0.2	0.1
Northeastern	0.5	0.5	0.3	-1.1	-0.3
Western	0.6	-0.2	1.0	0.5	-0.1
Central	0.3	-0.1	0.0	-0.5	0.2
Eastern	0.6	-0.1	0.7	-1.3	0.0
Southwestern	0.6	0.0	0.8	-0.2	-0.6
Southern	0.4	-0.1	0.6	1.2	-0.2
Southeastern	0.3	-0.1	0.1	0.8	0.0

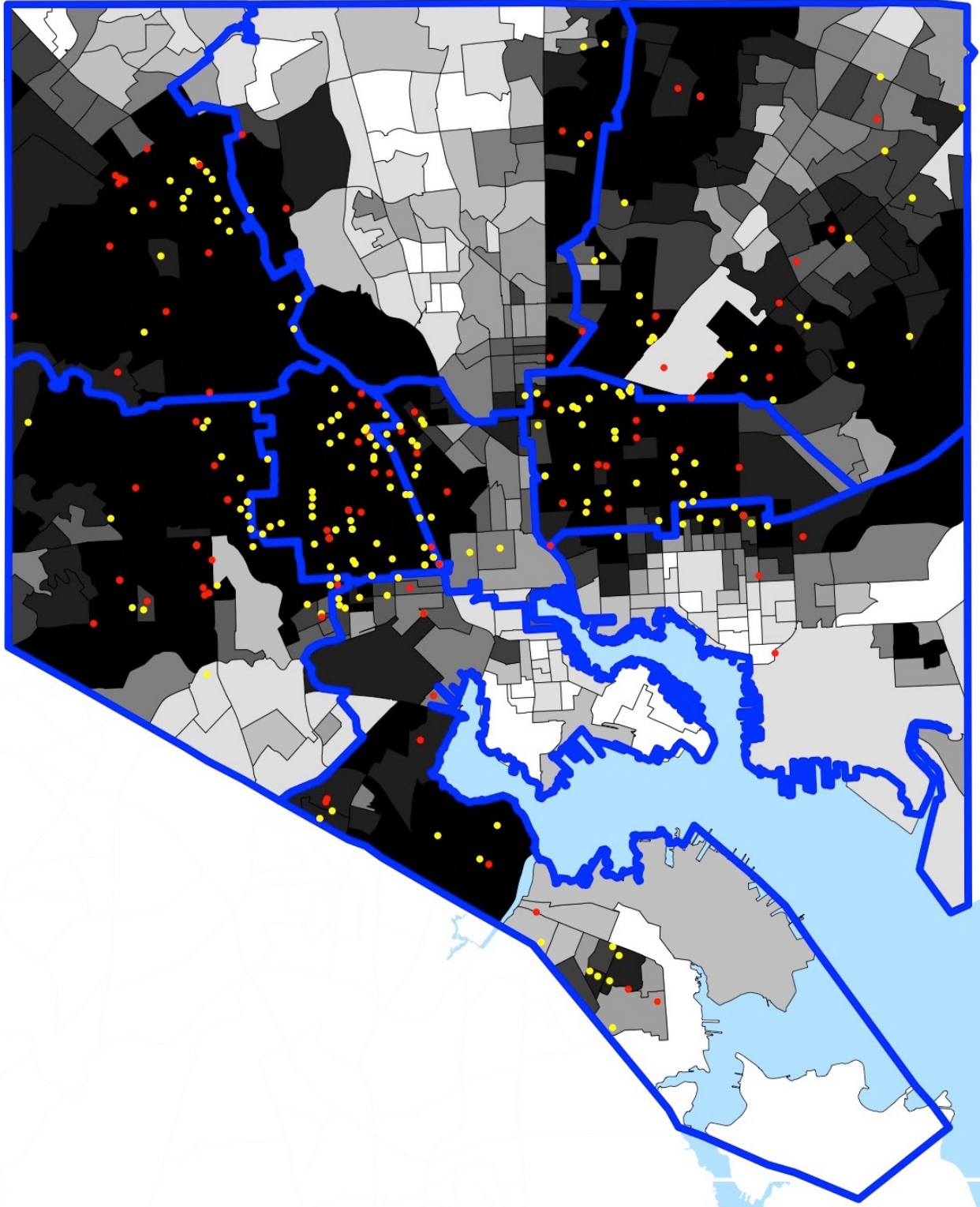


Figure 11. Locations of Shootings (yellow dots) and Homicides (red dots) During the Gray Period, with Census Block Groups Shaded by Percent of the Population Estimated to be Non-White.

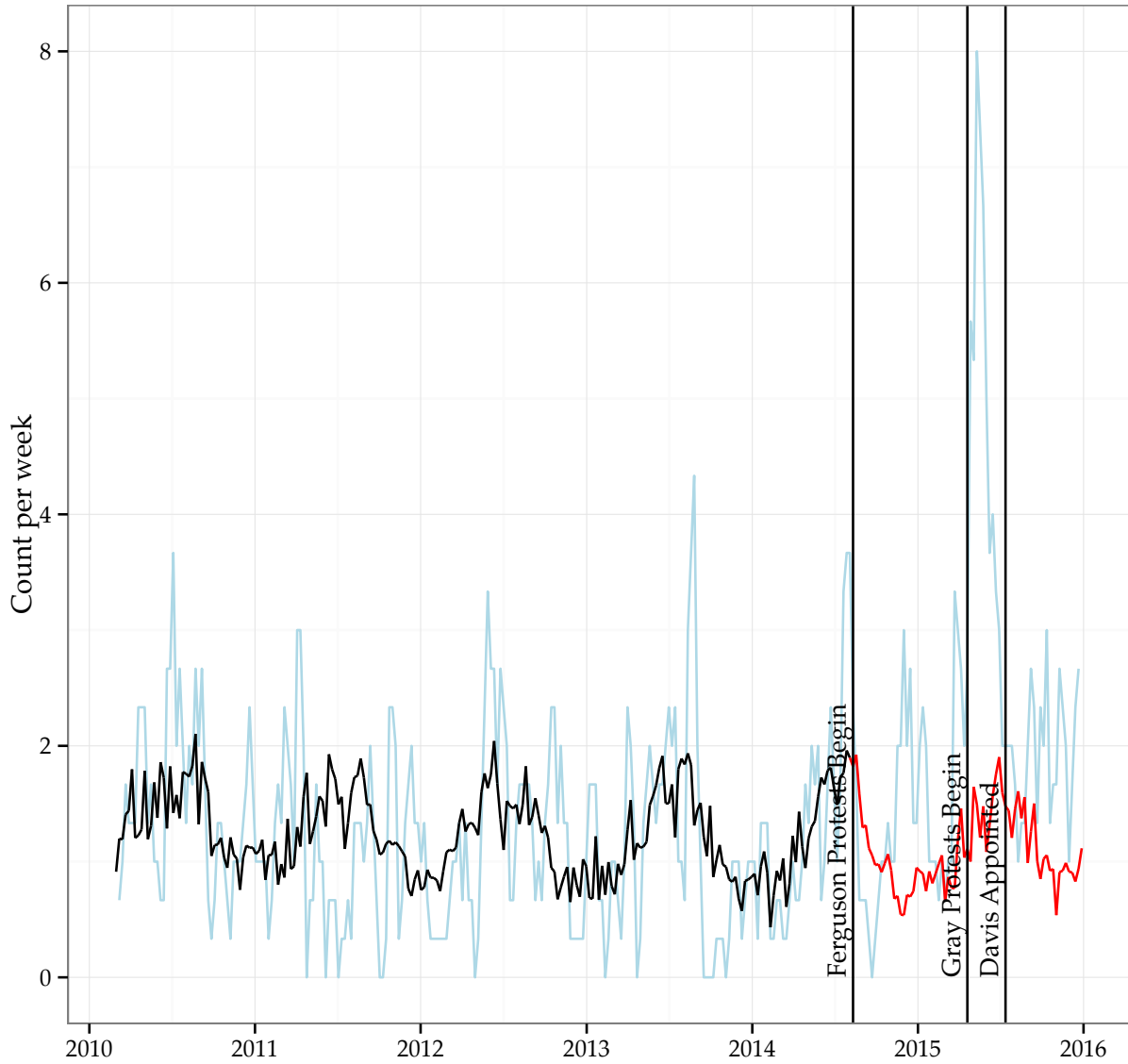


Figure 12. Total Weekly Shootings in the Western District (three-week moving average, blue line) with Predicted Values from the Model Before the Ferguson Protests Began (black line) and Extrapolated Counterfactual Values After the Ferguson Protests Began (red line)

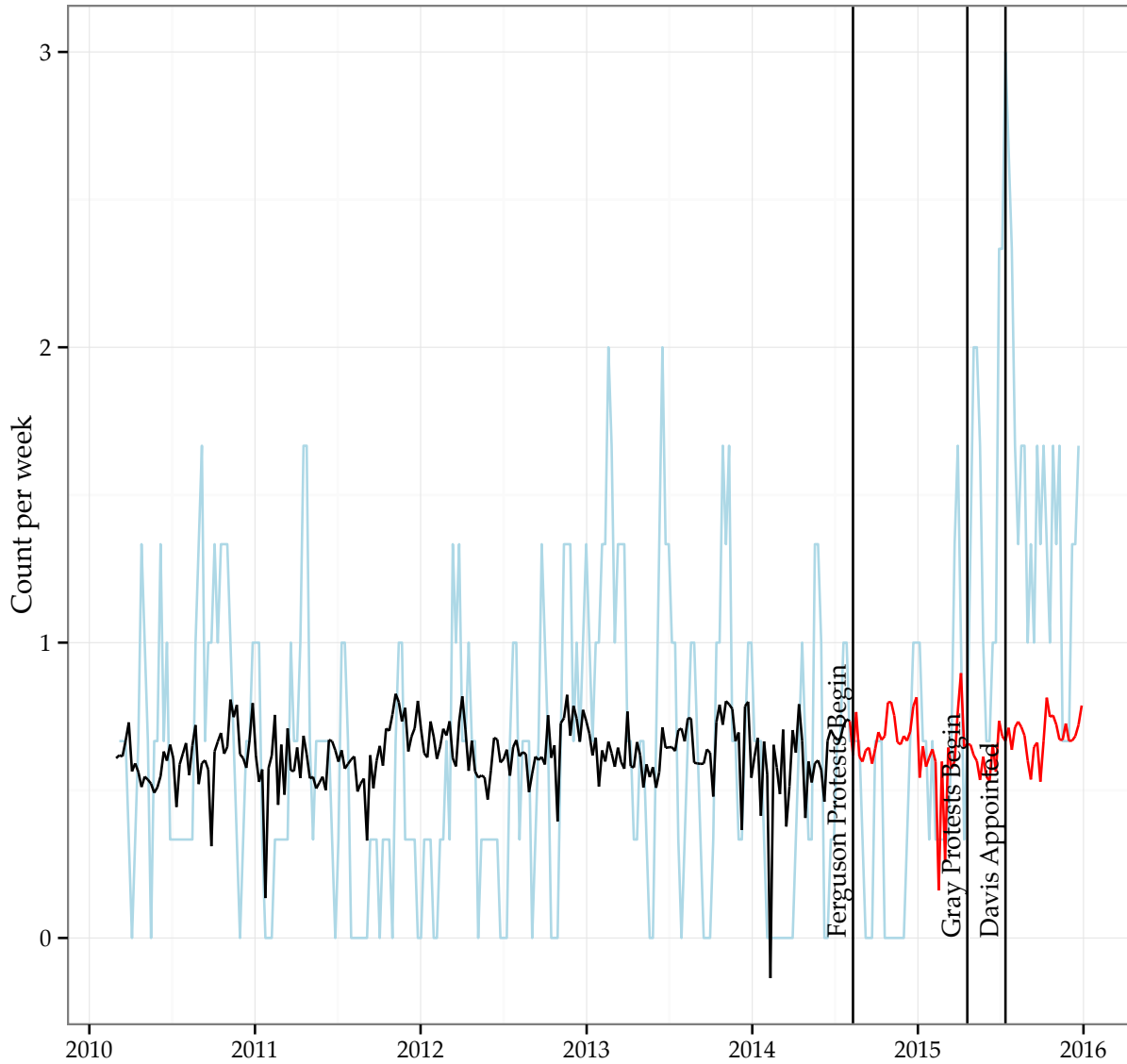


Figure 13. Total Weekly Homicides in the Western District (three-week moving average, blue line) with Predicted Values from the Model Before the Ferguson Protests Began (black line) and Extrapolated Counterfactual Values After the Ferguson Protests Began (red line)

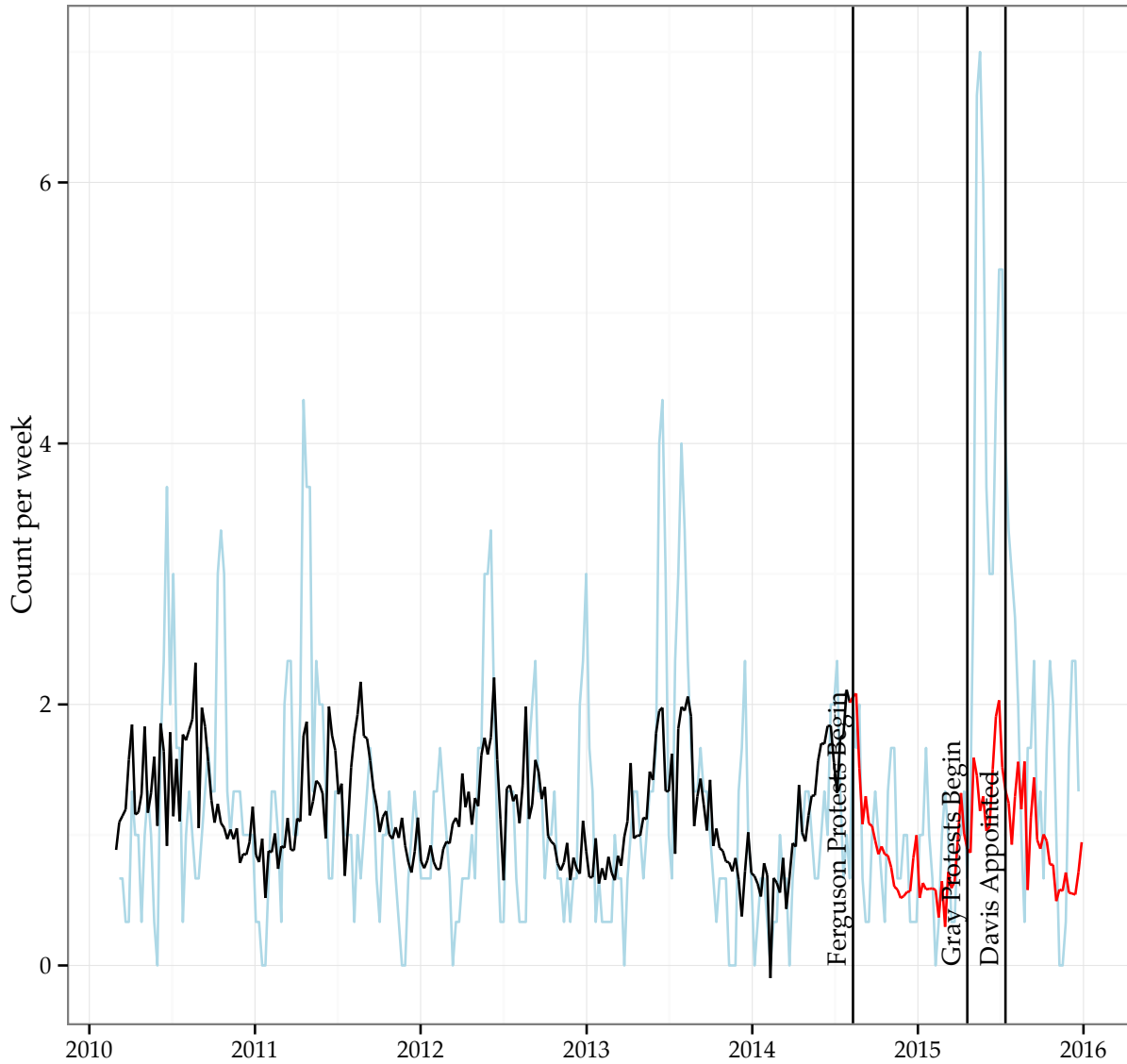


Figure 14. Total Weekly Shootings in the Eastern District (three-week moving average, blue line) with Predicted Values from the Model Before the Ferguson Protests Began (black line) and Extrapolated Counterfactual Values After the Ferguson Protests Began (red line)

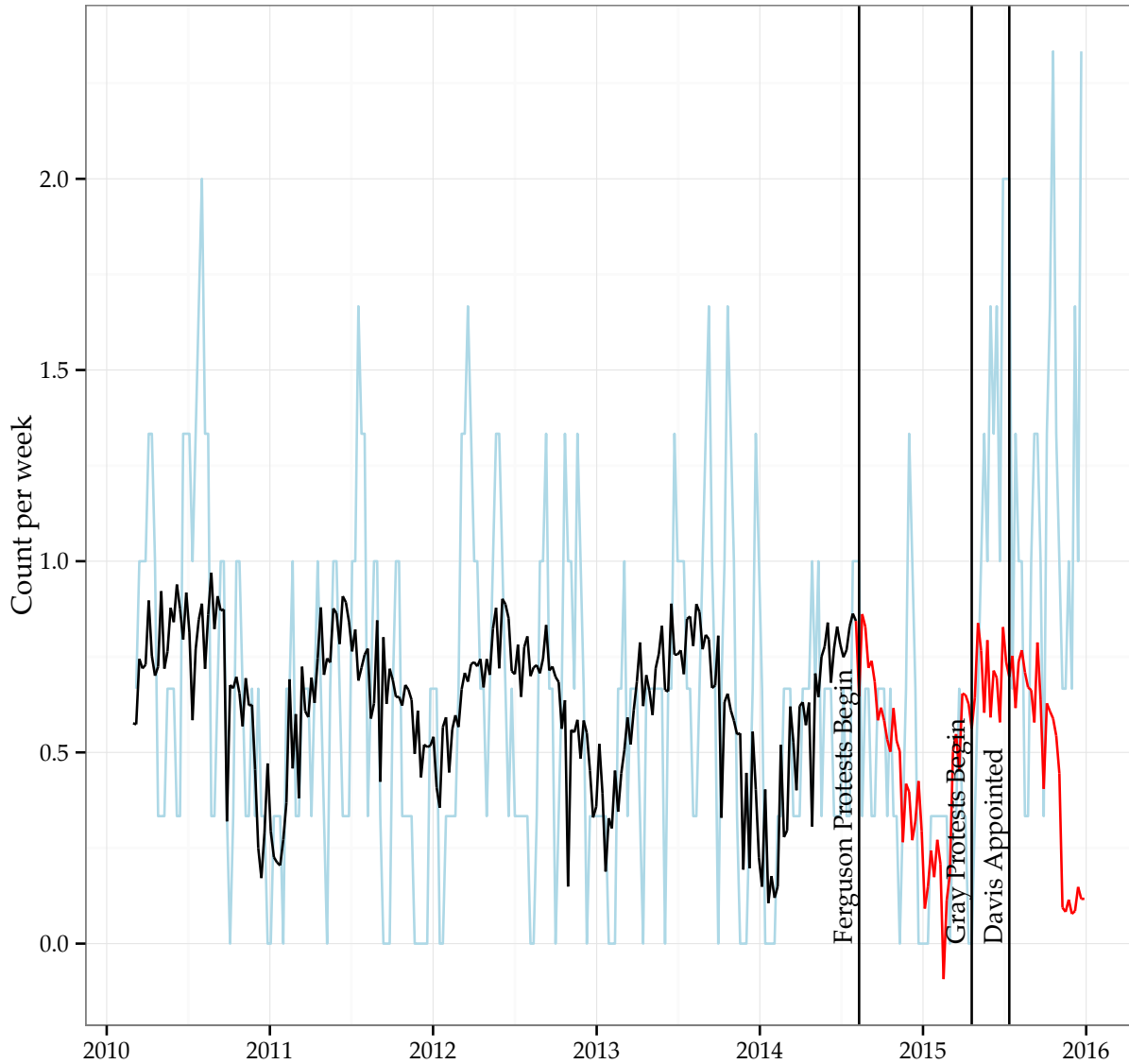


Figure 15. Total Weekly Homicides in the Eastern District (three-week moving average, blue line) with Predicted Values from the Model Before the Ferguson Protests Began (black line) and Extrapolated Counterfactual Values After the Ferguson Protests Began (red line)

3.4. Conclusions for Crime Incidents

Our period analysis of crime suggests three primary conclusions:

1. Adjusting for seasonality, evidence of a Ferguson effect on crime is very weak in the period before Freddie Gray was arrested.
2. The heavily reported spike in shootings and homicides that emerged in the three months following the arrest of Freddie Gray occurred alongside large increases in other types of crime. These increases receded only partially during the remainder of 2015 after the appointment of a new police commissioner.
3. It is fundamentally unclear whether the crime spike after April 20, 2015 should be regarded as evidence in support of the narrative of a Ferguson effect.

Although conclusions 1 and 2 are straightforward, conclusion 3 requires elaboration. Recall first that crime incidents evolved as usual over the eight months that followed the protests in Ferguson and that preceded the arrest of Freddie Gray. This is our primary finding number 1 above. Because of this finding of no unexpected change, there is no compelling evidence of a Ferguson effect for many months when there could have been evidence of a Ferguson effect in Baltimore.

After the arrest of Freddie Gray, evaluation of the Ferguson effect is challenging. It is undeniable that the unrest and its aftermath were deeply shaped by the media coverage of Freddie Gray's arrest, including the available cellphone video of it. These influential journalistic treatments drew connections to the ongoing nationwide focus on police conduct. As a result, the Gray effect is fundamentally entangled with the Ferguson effect narrative, and it is not surprising therefore that the debate on the Ferguson effect picked up momentum shortly after the unrest in Baltimore.

One reasonable interpretation of these entangled effects is that the crime spike in the Gray period could be a Ferguson effect that would have remained dormant had it not been ignited by a localized Gray effect. However, the size and duration of the crime spike is almost certainly attributable to particular features of the unrest, possibly including an increase in gang-related conflict over drug distribution as well as a police pullback in protest of the city's leadership. These accelerants have little or no connection to the core narrative of the conjectured Ferguson effect, and as a result at least some portion of the crime spike is probably a genuine Gray effect that cannot be attributed to the Ferguson effect narrative championed by some commentators. We will elaborate on this interpretation below, after our full analysis of arrest patterns in the next section.

4. Results for Arrests

Parallel to our analysis of crime incidents, our analysis strategy in this section is to first estimate a model of the cyclical arrest trend through Sunday August 10, 2014 and then use this estimated model to predict a counterfactual arrest trend, as if the protest events and any changes in police practice after August 10, 2014 had not occurred. We then estimate analogous effects of interest as layered average differences between observed and counterfactual values from August 11, 2014 onward.

Publicly available data on arrests are more challenging to model and cover a shorter period of time than the data we have analyzed for crime incidents. As noted above, considerable effort was required to categorize arrests into a manageable number of types. Our procedures for doing so are summarized in Appendix 1.

One limitation that is not solvable, using the data that are available on Open Baltimore as of now, is the shorter time interval for the pre-Ferguson time period. Unlike crime incidents, we do not have data from 2010, 2011, or 2012 in order to help estimate as reliable of a seasonal model and overall trajectory to de-trend the post-Ferguson data. And, as a result, we must offer a caveat before presenting our results.

Caveat: Less Confidence in the Analysis of Arrests

Because we have fewer pre-Ferguson data points for weekly arrest counts, we have less confidence in the underlying counterfactual models for trends in arrests.

Nonetheless, many of the patterns allows us to offer strong conclusions, even with a shorter time span of data, because of the magnitude of the changes. When we encounter models for counterfactual trends that cause us to lower our confidence, we will indicate in the text and adjust our conclusions accordingly. Altogether, we think the arrest data offer overall conclusions that are as strong as those for crime incidents, but this is a matter of judgment.

4.1. Primary Findings

Our main results are presented in Table 5. After summarizing these findings for our analysis of arrests, we will explain in the next subsection how the percentage changes in the cells of Table 5 were calculated. For now, we interpret only the numbers in Table 5 that are printed in black typeface, leaving those in gray for a qualified discussion in the next subsection. (Curious readers are welcome to read the results in gray typeface as this section unfolds and verify that, even if were to regard them with as much confidence as those that we do discuss in this section, the overall shape of our primary conclusions would not change much.)

Baseline Counts. The first column of Table 5 presents baseline counts of arrests per week. These values are the average of predicted weekly counts for the year prior to the beginning of the Ferguson period, separately for each type of arrest, and with the total presented in the last row of the table. These baseline counts demonstrate the wide variation in weekly arrest counts, which span a range from low frequency arrests such as arson (at 1.3 arrests per week) to high frequency arrests such as common assault (89.6 arrests per week). The last row of the table offers the total baseline arrest count of 800.1 arrests per week.

The Ferguson Period and Arrests. Unlike the pattern of recorded crime incidents, the pattern of change in arrests coincides with a Ferguson effect on police conduct during the post-Ferguson, pre-Gray period from August 11, 2014 through April 19, 2015. Arrests decreased substantially for many areas of less serious crimes, and these declines occurred during a period characterized by typical fluctuation in recorded crime incidents, as documented in our prior analysis of crime incidents.

The total arrest count, which is not subject to under-reporting, fell by 19% between August 11, 2014 through April 19, 2015 in comparison to the prior 52-week period, and after adjustments for seasonality. In particular, the average weekly total of 800 arrests declined by 152 arrests per week.

Although the charges associated with each arrest are very difficult to categorize, the declines are most substantial for categories of less serious crime, such as property destruction (down 34%), driving violations (down 33%), and disorderly conduct (down 34%). Many categories of arrest for violent crimes, such as murder (including attempted murder) and robbery did not decrease over the same time period, suggesting that the declines in arrests were in areas where police have discretionary alternatives to arrest. It is likely, but very far from verified, that these changes reflect evolving police practice, and that these practices evolved in response to the Ferguson protests and other attention to police conduct, as we discuss below.

To clarify some of these categories of arrests that we have labeled as more discretionary than others, consider the charge descriptions embedded in two of the broad categories summarized in Table 5. Disorderly conduct includes among its most common charges “Failure to comply” and “Obstructing and hindering,” as well as the general “Disorderly conduct.” Driving violations includes among its most frequent charges, “Driving with a suspended license” and “Driving without a license.”

Table 5. Baseline and Percentage Change in the Weekly Count of Arrests

	Baseline Count Per Week	Ferguson Effect (percent change)	Gray Effect (percent change)	Unrest Effect (percent change)	Davis Effect (percent change)
Murder (and attempted)	6.0	2.5	-29.9	-45.1	42.6
Robbery	15.7	4.8	-4.6	-50.7	5.8
Aggravated assault	23.7	23.7	-9.6	-35.7	41.0
Burglary	23.2	-12.4	-37.3	355.4	28.1
Larceny	42.7	-11.4	-39.0	17.9	18.5
Arson	1.3	-26.1	-10.9	37.6	40.2
Common assault	89.6	-12.6	-0.2	-40.8	5.3
Drug distribution	64.6	20.4	-30.4	-29.9	57.3
Deadly weapon	16.0	-12.2	-10.9	-17.7	39.3
Non-deadly weapon	1.9	-85.2	-72.4	-37.6	28.3
Property destruction	7.1	-33.5	2.5	50.1	5.3
Police non-compliance	12.2	-15.7	-57.5	-4.1	25.0
Court non-compliance	129.3	-43.9	-49.7	-28.2	-4.6
Drug possession	219.9	-21.5	-28.1	-18.6	33.5
Driving violation	15.2	-33.0	-44.2	-34.5	24.5
Prostitution	12.2	-33.2	-39.9	-29.9	-1.6
Trespassing	11.1	12.9	-71.6	-39.6	40.6
Forgery, fraud, and extortion	4.8	-21.6	-44.6	-43.9	11.8
Domestic	6.6	-6.9	-3.9	-50.5	24
Sex offense (and rape)	4.2	-18.2	-35.2	-33.5	43.6
Disorderly conduct	21.4	-33.5	-49.3	820.8	23.3
Loitering, vagabond	2.0	-2.8	-21.9	-41.4	9.4
Only temporarily detained	8.7	-2.7	-33.1	-39.3	21.0
Unknown	53.4	-38.4	-29.4	177.9	-14.7
Ungrouped	7.4	-41.1	-44.1	-3.8	10.6
Total	800.1	-19.1	-30.3	22.9	20.0

Notes: Among the categories of arrests, those percentage changes that are shaded gray are more difficult to interpret because of pre-Ferguson trajectories, estimated based only on 18 months of data. Court non-compliance has a strong upward pre-Ferguson trajectory while drug distribution and drug possession have strong downward trajectories. Non-deadly weapon, ungrouped, and unknown have slight upward trajectories. Aggravated assault, trespassing, and loitering-vagabond have slight downward trajectories. Appendix 3 presents a full set of results that demonstrates these trajectories.

The Gray Period, Unrest Period, and Arrests. Arrests declined further from April 20, 2015 through July 12, 2015, even after removing the complex pattern of arrests that emerged during the week of unrest. These declines are consistent with the widely discussed claim that the Baltimore police pulled back from some routine policing activity in response to a perceived lack of support from the city's leadership. These declines are also consistent with other narratives, such as the onset of a period of recovery following the overtime work of the police during the week of unrest, and an accentuation of the Ferguson effect on arrests that may have emerged first during the post-Ferguson, pre-Gray period. This accentuated effect may be attributable to a precipitous decline in cooperation with the community, which made the pursuit of basic police work more difficult than before the unrest.

In particular, the total arrest count declined by an additional 30% between April 20, 2015 and July 12, 2015, excluding the disrupted pattern of arrests during the week of unrest that began on Monday, April 27th, 2015. Among the areas of arrest that declined during the preceding interval and that may reflect a Ferguson effect on police activity, many of these areas of arrest continued to decline. For example, arrests for driving violations and disorderly conduct declined by an additional 44% and 49%, respectively.

Some areas of arrest that did not decline substantially during the pre-Gray, post-Ferguson period contributed to the overall 30% decline in arrests during the Gray period. Arrests for burglary and larceny declined by 37% and 39%, respectively, while arrests for a broad category that we label "police noncompliance" declined by 58%. As part of the narrative of a decline in discretionary police activity, consider the charge descriptions most common in our "police noncompliance" category. They are: "Failure to obey," "False statement to an officer," and "Resisting or interfering with an arrest."

Now, however, we also have declines in arrests for violent crime. Arrests for murder and attempted murder decreased by 30%, and arrests for deadly weapons violations decreased by 18%. These are not discretionary arrests, and instead they are likely to reflect narratives of other types, including declines in community cooperation with police, as well as recovery from overtime and other new obligations following the unrest.

The Davis Period and Arrests. Arrests increased during the remainder of 2015, after the appointment of a new police commissioner. Adjusting for seasonality, the weekly total arrest count increased by 20% between July 13, 2015 and the end of the year, bringing the count back up to 77% of the weekly total arrest count that prevailed in the year before the Ferguson protests.

These arrests surely reflect a natural response to types of crime that increased in the summer of 2015, such as arrests for murder and attempted murder, which increased by 43%, and arrests for deadly weapons violations, which increased by 39%. Arrests in many of the other areas that had declined before Commissioner Davis was appointed also increased.

Arrests for burglary, larceny, and driving violations increased by 28%, 19%, and 25%, respectively. Arrests for our category of “police noncompliance” increased by 25% as well.

4.2. The Models Beneath the Primary Findings for Arrests

Figure 16 presents the total weekly count of arrests from January 1, 2013 through the end of 2015, which is the same outcome analyzed for the last row of Table 5. For Figure 16, the gray dots are the observed weekly totals, plotted according to the week of each year. The three vertical bars in the figure demarcate the beginning of the Ferguson, Gray, and Davis periods.

Partly because of the shorter time span, but perhaps also because of the nature of police investigative activity, seasonal variation in arrests is less clear than for the total crime count, as can be seen from a comparison of Figures 3 and 16. Nonetheless, in the pre-Ferguson period, the arrest count was lowest in the 2013-14 winter and rose back to about the same spring-summer level in 2014 as was the case for the spring-summer of 2013.

Just as for our prior analysis of crime incidents, the jagged black line is a predicted time series from a model that uses the data on weather, hours of darkness, and school days to predict the weekly total arrest count for the pre-Ferguson period. The jagged red line is then an analogous extrapolated cyclical trend, generated by forming predictions from the parameters of the pre-Ferguson model when applied to the observed values for weather, hours of darkness, and school days from August 11, 2014 onward. Furthermore, the differences between the gray dots and the red line, within the three intervals that begin to the right of the three vertical bars, is the source of variation that generates the estimates for percentage change reported in Table 5 for the Ferguson, Gray, Unrest, and Davis periods.

For comparison, and visual clarity, Figure 17 includes a light blue line for the three-week moving average of the observed weekly totals that were represented instead by gray dots for each week in Figure 16. Whether considering Figure 16 or 17, the declines in the total arrest count in the Ferguson and Gray periods, and the bounce-back in the Davis period, are clear.

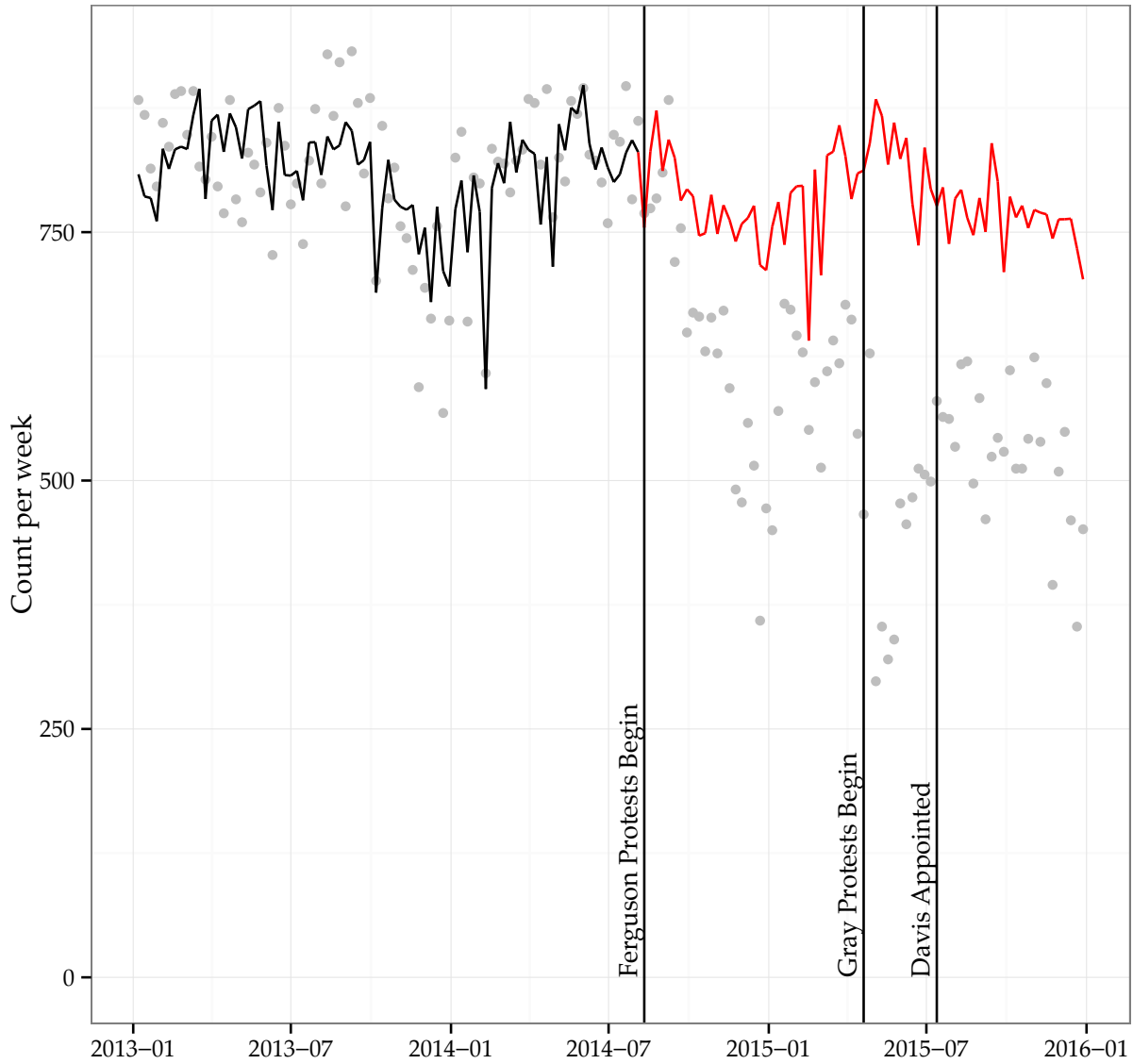


Figure 16. Total Weekly Arrests (gray dots) with Predicted Values from the Model Before the Ferguson Protests Began (black line) and Extrapolated Counterfactual Values After the Ferguson Protests Began (red line)

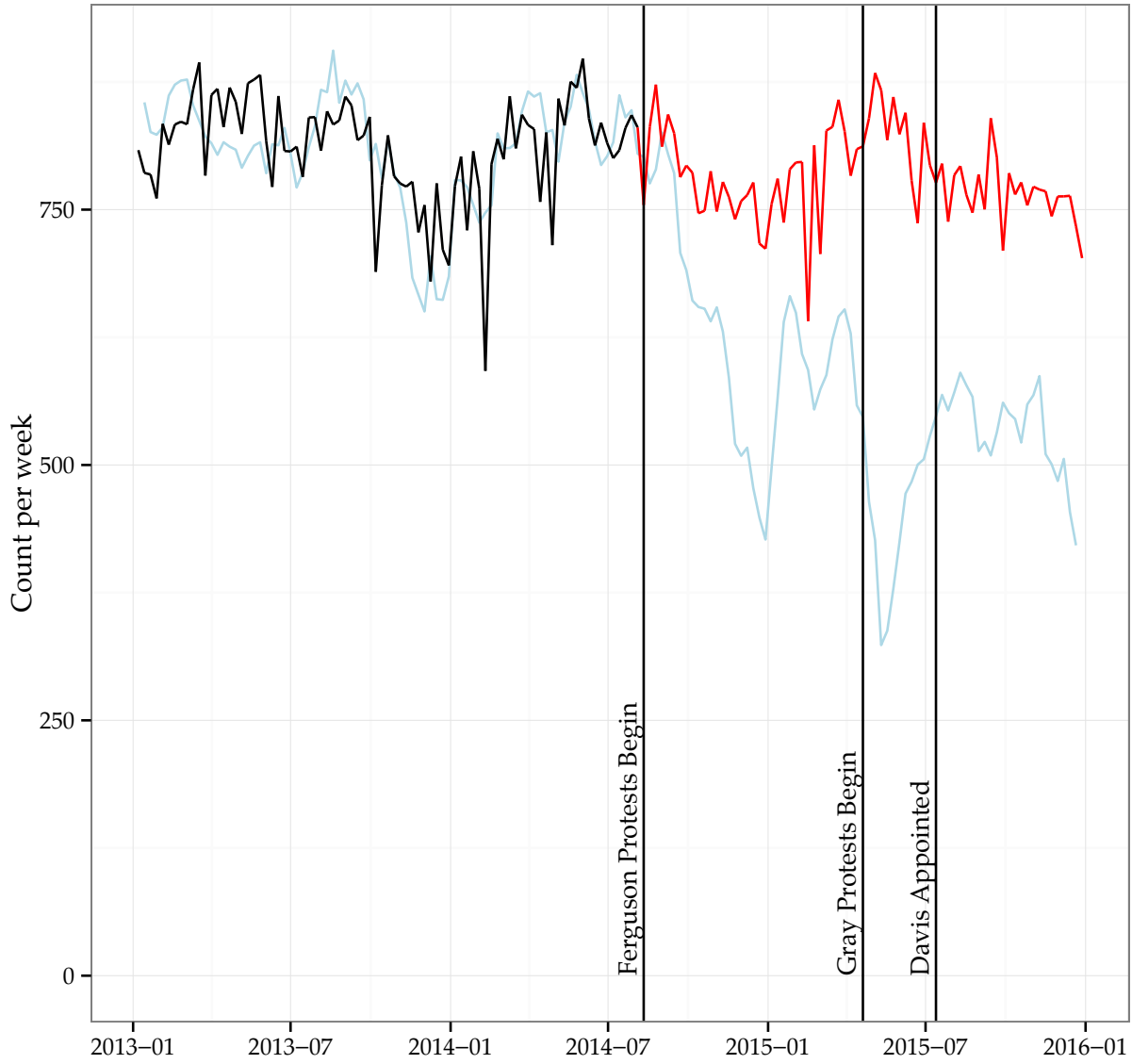


Figure 17. Total Weekly Arrests (three-week moving average, blue line) with Predicted Values from the Model Before the Ferguson Protests Began (black line) and Extrapolated Counterfactual Values After the Ferguson Protests Began (red line)

The models that generate the specific changes in the last row of Table 5 are presented in Table 6. (Appendix 3 reports models of the same structure as those in Table 6 for all of the outcomes in the others rows of Table 5.) The first column of Table 6 presents coefficients for the model that generates the predictions plotted as the jagged black line in Figures 16 and 17. The predictor variables are the same as those specified for the models of crime, and these predictors collectively generate a model that explains 51 percent of the variance of weekly arrest totals in the pre-Ferguson period from January 1, 2013 through August 10, 2014. As with the models for crime, we again caution against attaching too much meaning to any single coefficient, since most of these predictor variables move together in seasonal fashion. Nonetheless, there are some slight differences in comparison to the prior model for the total crime incident count (see Table 3). While snowfall and precipitation are again strongly predictive and in the same direction as for crime, the predictor variables for temperature, darkness before midnight, and school days in the week work together in a different configuration than for crime. Overall, these predictors generate a seasonal trajectory that fits the pre-Ferguson arrest pattern nearly as well as the pre-Ferguson crime pattern.

The coefficients in the second column represent our preferred model, and they provide the values that, when scaled by the baseline count for the outcome, determine the percent change findings reported above in Table 5. The outcome variable for the preferred model is the de-trended arrest count (i.e., the raw arrest count deviated from predicted values based on the model from the first column of Table 6). The first coefficient, -152.49, is the raw decline in arrests during the Ferguson period. Dividing this coefficient by 800.1 yields -.1906, which is the decline of 19.1% for arrests per week in the last row of the second column of Table 5. The other three indicator variables yield raw coefficients that, similarly scaled, fill in the remaining cells in the last row of Table 5.

As with our analysis of crime incidents, we offer one additional model in Table 6, which is reported in the final column. It is an alternative to our preferred model, and it fits coefficients for weather, hours of darkness, and school days simultaneously with coefficients for the four period indicator variables. Our preferred model assumes that the model for the cyclical trend identified in the first column of Table 6 is invariant across the full time series (i.e., even after the Ferguson period commences), and we can cleanly estimate this pre-Ferguson model without contamination from the subsequent period effects of primary interest. The alternative model yields somewhat different values for the period changes, such as a smaller Ferguson effect and a larger Davis effect for the total arrest count. We think the alternative model is allowing the period effects to contaminate the seasonal model, and vice versa. Nonetheless, the basic shape of the results is the same for the total arrest count.

Table 6. Coefficients from Three Models for Total Weekly Recorded Arrests

	3/1/2010 – 8/10/2014 Model	Preferred Model	Alternative Model
Time Counter (in weeks)	-0.24		-0.76
After Ferguson Protests Begin (week of 8/11/14 onward)		-152.49	-113.98
After Gray Protests Begin (week of 4/20/15 onward)		-242.37	-251.98
Unrest and National Guard (during week of 4/27/15)		183.46	196.15
After Commissioner Davis Hired (week of 7/13/15 onward)		159.89	183.32
Average Maximum Temperature to 50 Degrees	-0.35		-1.15
Plus Degrees in the 50s	-3.08		2.86
Plus Degrees in the 60s	0.14		-5.79
Plus Degrees in the 70s	8.35		8.96
Plus Degrees Greater Than 80	-11.20		-10.35
Snowfall (inches)	-75.92		-57.68
Precipitation (inches)	-158.94		-104.59
Darkness Before Midnight (hours)	-38.28		-37.28
School Days (proportion of week)	72.05		60.96
Observations (weeks)	83	156	156
Proportion of variance explained (R-squared)	0.51	0.76	0.82

Notes: The outcome variable for the first and third columns is the same – the total weekly recorded arrest count – but the R-squared values cannot be compared across the two columns because the weeks for the model differ. Relatedly, the outcome for the second column is a residualized total weekly arrest count, and as such the R-squared value of 0.76 cannot be meaningfully compared to either 0.51 or 0.82 in the first and third columns, even though the models in the second and third columns are estimated for the same weeks.

Now, we must explain the rows in Table 5 that have percentage changes offered in gray, rather than black, typeface. These are for outcomes that we indicated above have pre-Ferguson trajectories that are substantial, net of seasonal effects. To understand what we mean, consider Figures 18 and 19, which have the same structure as Figure 17, but for models of arrests for drug distribution and drug possession, respectively, rather than the total arrest count. In the pre-Ferguson period, these figures show that there is a strong downward trend in arrests for both drug distribution and drug possession, net of the seasonal downturn in the winter of 2013-14. These downward trajectories differ substantially from the trajectory of the total arrest count in Figure 17, which is very slightly downward during the same time period.

Because the period effect estimates are based on comparisons to the extrapolated red jagged line, the downward trajectory in that line has substantial influence on the period effect estimates. Consider the jagged light blue line in Figure 18, which is the smoothed raw data for arrests for drug distribution. The overall shape of this line, after the beginning of the Ferguson period is mostly flat, with a noticeable drop during the Gray period. However, the red jagged

line continues relentlessly downward. As a result, the period changes reported in the corresponding row of Table 5 reveal increases during the Ferguson and Davis periods of 23.7% and 41.0% as well as a decline in the Gray period of 35.7%. These numbers are not necessarily incorrect, but we regard them with substantial suspicion, in part because the overall trajectory is estimated based on only 83 weeks of pre-Ferguson data. With access to more pre-Ferguson data that suggested only a slight downward trajectory, the models would deliver smaller Ferguson and Davis increases and a larger Gray decrease. The situation for drug possession is similar. More data would probably suggest an alternative downward trajectory, increasing the declines estimated for the Ferguson and Gray periods and moderating the increase estimated for the Davis period.

We now return to our caveat above, which is that we have less confidence in our period change estimates for arrests than for crime because of the comparative scarcity of pre-Ferguson data for arrests. We have therefore adopted a cautious reporting strategy, which is to focus our main conclusions based on types of arrests that have only weak pre-Ferguson trajectories. These percentage changes are reported in black typeface in Table 5, and we offer representative figures for them below.

The next two figures below present time series graphs for murder and attempted murder (Figure 20) and robbery (Figure 21). These figures demonstrate that non-discretionary arrests for the most violent crime do not follow the Ferguson effect conjecture. The following six figures – for burglary (Figure 22), larceny (Figure 23), police non-compliance (Figure 24), driving violations (Figure 25), prostitution (Figure 26), and disorderly conduct (Figure 27) – instead demonstrate declines in both the Ferguson and Gray periods, which are consistent with the Ferguson effect narrative.

Our position is that the period effects reflected in Figures 20 through 27, and detailed precisely in Table 5, are not strongly shaped by pre-Ferguson trajectories. The pre-Ferguson trajectory (the jagged black line) is mostly flat in all of these figures. However, a careful reader will understand that this does not guarantee that the period effect estimates for these eight outcomes are necessarily closer to the true period changes. It is possible that one or more of these types of arrests have misleadingly flat pre-Ferguson trajectories. If so, the corresponding period effect estimates are insufficiently shaped by the overall slope of the counterfactual extrapolation represented by the red jagged line.

Overall, however, we see a good deal of consistency across the estimates, most of which line up with the pattern for the total arrest count: cumulating declines in the Ferguson and Gray periods, entangled as they are, and then increases in the Davis period. The exception is for violent crimes -- murder, robbery, and aggravated assault – which do not have negative Ferguson effects before the arrest of Freddie Gray, and these are the exceptions that support the overall interpretation. Arrests for violent crimes such as these are not discretionary.

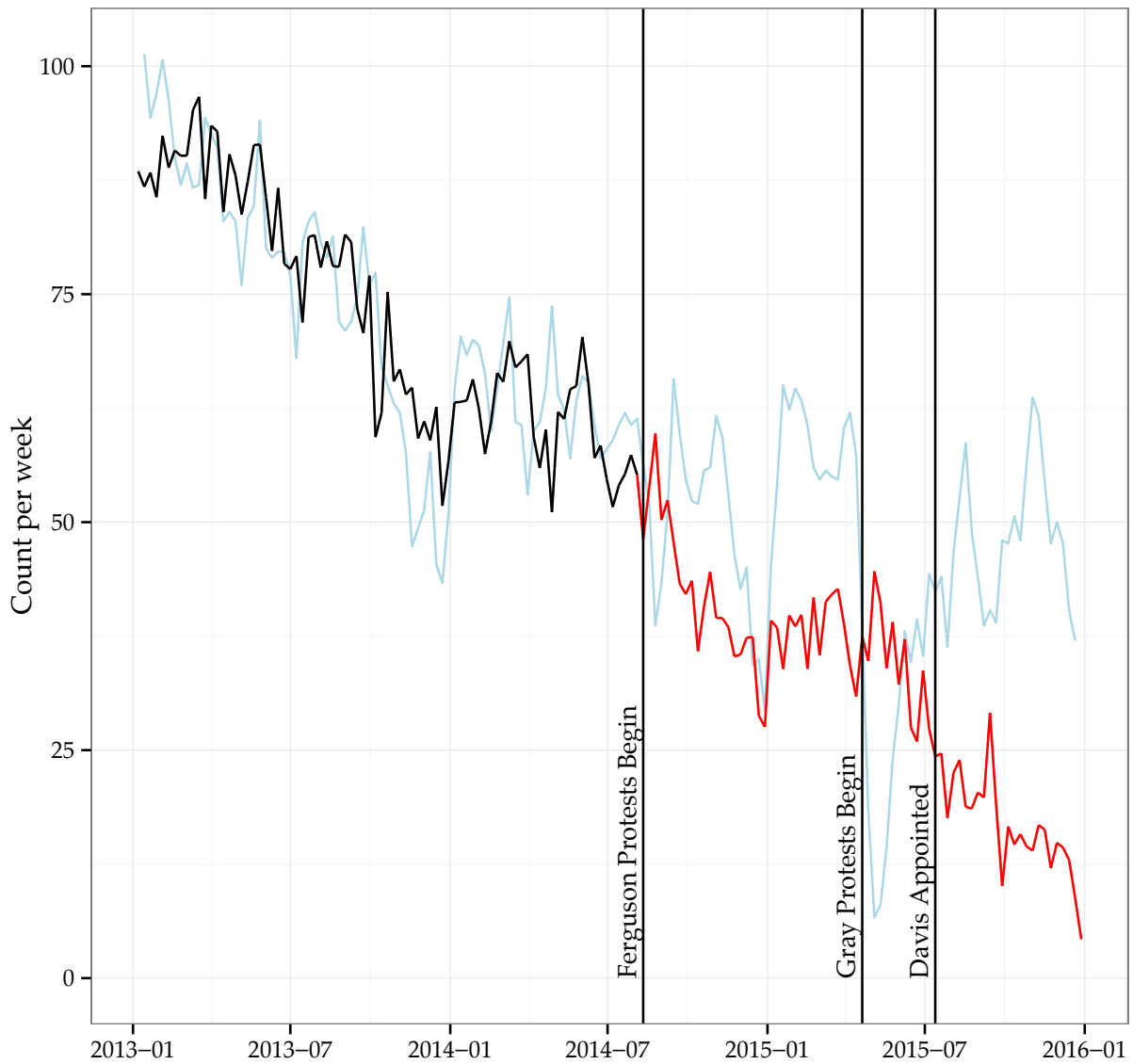


Figure 18. Total Weekly Arrests for Drug Distribution (three-week moving average, blue line) with Predicted Values from the Model Before the Ferguson Protests Began (black line) and Extrapolated Counterfactual Values After the Ferguson Protests Began (red line)

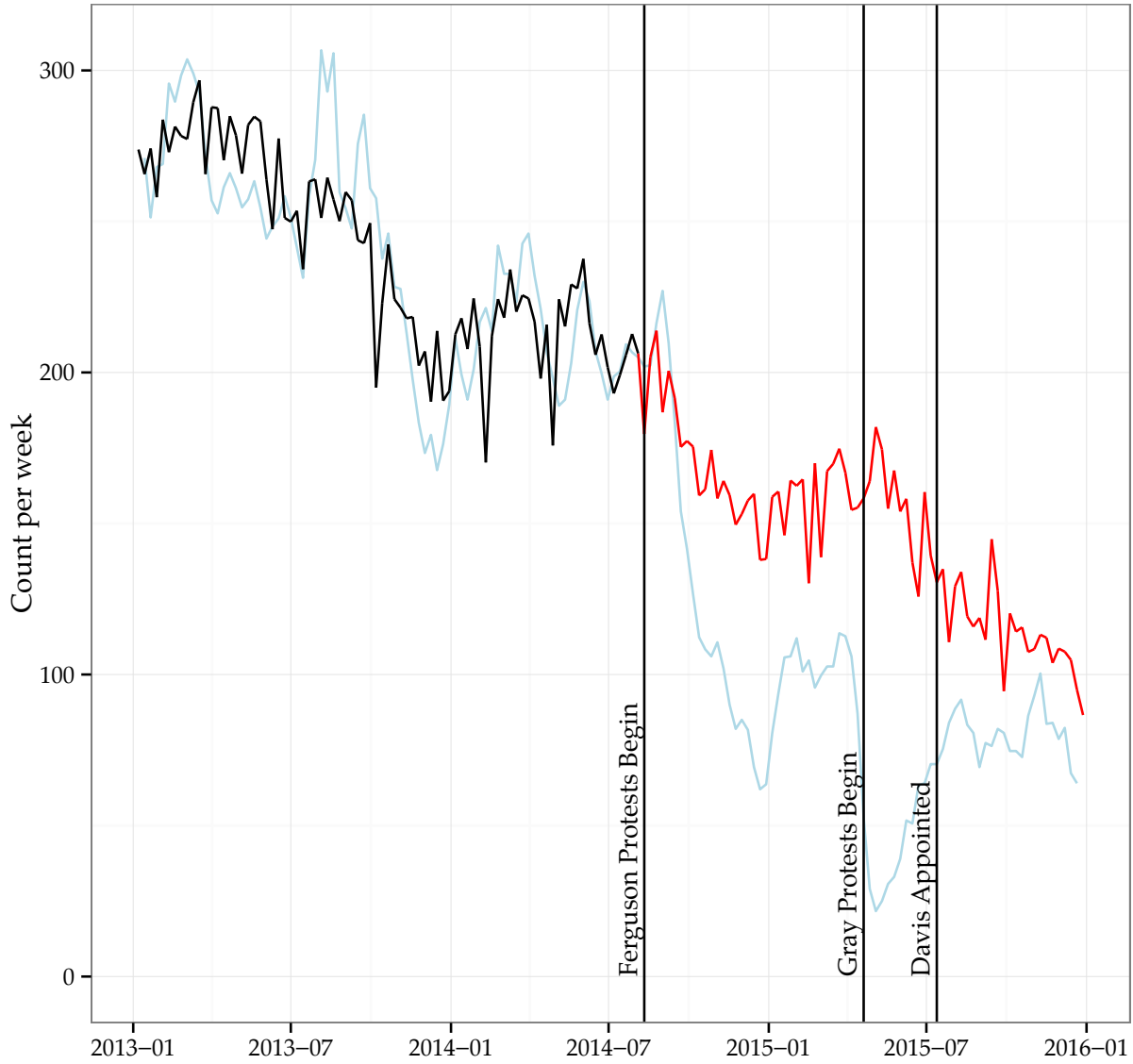


Figure 19. Total Weekly Arrests for Drug Possession (three-week moving average, blue line) with Predicted Values from the Model Before the Ferguson Protests Began (black line) and Extrapolated Counterfactual Values After the Ferguson Protests Began (red line)

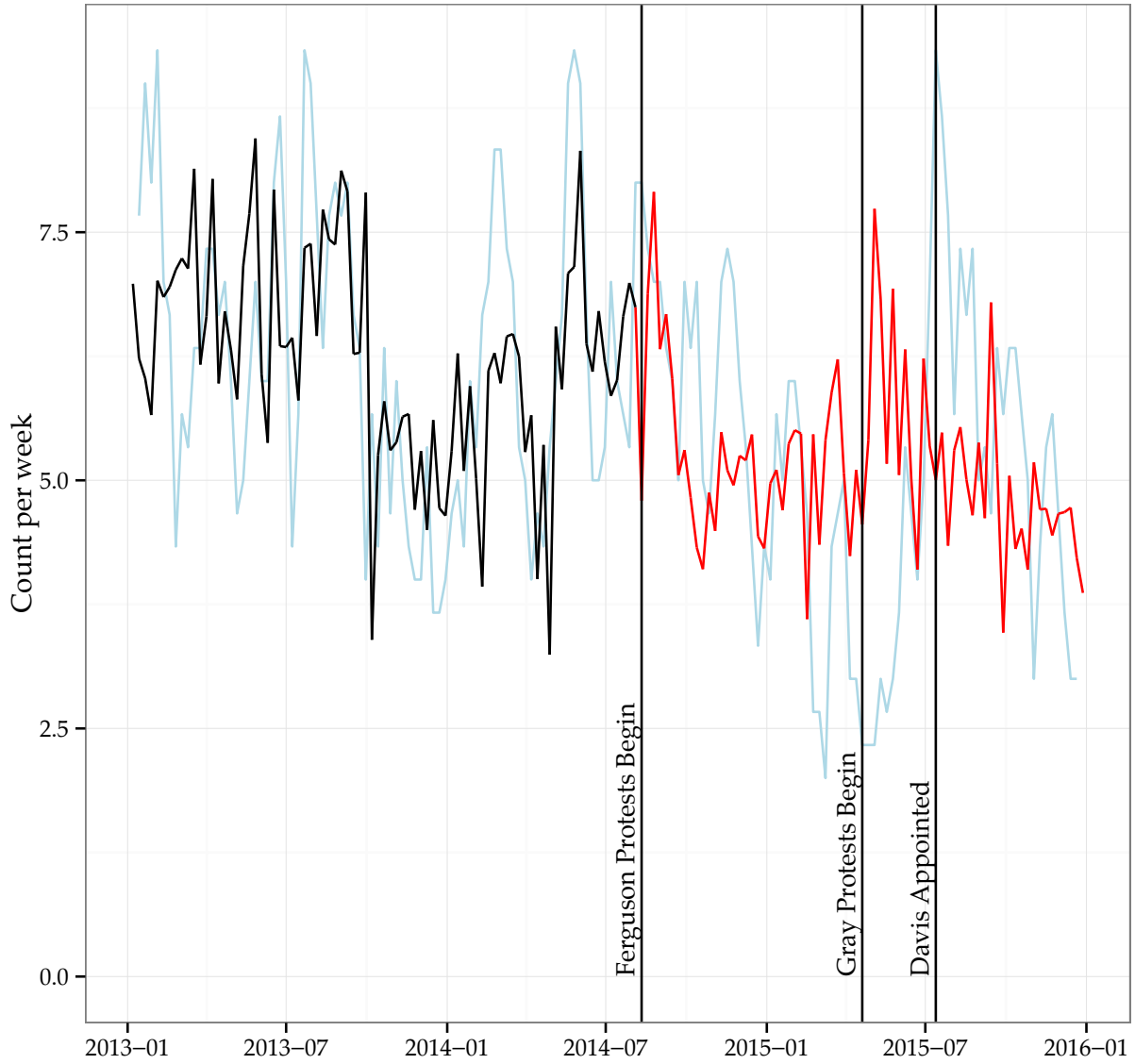


Figure 20. Total Weekly Arrests for Murder or Attempted Murder (three-week moving average, blue line) with Predicted Values from the Model Before the Ferguson Protests Began (black line) and Extrapolated Counterfactual Values After the Ferguson Protests Began (red line)

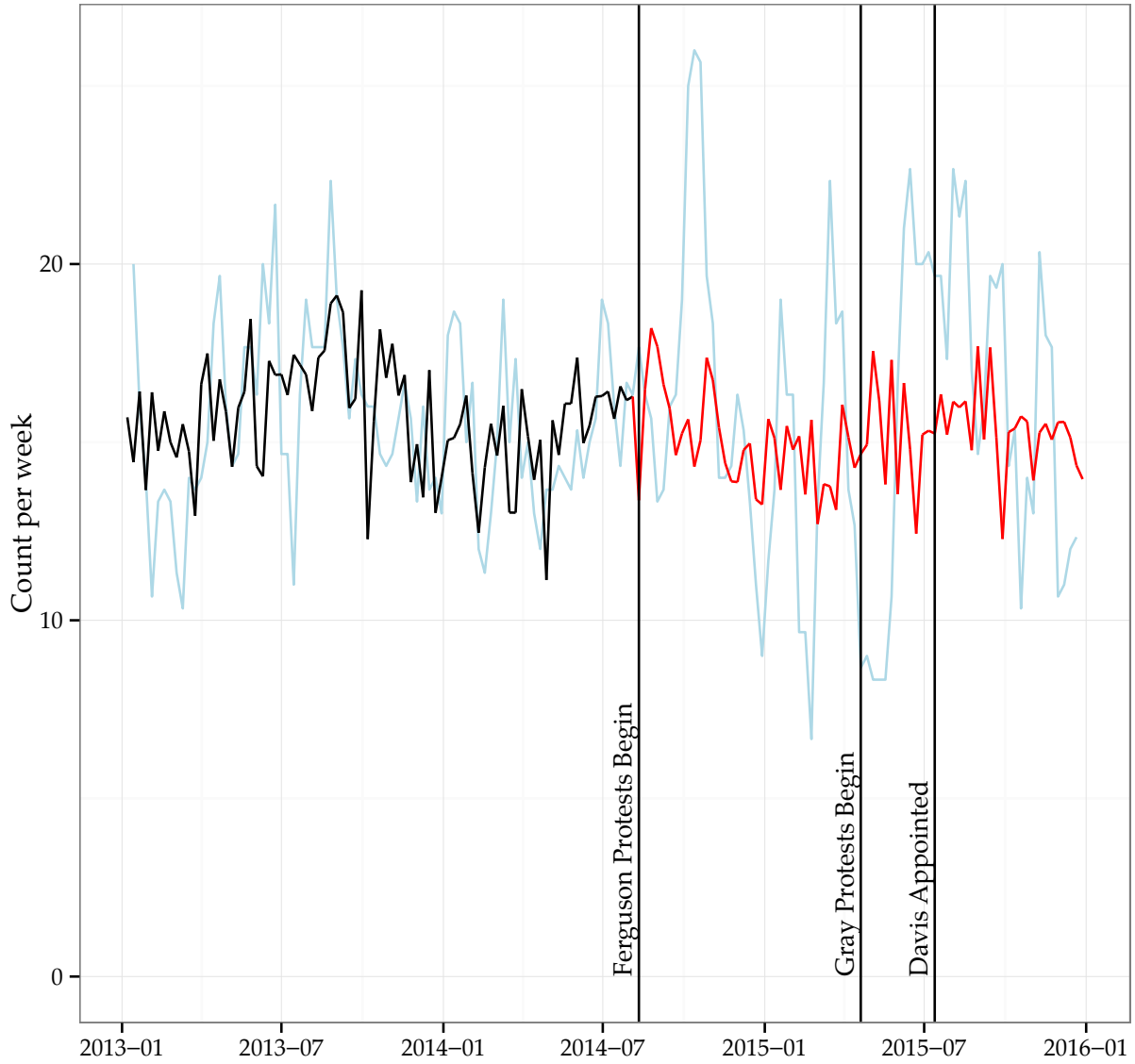


Figure 21. Total Weekly Arrests for Robbery (three-week moving average, blue line) with Predicted Values from the Model Before the Ferguson Protests Began (black line) and Extrapolated Counterfactual Values After the Ferguson Protests Began (red line)

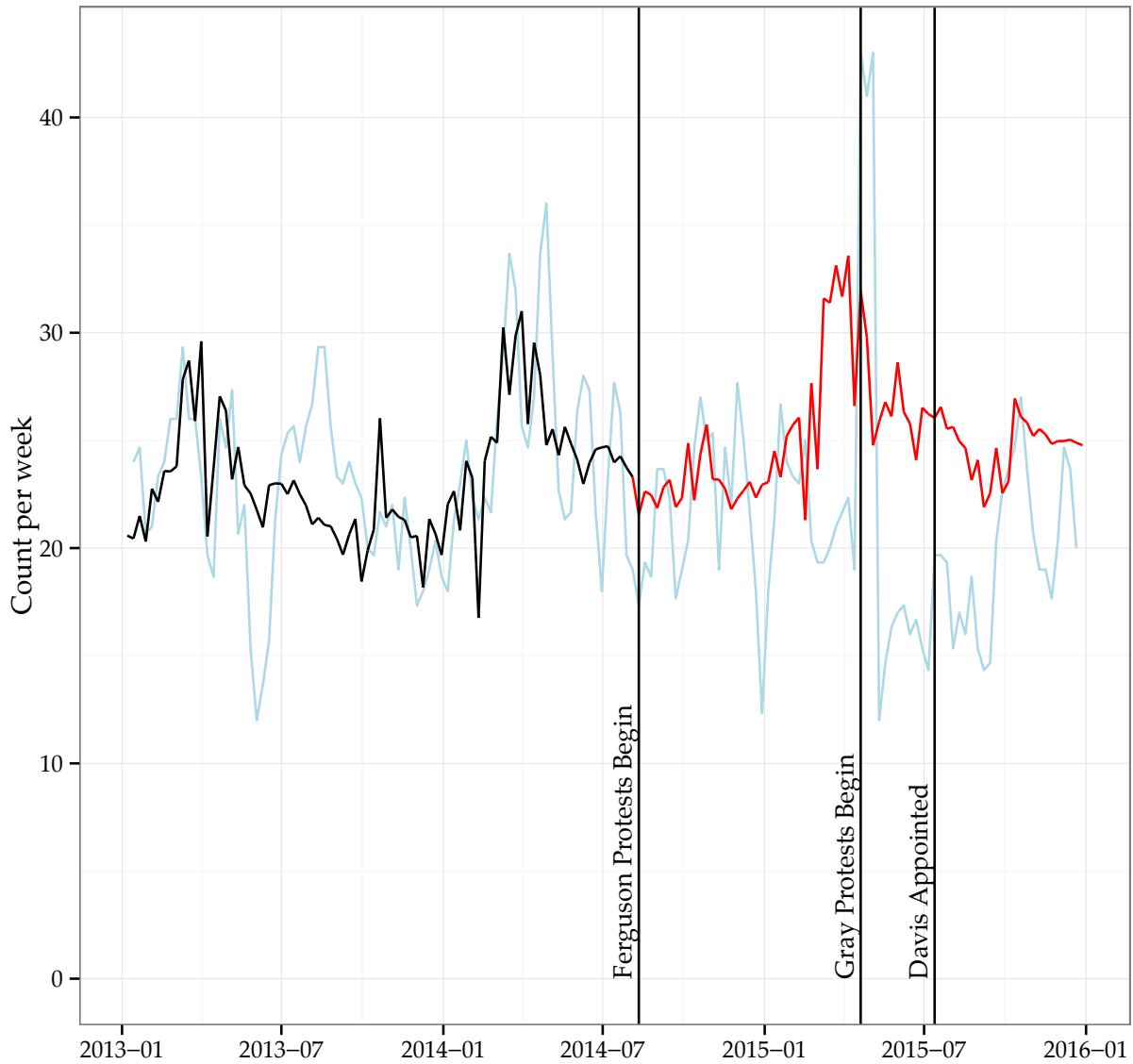


Figure 22. Total Weekly Arrests for Burglary (three-week moving average, blue line) with Predicted Values from the Model Before the Ferguson Protests Began (black line) and Extrapolated Counterfactual Values After the Ferguson Protests Began (red line)

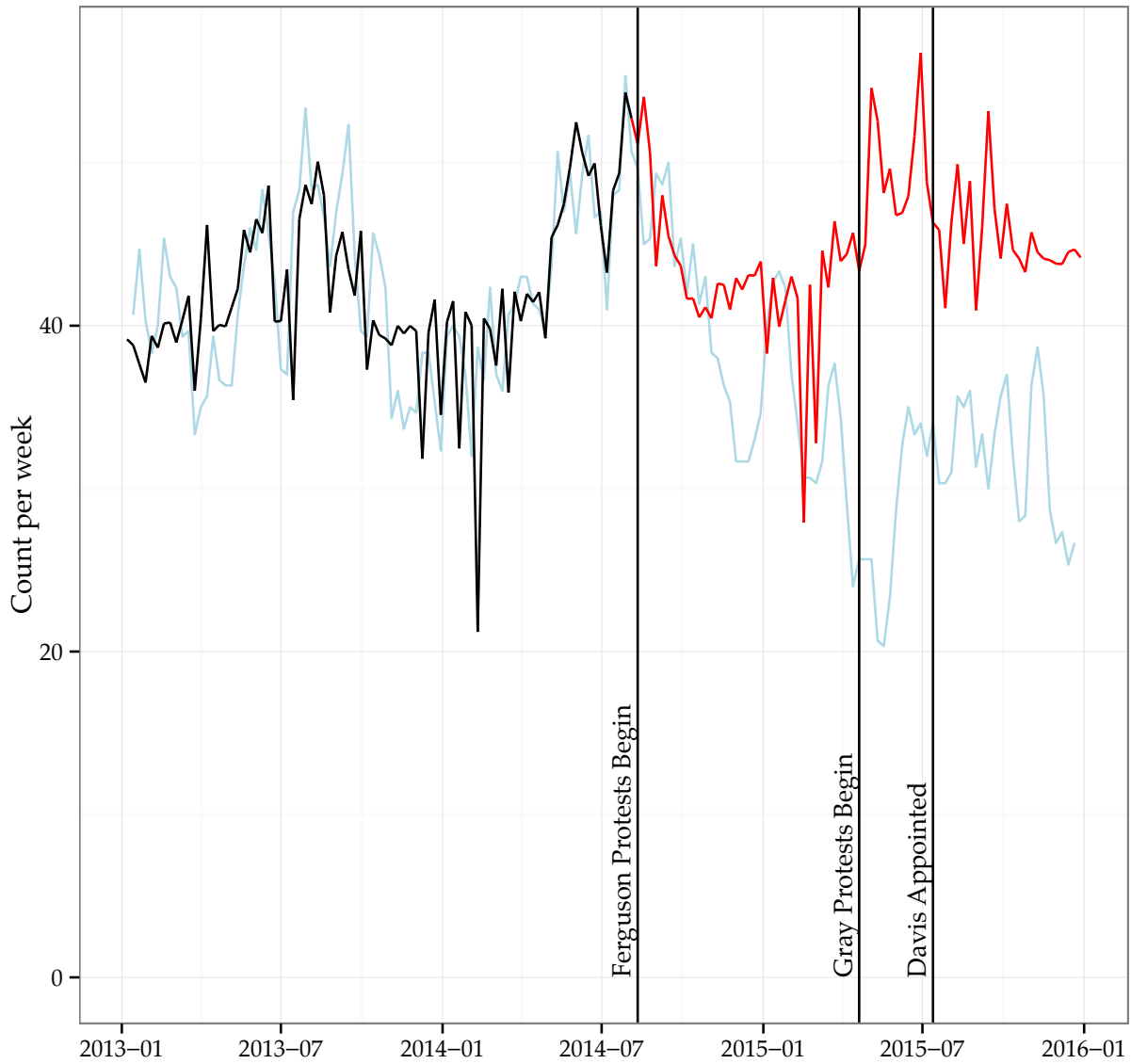


Figure 23. Total Weekly Arrests for Larceny (three-week moving average, blue line) with Predicted Values from the Model Before the Ferguson Protests Began (black line) and Extrapolated Counterfactual Values After the Ferguson Protests Began (red line)

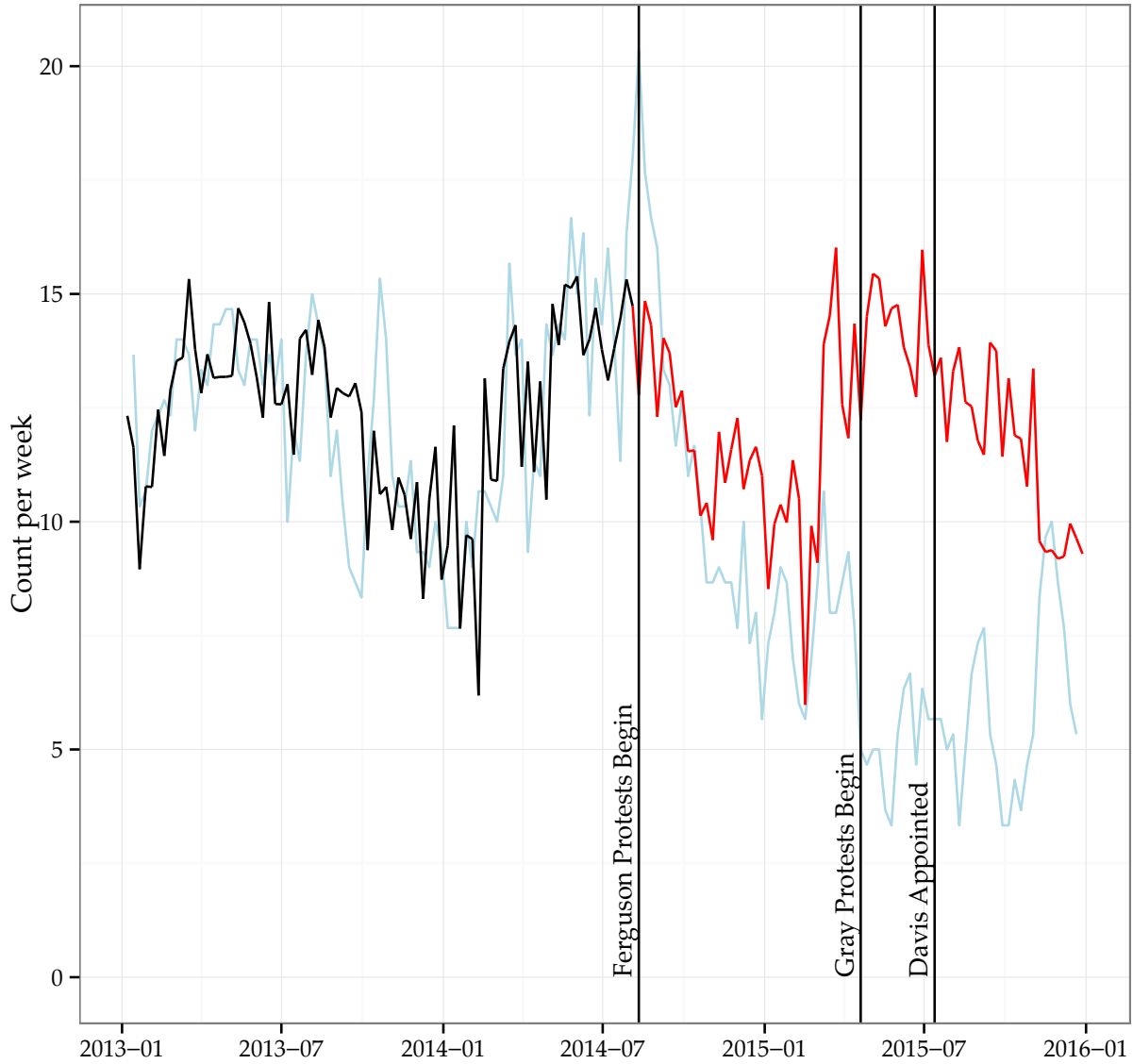


Figure 24. Total Weekly Arrests for Non-Compliance with Police (three-week moving average, blue line) with Predicted Values from the Model Before the Ferguson Protests Began (black line) and Extrapolated Counterfactual Values After the Ferguson Protests Began (red line)

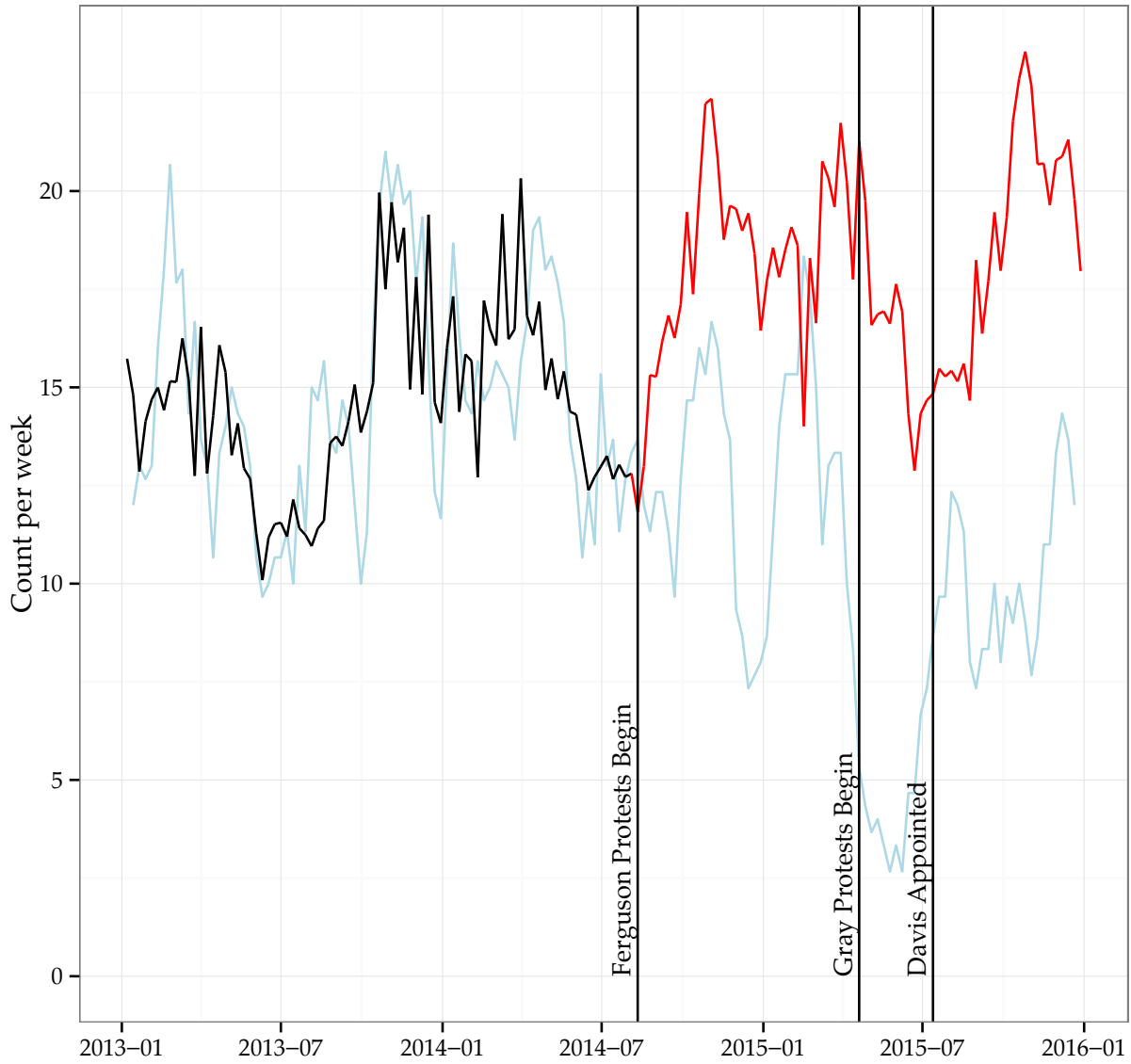


Figure 25. Total Weekly Arrests for Driving Violations (three-week moving average, blue line) with Predicted Values from the Model Before the Ferguson Protests Began (black line) and Extrapolated Counterfactual Values After the Ferguson Protests Began (red line)

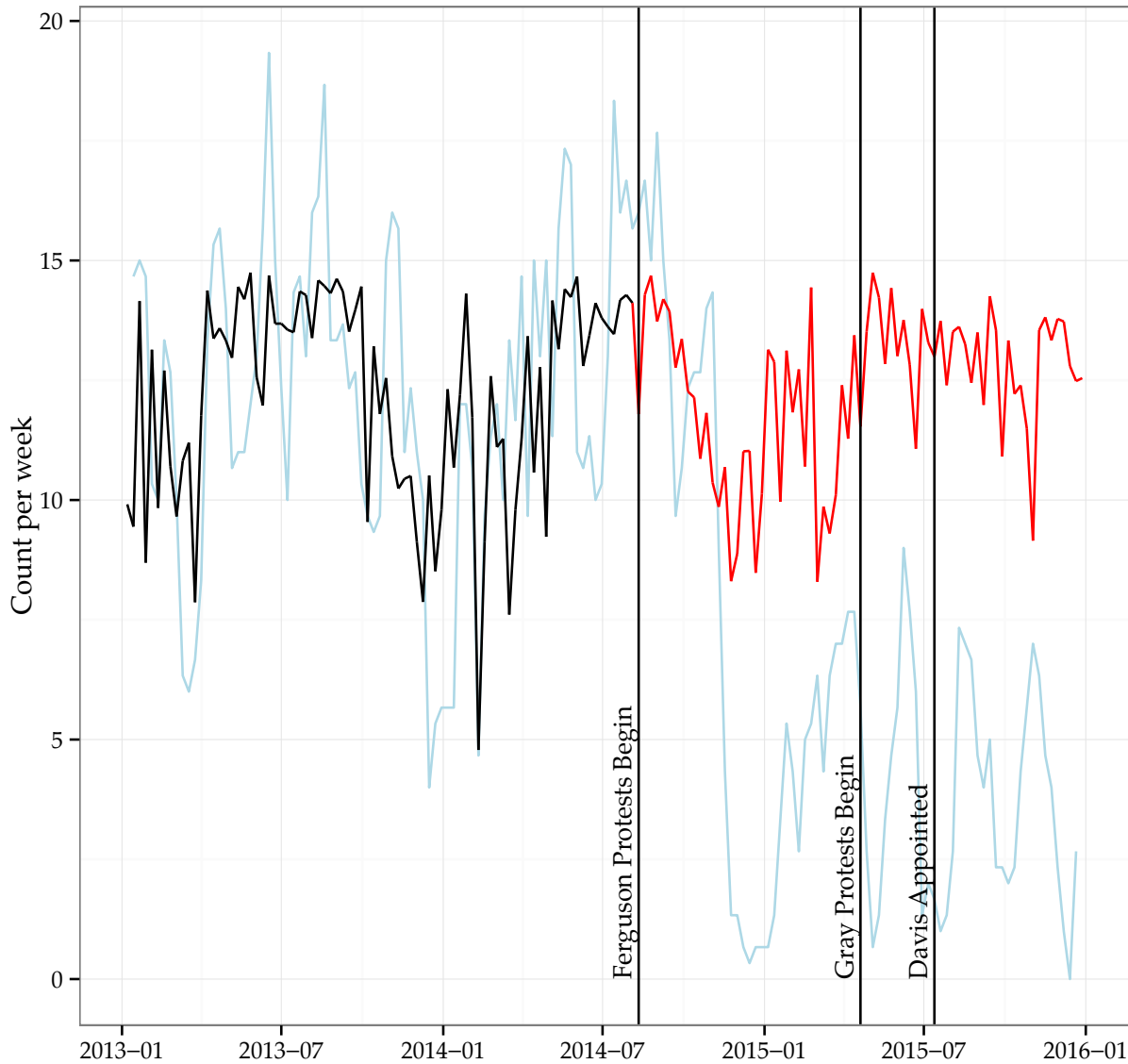


Figure 26. Total Weekly Arrests for Prostitution (three-week moving average, blue line) with Predicted Values from the Model Before the Ferguson Protests Began (black line) and Extrapolated Counterfactual Values After the Ferguson Protests Began (red line)

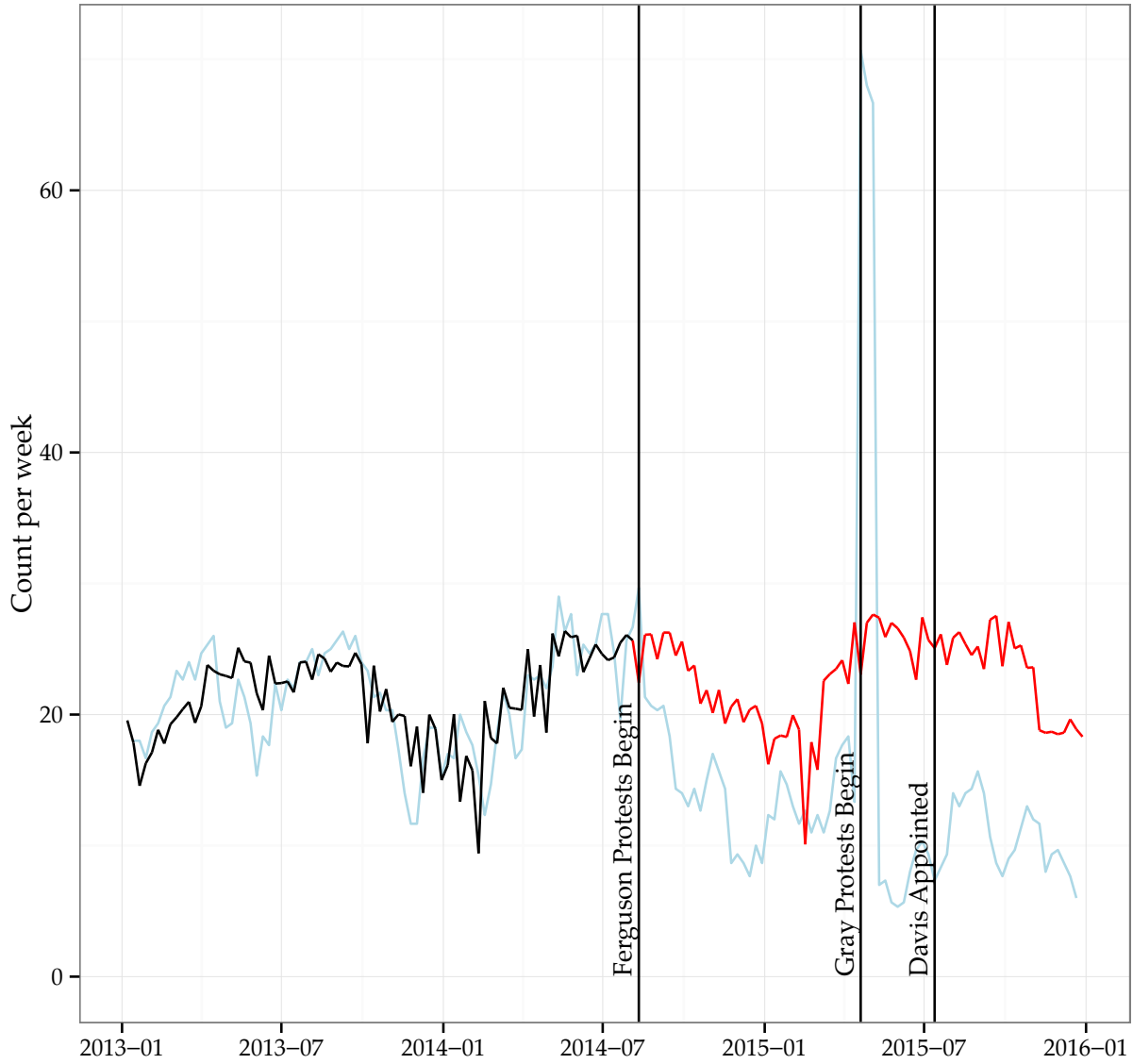


Figure 27. Total Weekly Arrests for Disorderly Conduct (three-week moving average, blue line) with Predicted Values from the Model Before the Ferguson Protests Began (black line) and Extrapolated Counterfactual Values After the Ferguson Protests Began (red line)

4.3. Conclusions for Arrests

Our period analysis of arrests suggests three primary conclusions:

1. During the post-Ferguson, pre-Gray period from August 11, 2014 through April 19, 2015, changes in arrest rates are consistent with a Ferguson effect on police conduct. Arrests decreased substantially for most areas of less serious crime, and these declines occurred during a period characterized by typical fluctuation in recorded crime incidents, after adjustments for seasonality are deployed. Only non-discretionary arrests for violent crimes, such as murder and robbery, held steady during this period. We have interpreted this decline as “consistent with” a Ferguson effect on police conduct, suggesting that Baltimore’s police officers may have used discretionary alternatives to arrest more frequently out of concern that the appropriateness of their conduct could become the subject of controversy. We do not, however, have any direct evidence for this mechanism, and it may be the case that the decline reflects a change in policy that occurred at the same time and that may or may not be a response to the emergent national dialogue on police conduct. Our sense is that the language of a “chill wind” adopted by FBI Director Comey (see our introduction) is similarly meant to capture a variety of such mechanisms, the origins of which are unclear but assumed to be related.

2. Arrests declined further by an additional 30% from April 20, 2015 through July 12, 2015, after removing the complex pattern of arrests that emerged during the week of unrest. These declines are consistent with the widely discussed conjecture that the Baltimore police pulled back from some routine policing in response to a perceived lack of support from the city’s leadership. These declines are also consistent with other narratives, such as the onset of a period of recovery following the overtime work of the police during the week of unrest, and an accentuation of a Ferguson effect on arrests that appears to have emerged first during the post-Ferguson, pre-Gray period. This accentuation may also reflect a subsequent decline in cooperation from the community.

3. Arrests increased during the remainder of 2015, after the appointment of a new police commissioner. Although some of these increases reflect a natural response to the crime spike that emerged during the spring and summer of 2015, the increase in arrests in the second half of 2015 was more widespread, suggesting that a resumption of more routine police work had occurred, perhaps aided by greater cooperation from the community.

5. Joint Conclusions from the Analysis of Crime Incidents and Arrests

In prior sections of this report, we have offered six primary conclusions – three for crime incidents and three for arrests – based on a comprehensive analysis of the data released by the Baltimore Police Department through the Open Baltimore data portal. Additional details of the full analysis are provided in the three appendices that accompany this report.

In this concluding section, we offer four additional joint conclusions. Because these final conclusions entail reasoning that is beyond the empirical analysis that we can offer, they are more tentative. As a result, we have also excluded them from the Executive Summary, lest these conclusions be considered as reliable as the conclusions conveyed there.

Our four joint conclusions are:

1. In Baltimore, changes in arrest patterns that are consistent with a Ferguson effect preceded changes in crime incidents that are consistent with a Ferguson effect. In fact, the only changes in crime incidents that are consistent with a Ferguson effect are those that are deeply entangled with Baltimore's localized Gray effect.
2. The decline in arrests that is interpretable as a Ferguson effect in the period of time before the arrest of Freddie Gray can be considered a positive development for the Baltimore community. This conclusion would follow from the position that a decline in discretionary arrests is a desired goal, following a period in Baltimore during which many residents and their local leaders concluded that the robust policing of struggling communities is not helpful for their redevelopment. Moreover, this beneficial change may reflect a turn away from broken-windows policing and stop-and-frisk policing that would have occurred even in the absence of the national dialogue on police conduct that first captured headlines in the summer of 2014.
3. However, this same decline can also be considered a negative outcome for the Baltimore community if the decline in discretionary arrests encouraged the subsequent crime spike that emerged after the unrest receded. This conclusion would follow from the position that (a) the unrest itself was made more likely because of the decline in discretionary arrests and/or (b) the crime spike represents opportunistic crime that would have emerged even if Freddie Gray had not been arrested and the resulting unrest had not occurred.
4. On balance, we reason that the positive outcome scenario is more likely, although we concede that we are not immune from hopeful thinking. We believe that the composition of the crime spike that began in May 2015 is more likely attributable to the particular features of the unrest and how it was handled than by the decline in discretionary arrests that preceded it. In particular, we see little or no evidence of a decline in arrests for violent crime in the post-Ferguson, pre-Gray period, and only a temporary decline in such arrests in the weeks that followed the unrest. The crime spike that followed the unrest has been shocking because it has been particularly violent, and it is not obvious to us that one can develop a convincing case that

a decline in discretionary arrests before the unrest is central to the explanation for the increase in violent crime after the unrest. It is not impossible that tit-for-tat shootings and territorial gang conflict are more likely to flourish after decreases in arrest rates for “failure to obey” and “driving without a license,” but we are not persuaded to adopt this interpretation. We would be more persuaded by this interpretation if evidence were available that young men in and near the Western and Eastern districts became (a) more likely to carry guns because of the reduced odds of being frisked and/or (b) more likely to use guns because of the reduced odds of community members aiding police investigations. Such evidence may exist, but the data we have analyzed do not address these possibilities.

If the second and fourth conclusions have merit, then they suggest one important implication for practice. The escalation of arrests that has unfolded in the latter half of 2015 must be managed with care so that over-policing does not emerge. If the third conclusion has more merit, no such implication is available, and only deeper solutions to the challenges that face Baltimore are worthy of our close attention. Relatedly, in this case the distinction between appropriately robust policing and over-policing may matter less than many think it should.